## IS THE EYE LIKE WHAT IT SEES?

## A CRITIQUE OF ARISTOTLE ON SENSING BY ASSIMILATION

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Philosophers sometimes go wrong by seizing on what they think is a powerful paradigm and extending it to domains where it has no purchase at all. And sometimes, their error is compounded by the fact that the starting point is less firm than it first appeared. This is what happened with Aristotle’s views on colour, an alluring paradigm of the senses that he extended to theoretical knowledge. In the second half of this paper (sections VI onward), I will show how his entire journey is misdirected, from its beginning in the theory of the senses to its destination in the theory of knowledge. But first I want to show how, by trying to demonstrate how his theory contains what they mistakenly take to be a kernel of truth, many contemporary scholars have fallen into serious errors of interpretation.

###  Introduction: Aristotle’s Errors

Aristotle’s theory starts from two plausible ideas:

I1. Sensing is a causal process that starts with an external object and culminates in a sensory state.

I2. Sensory states are *accurate*, or *true*, only if their structure mirrors the state of the external object from which the sensing starts.

Reflecting on these intuitions, Aristotle arrived at the implausible notion that colour is a visible form that is transmitted from an external object and received by a subject’s sense-organ. Transmission of a form through a medium satisfies I1, and fits well with Aristotle’s paradigm of end-directed change, though obviously it is not the only causal process that fits the bill. And this yields an obvious way to satisfy I2: the resulting sensory state is accurate only when the form received by the subject’s sense-organ conforms to the object’s visible form—though, as we shall see, there are other ways of understanding I2. Thus, starting from two reasonable ideas, Aristotle arrived at the quite implausible account of sensing.

It’s likely that Aristotle understood this “assimilation” theory literally. That is, it’s likely that he held that:

(a) there is a transmissive process that radiates outward from a *C*-colouredexternal objectto the eye,

(b) which results in (a part of) the eye receiving colour *C’* (or some formal component thereof),and

(c) this change in the eye’s colour is an act of sensing,

(d) which is accurate if *C’* is the same as *C*.

Let’s call this the *Literal Assimilation Thesis*. Aristotle extended this idea to the intellect: humans come to know by assimilating intelligible form. The Literal Assimilation Thesis is even less at home in the realm of knowledge than it is in the theory of sensing.

My primary aim in this paper is to examine the Literal Assimilation Thesis. This theory is mistaken in many ways, but it has two glaring flaws that have not sufficiently been probed by commentators.

F1. The first flaw is that Aristotle so concentrates on *the* (i.e., the one and only)thing that a subject supposedly sees that he apparently does not notice that in fact she usually sees many things at the same time. Thus, he fails to appreciate the central importance of visually registering the spatially arrayed places that differentiate multiple objects of vision.

F1 was largely corrected by Kepler, whose explication of the ocular lens and retinal image was swiftly adopted in scientific and philosophical discussions of vision. Today, Aristotelian scholars seem to take Kepler’s innovation so much for granted that they fail to notice the problem in Aristotle.

F2. The second flaw is at the heart of the idea of assimilation itself, the idea that vision consists in the reception of a bodily quality whose essence is independent of the sensing subject.

Regrettably, vestiges of F2 persist in contemporary philosophy of perception, where some hold that colour is a physical quality, the essence of which is independent of the sensing subject. Contemporary philosophers do not, of course, maintain that colour is a visible form that is assimilated by the eye. But inasmuch as they assume that colour is defined independently of the visual system, they repeat a part of Aristotle’s error. And because they repeat this error, they are inclined to think that Aristotle’s theory is, in some important way, an important insight. We will see, however, that colour must be defined in a subject-involving way, and that visual accuracy can be understood in a way that accommodates this.

My secondary aim in this paper is to question what I take to be a persistent trend in Aristotelian scholarship, namely the urge to interpret Aristotelian philosophy of nature in a maximally “charitable” way. Many readers of Aristotle’s psychology seem to adopt the stance that, just as we can learn something of contemporary value by paying close attention to Aristotle’s philosophy of science (to say nothing of his moral and political philosophy), so also, we might gain new philosophical insights into sense-perception from works such as the *de Anima*,if we read them in a way that can accommodate contemporary perception-science and philosophy of perception*.* In my view, this is a mistake.

As we shall see, recent commentators have used concepts such as *perception*, *transduction*, *binding*, and *direct realism* in discussions of Aristotle’s theory of sense. By reading such notions back into the ancient texts, they not only risk getting Aristotle wrong, but also fail fully to do justice to the revolutionary import of later thought. Rather than straining to interpret Aristotle in a way that satisfies (highly tendentious) contemporary intuitions, it would be historically more revealing to note how he lacks the theoretical means to address his intuitions, I1–2 above without falling into jeopardy with regard to F1–2, and to narrate the revolutionary later developments from Kepler down to the twentieth century that have enabled us to correct the deep flaws in his theory.

###  Aristotle’s Conception of Sense

Aristotle’s theory of colour vision is explanatorily subordinate to his definition of *sensing*. Let’s start with this definition:

In general, and with respect to all of the senses, we say that sensing is the capacity to receive sensible forms without the matter, in the way that wax receives the stamp of a signet ring without the iron or gold out of which the ring is made; it takes the stamp *of* the gold or bronze but not *as* gold or bronze. (*de Anima* II 12, 424a17-21; translations of this work adapted from Hamlyn)

In Aristotle’s conception, an act of sensing occurs by means of a causal influence that runs from an *active* power that inheres in a sensed substance to a matched *passive* power in the sensing subject. Actually, as Anna Marmodoro (2014) points out, there are two entities on the sensing subject’s (or passive) side of this transaction, the sense-organ and the subject herself. Thus, as she writes, “there is a one-to-one correspondence among the type of an instantiated perceptible quality, the type of the corresponding alteration of the sense-organ, and the type of the content of the resulting perceptual experience” (84).

A preliminary remark. It is somewhat incautious to use terms like ‘perception,’ ‘experience,’ and ‘content’ when we talk about Aristotle’s theory. Thomas Reid famously distinguished *sensation* and *perception* in a way that continues to be important in contemporary studies of perception: sensation is a state of the sensing subject that lacks any essential intrinsic significance beyond itself; perception is a state of the subject that *essentially* and *by its intrinsic nature* intimates the presence of something outside itself. It is, as we shall see, dubious that Aristotle made this distinction. For while it is true that he believed that sensory states inform us of the world outside, he is (as we shall see) quite unreflective about *how* they manage to do this. And it would almost certainly be wrong to think that he formulated a notion of a sensory state—a *perceptual* state—that is, by its intrinsic character, informative about something distinct from itself. Nor is it clear that he thinks of *experience* as defining such states. It is better, for these reasons, to speak simply of the soul’s (or the subject’s) act of sensing, and *not* (as Marmodoro does) of a perceptual experience with (representational?) “content.”

Returning now to the definition of sensing, Marmodoro insightfully demonstrates how Aristotle’s theory of change provides essential context for his theory of sensing. It envisages two types of change (*Met* IX 7). One, called *energeia*, is defined by its process, not its end-point. If I simply *walk*— meander along to no particular destination—my motion has no natural cessation point and carries on for as long as I would like it to. Walking to no particular destination is thus defined by the *process*—i.e., by putting one foot in front of another in a particular pattern.

This is different from the action described as *going to the office*, which (a) implies nothing about process, (b) predictably leads to arriving at the office, and (c) predictably ceases when I arrive. Aristotle calls the latter type of change *kinēsis*. In modern terminology, *kinēsis* is either

*teleonomic*, i.e., where the end of movement is predictable, but has noexplanatory value(as when a living thing dies, or when spring gives way to summer), or

*teleological*,where the end is not only predictable but also explanatory,

because it is achieved *purposively* (as when I go to the office), or

because the end is good (as Aristotle claimed the rain in winter is for the good of the crops), or

(a contemporary conception) because the process leading to this end was *naturally selected* during evolutionary history (as in the case of homeostatic organic processes).

In the Aristotelian system, an especially important type of *kinēsis* occurs when one thing affects another by transmitting to that other thing some quality or form that is present in itself. The end-result is that the second, or passive, entity acquires the form of the first. In the terminology that some use in this context, the passive entity ‘assimilates’ the form that is present in the actuator of change.

Here are some examples of assimilation.

A *house-builder* has in his mind an idea of a house; he imparts this to unshaped bricks and mortar, which become an instance of the form present in his mind. Note that the building process here is specified in terms of where it will end up—i.e., in the bricks and mortar becoming a house—and ceases when this end is achieved.

In *natural gestation*, a male has within himself the form of his offspring. He implants this in the unformed genetic matter present in the female, and this matter comes to resemble him (with respect to form).

In Aristotle’s conception, sensing is a form-transmitting *kinēsis*. Here, the actuator is a bodily substance that possesses ‘sensible form’—this is the sensed object. This sensible form is transmitted to the sensing subject through an appropriate medium. The subject’s faculty of sense is defined by its capacity to assimilate sensible form. When it does so, (a) a new instance of the sensible form comes to be in the subject’s sense-organ. And the net result is (b) that the subject senses the object. (Where convenient and not misleading, I’ll elide these twin effects by using the term ‘act of sensing.’)

The theoretical apparatus of form-transmitting *kinēsis* sheds considerable light on why Aristotle sets his theory up in the way that he does. (*De Anima* II 7 contains several good illustrations of his use of this theoretical apparatus, in particular arguments that oppose the atomist alternative.) However, the theory of *kinesis* commits him to both the perceiver-independent definition of sensible forms and to the idea that accurate sensing is a process of coming-to-resemble. And these are problems for any contemporary deployment of his apparatus.

###  Aristotle on Colour as a Primary Quality

In sensing, only the sensible form of a bodily substance affects the sensing subject; no *other* feature of this object affects her. Every other feature of the sensed object, including its identity, is left behind; these other features have no causal influence on the sense faculty. This accounts for the two starting points of Aristotle’s theory of vision, stated at the beginning of the chapter on vision, *de Anima* II 7 (418a28).

Colour is the special object of vision; that is, we see by seeing colour. (It is the form that is transferred from sensed object via the transparent to the visual sense.)

Colour resides in that which is of itself visible.

In short, colour is visible form.

Aristotle says that sensible form is the *special* and *intrinsic* object of sense. A sapphire, for example, is a bodily substance that is visually sensed but only insofar as it has colour. *Blue* is the special and intrinsic object of vision here; the sapphire is incidentally sensed. Moreover, since it may also be *felt* by touch or *heard*, for instance if it is scratched or dropped, the sapphire is not *special* to vision.Bodily substances like the sapphire are *incidental* objects of sense; they are sensed only insofar as some sensible form that they possess affects the subject through some sense faculty.

Material substances possess a generic colour-power. Visual sense is by nature matched to this power; it receives colour. A particular body, such as the sapphire, possesses a *determinate colour*; this is aquantitatively measurable mixture, or *ratio*, of lightness and darkness, which constitutes, in the case of the sapphire, its blue colour (*de Sensu* 3, 440b14-26). (Mark Kalderon 2015, chapter 6, has a lively and informative discussion of the ‘generation of the hues.’) Other colours are constituted by other ratios; blue is different from pink, for instance, because it is a different ratio of light and dark. It is by my visual faculty assimilating the mixture characteristic of a particular shade of blue that I sense the sapphire.

I’ll make four preliminary remarks about Aristotle’s definition of colour.

1. Though the definition of *sense* is prior in the order of explanation, it seems plausible to think that it is a generalization from, or at least that it is particularly intuitive for, the case of colour. When you look at somebody’s eye, you see things reflected in it—the eye thus seems to have taken on the colour of distant things. As it turns out, this phenomenon is superficial—these reflections (known as Purkinje-Sanson images) are from various layers of the cornea and from the outer surfaces of the lens and have nothing to do with vision as such. But nothing like this is true of any other sensible: nothing within you becomes hard to the touch when you come into contact with iron or soft when you stroke velvet; your nose does not smell acrid when you catch a whiff of burning sulphur or sweet-smelling when you sniff a rose; your ear does not sing when Beyoncé does.[[1]](#footnote-1) So, we may speculate that starting from what seemed like a significant fact regarding vision and the eye, Aristotle arrived at the conclusion that, in some less obvious manner, all sensible forms are transferred from perceptible things to the corresponding organ of perception.

2. However that might be, Aristotle did not need to insist that sense-faculties literally receive sensed qualities, and this may not actually have been his position. For it was open to him to hold that the sense quality itself (and not just the sensed object) is analysable into form and matter. According to Aristotle, colour is a ratio of lightness and darkness. He *could* have held that this ratio is the form of *colour*, and that lightness and darkness are its matter. If this is his position, then he could have said that the visual faculty receives only the numerical ratio that constitutes colour. Then, as Victor Caston (2015) writes:

To receive the form ‘without the matter’ would be to embody only certain essential features of the form in a different type of material, without producing a replica. For example, according to Aristotle each colour is defined by a ratio of black to white. On the present suggestion, the eye would receive a colour ‘without the matter’ by embodying the same numerical ratio in a different pair of opposites—hot and cold, say, or runny and viscous—in the vitreous jelly, which Aristotle believes is the sensitive part of the eye, without the jelly needing to change colour at all. In effect, the senses would act as *transducers*: they would preserve certain essential features of the perceptible form in a new medium (*ibid*,45).

Caston’s talk of ‘transducers’ is meant to serve as a bridge to contemporary thinking. In today’s terminology, visual transduction is the physical process by which a retinal cell produces an electrical impulse when light falls on it—this electrical impulse serves as a measure of the incident light energy in subsequent processing. Caston is suggesting that for Aristotle, visual sensing is akin to this process—a numerical ratio realized in the matter of the sensible object is replicated by means of this process in the different matter of the sense-organ. In this new matter, the ratio is not colour, but rather a formal analogue of colour.

This terminology is misleading for two reasons. The first is that in Aristotle a visible form literally moves from an external object, through a medium, to the sense-organ wherein it comes to reside. Regardless of whether this form is a colour or merely a numerical ratio, Aristotle has no good account of this movement—all that the *kinēsis* theory tells us that it has the power to be instantiated in something else. The question was investigated only later— first by geometrical optics, with its rays of light, and then by modern physics with its theory of electromagnetism. But Caston’s talk of transduction makes it sound as if these later contributions were merely a footnote to Aristotle. And, secondly, it masks the fact that in contemporary conceptions, transduction is only the first stage of vision—the neural electricity it provides is only the beginning of a complex hierarchical process that culminates in the brain’s cortex. To equate visual sensing with transduction creates the entirely misleading impression that Aristotle anticipated a few vital parts of contemporary theory. And this undervalues the importance of later contributions.

3. According to Locke, the sensing subject’s *ideas* of primary qualities resemble the qualities themselves. For instance, our idea of a *square* resembles a square. In Aristotle’s theory, this is true of all of the special objects of the senses. The external object of sense is a form (whether the colour itself or the formal ratio of the colour); the sense faculty takes on this form when it is activated. Thus, the eye comes literally to resemble the sensed object. We may infer that the special objects of the senses are primary qualities in Locke’s resemblance sense. They are what they are independently of being sensed.

4. In Aristotle as in Locke, colour is a power to affect sensing subjects. For Locke, such powers are *secondary* qualities. However, the order of dependence is reversed in Aristotle. Locke defines these qualities by reference to the subject: colour, for instance, is the power in a body to evoke a colour experience. In Aristotle, by contrast, the external object of sense is prior. Colour does not depend on being sensed (*de Anima* III 2, 426a20-26); on the contrary, vision is defined by its power to match colour.

###  Aristotle’s Indirect Realism

It’s an important consequence of Aristotle’s ontology that the objects of sense are fungible, or substitutable, relative to the sensory state they evoke. Take a painted depiction of the sapphire: assuming that it portrays the sapphire’s colour accurately, it possesses the same ratio of light to dark, and its effect on my eye and on me is the same. So, if on a given occasion I were looking at the painting rather than the sapphire, my sensory state would be the same. As far as this is concerned, all that matters is that some external object transmitted this particular shade of blue to my eye. Thus, we have:

*Fungibility* A sensory state *S* consists in quality *Q* inhering in sense-organ *O*. *S* would be no different if *Q* had been assimilated by *O* from a different external object.

This fits with what Aristotle says about the *substances* we sense. They are only incidental objects of sense; we perceive them only as the possessors of proper sensible qualities. The sapphire and the painting possess the same quality; so, they are equivalent as far as the visual state they evoke in me. I perceive an external object “incidentally,” or indirectly—through its qualities.

But what about the *colour itself*, the proper sensible? Is my seeing-blue one and the same regardless of whether it happens to be brought about by the blue-of-the-painting or the blue-of-the-sapphire? Once again, the answer seems to be yes. The blue that is in my eye would be the same—*numerically* the same—regardless of whether I am looking at the sapphire itself or a painting that accurately reproduces its colour. Thus, there is nothing about this state taken on its own that enables me to infer which object it came from. Indeed, there is nothing about this state taken on its own that enables me to infer that it came from *any* other thing. So, one might ask: In what sense is the blue-in-my-eye a *perception* of something beyond? Call this:

*The Problem of Perception* What is there in the reception of a sensible form by a sense-organ that indicates a particular sense-*object* beyond the sense-organ? My eye is blue. How does this indicate a particular blue object yonder?

Mark Kalderon (2015, 175) attempts to circumvent the Problem of Perception by employing direct realism to contest the fungibility of sense objects. He writes that for Aristotle “sensory impressions are individuated by their objects.” Kalderon expands on this thought as follows: “these objects constitutively shape our sensory impressions of them . . . The whiteness of the sun is a constituent of your experience.” To me, this seems completely off-track. It’s true that the *shade* of white that is present in the Sun is transmitted to and inhabits my eye. But what Kalderon seems to miss is that when this shade of white is instantiated in my eye, the result is a *new and numerically distinct* instance of that shade of white. The white that is in the eye is individuated by the eye, not by the external object whence it came.

In a review of Kalderon’s book, Paul Coates (2015) writes: “it is not obvious that anything like this direct realist analysis comes out unequivocally in Aristotle’s writings.” Coates understates the difficulty—the colour in the sensed substance is one instance of colour; the colour in the eye is a numerically distinct instance of the same quality. There is nothing in the latter that indicates the former, no reason to take the latter as having the Sun as its “content,” to use Marmodoro’s questionable term. (I’ll come back to this issue in Section IV below.)

Kalderon is also wrong, I think, to suggest that a certain kind of infallibility is implied by Aristotle’s account of sensing:

The perceiver’s perceptual experience could not be as it is if a Cartesian demon eliminated the perceived object. If perception is a mode of assimilation, then the visual experience that the perceiver undergoes in seeing a particular could not be as it is if that particular differed in visible respects relative to the perceiver’s point of view. (*ibid.* 193)

Of course, Kalderon is right to say that my eye is caused to take on a sensible quality by a particular sensed quality in an individual bodily substance. But clearly this does not mean that the same result cannot have been brought about by another object or another instance of the quality. To repeat: sensory objects are fungible with regard to acts of sensing.

Now, it is true that Aristotle *claims* a certain infallibility of sensory states:

Each sense has one kind of object which it discerns, and never errs in reporting that what is before it is color or sound (though it may err as to what it is that is colored or where that is or what it is that sounding or where that is). Such objects are what we propose to call the special object of this or that sense. (*de Anima* II 6, 418a14-17, tr. Marmodoro)

Marmodoro explains the thought this way: ‘this is so because it is only color that can stimulate the sense-organ of sight, so sight cannot be mistaken about that’ (85). What Kalderon and Marmadoro fail to notice here is that Aristotle is simply wrong about this, even within his own system. For he clearly recognizes that some occurrences occur regularly only ‘if nothing interferes.’ The blue in my eye is *normally* the effect of something blue outside, but even by Aristotle’s own theory of causation, it *can* be caused by something green if some unusual circumstance were to interfere. (Think of the square tower that looks round at a distance.) Moreover, as synaesthetes are well aware, sound can make me see blue by a non-standard causal chain—I don’t see any reason why this kind of phenomenon contradicts the Aristotelian theory of *kinēsis*.

Aristotle also allows that things that regularly happen by one causal pathway can also happen spontaneously, or without any cause at all. In fact, this is his explanation of spontaneous generation in *Generation of Animals* III; an insect that normally comes to be by biological generation can, on occasion, come to be spontaneously (Balme 1962). By the same reasoning, I should be able to see blue without there being anything blue in front of me. There is, after all, plenty of fire and light and darkness around. It is not impossible for them to come together spontaneously to make my vitreous jelly blue in the requisite way.

Given these difficulties, we can restate the Problem of Perception in this way: What is there in the eye being blue that indicates to the subject that something outside herself is blue? It is not clear that Aristotle ever posed this question, much less answered it. He is a realist, but he never argues for his realism. There is certainly no reason in the text to impose *direct* realism on his theory of sensing.

###  Aristotle on the Distant Cause of Sensing

Now, let’s examine another approach to the Problem of Perception. Aristotle held that

(D) Every act of sensing is caused an object at a distance.

As Katerina Ierodiakonou (2016) puts it, “Aristotle thinks that a necessary condition for sensing an object is for that object to be at a distance from the perceiver.” But there is an often-unnoticed gap between (D) and this further position:

(D’) Every act of sensing is as of an object at a distance.

For though *O* (an object) might be the cause of *S* (an act of sensing), and *O* might be at a distance from the sense-organ involved in *S*,it may well not be possible to infer from *S* alone that *O* is at a distance. For this reason, the doctrine that sensing (always or normally) has a distant cause is not by itself an answer to the Problem of Perception. Yet this is how many commentators have taken it.

It is an important element of the *kinēsis* model of change that active powers activate passive powers by ‘contact.’ But visual objects are at a distance. So, the visual faculty must so be constituted as to be affected through an intermediary that touches the sensed substance at one end and the sensing subject at the other. Vision must, in other words, occur through a medium. According to Aristotle, fire actualizes this medium, which becomes transparent as a consequence; *light* is the actuality of the medium—light dawns when the sun makes the air actually transparent. In the absence of fire, this medium is merely *capable* of transmitting the influence of colour but does not actually do so; in this condition, it is dark (*de Anima* II 7, 418b9-10).[[2]](#footnote-2) The visual faculty assimilates colour through the transparent medium and is *not* able to do so directly from coloured bodies. Thus, ‘if one were to place a coloured thing directly on the eye, it would not be seen’ (*ibid,* 419a12-13). Oddly, he even applies the model to touch by an explicit analogy with vision: ‘If you place the object on the organ, it is not perceived; if you place it on flesh, it is; so, flesh is the medium’—not the organ (*de Anima* II 11,423b25-26). The organ of touch is inside the body, and it is activated by something at the surface of her body.

Kalderon (2015, 6) argues that Aristotle’s medium solves what he calls ‘the Empedoclean puzzlement.’ Empedocles held that a sensible object must be in contact with a sensing subject. So, he proposed (as did Democritus) that we see distant objects by means of a stream of effluences that flow out of sensible objects and enter the eye. According to Empedocles, these effluences establish the *contact* needed for vision. As we just saw, Aristotle opposed Empedocles on empirical grounds; he suggests that direct contact abolishes vision and insisted that vision can only occur at a distance. But instead of being content to say that vision operates differently from touch, contrary to the Empedoclean assumption, Aristotle insists that touch too operates at a distance.

I very much doubt that Aristotle has a coherent model for the transmission of causal influence from sensed object to sensed organ; it seems to me that Empedocles has the advantage over him in this respect. But put this to one side. The point I want to make at this juncture is that neither Empedocles nor Aristotle addresses the Problem of Perception. Start with Empedocles: If vision occurs by the contact of the effluences, then how, on his theory, do we see beyond the effluences to the distant object? It is the effluence, not the distant object, that touches the eye. What in the effluence serves as a place-of-origin stamp that informs the sensing subject of something beyond itself? And correspondingly, with regard to Aristotle’s theory, if vision occurs by a distant object affecting the sense-organ through a medium, how does the subject become aware of anything other than the change in her own state?

Thomas Johansen (1998, chapter 2) attempts to solve the problem by simply erasing the gulf. He says that, in Aristotle’s view, the sensed object’s causal effect is nothing other than that it makes the subject aware of it. In other words, the change in the sense-organ—the eye becoming coloured, for example—just is awareness of the sensed object. But this can’t be right. First, it neglects the fungibility of the sensed object. But more importantly, it skirts the question of how awareness can spread from the condition of the sense-organ back along the causal process that leads up to it. As the Empedoclean parallel makes clear, Aristotle aimed for an account that would explicate the physical process of transmission. And the question is: when you examine the traces of the transmissive influence at some distance from its origin, what mark do you find of that original cause? How would such a mark make its way from sensed object to sensing subject? How would it be recognized?

Austen Clark (2000) beautifully states the problem from the point of view of contemporary neuroscience:

Even if we think of a sensory system as yielding up a set of ‘meter readings’, it is difficult to see how one could provide any groups, tags, or labels that would tell it what those meter readings are *about*. . . (*ibid*, 47)

A neuron fires; what about this event betokens an event a metre to the front of the subject’s nose? Suppose that you were a homunculus sitting inside the brain and watching various neurons fire. Why would you think that a particular set of firings is “about” something outside the head? How would you decode the external spatial significance of these firings? It’s important to realize that Clark is not being a sceptic here. He is not denying that you know. He is, rather, posing a problem for the neuroscientist. How does the brain manage to sort things out this way? This is the Problem of Perception again. My worry is that Kalderon and Johansen make the problem disappear by simply throwing a cloth over it. They simply stipulate that the homunculus knows. But this is not the issue: the question is how he knows.

###  How Many Objects Can Aristotle See At One Time?

Aristotle renders the Problem of Perception intractable in a different and additional way. Clark’s worry was how to reconstruct external location out of a million unlabelled neurons inside the brain. In Aristotle the problem is compounded by the fact that that he accommodates only one sensor. When I look at a sapphire, my entire vitreous jelly becomes blue; thus, spatial differentiation is impossible. I cannot, in the same act of sensing, become aware of the green emerald that sits next to the sapphire in the jeweller’s display case—the vitreous jelly cannot become both blue and green.

Aristotle seems to acknowledge this point in *De Sensu* 7:

When there [are two objects] the actualized perceptions that perceive them will be two; but in one and the same faculty the perception actualized at any single moment is necessarily one, only one stimulation or exertion of a single faculty being possible at a single instant . . . Hence, it is not possible to perceive two distinct objects simultaneously with one and the same sense. (447b17-19)

So, you cannot see a blue and a green thing simultaneously, or even two blue things as two. And yet, obviously, we do. Let’s call this the *Problem of Simultaneous Perception*.

Aristotle passes over Simultaneous Perception in silence; he focuses instead on how we can attribute two qualities—for example, whiteness and sweetness—simultaneously to the same thing. His solution to the problem of simultaneous attribution appears to be that the soul is divided; redness actualizes one part and roughness another. (See Pavel Gregoric 2007, Part III, chapter 1 for an excellent discussion of this problem.[[3]](#footnote-3)) But this does not tell us how we perceive *the same thing* as white and sweet. Nor, more importantly for our present purposes, does it tell us how we visually *sense* one thing as green and another as blue. For on Aristotle’s account of them, the senses tell us nothing about position. The eye is only one colour: it cannot register the green emerald to the left, the blue sapphire to the right. By the same token, it cannot register that sweetness and whiteness are co-located, and thus that there is one single thing that is both sweet and white. Aristotle simply does not discuss the perception of place.

The groundwork for understanding spatial differentiation in vision was laid by the geometrical optics tradition, culminating in Kepler. Kepler discovered that the corneal lens projects a two-dimensional image on to the retina. In Kepler’s system, it is implicit that the retina is composed of an array of sensory receptors that together constitute our sensitivity to light and colour. The image thrown by the ocular lens affects each receptor differently. Each receptor can be thought of as a mini-eye as Aristotle thought of the eye. According to Kepler, each little receptor receives colour in the same manner as the Aristotelian one big vitreous jelly did.

Kepler’s lens and its retinal image transformed the dialectic around the Problem of Perception. The question of philosophical and scientific optics became this: how do we extract three-dimensional information from a pair of two-dimensional retinal images? (See Turner 1994 for a canonical account of the nineteenth century debate.) But, as noted, certain elements of the basic Aristotelian framework are left in place. Kepler was addressing a version of the traditional scholastic question: ‘How is the visible form of an external object transmitted to the eye?’—except that his question concerns the spatial layout of a whole scene. But this does not address the problem of what colour is.

In Kepler’s time, all agreed that visible form was *colour*! Kepler did not dissent. As David Lindberg (1975) wrote: ‘Kepler attacked the problem of vision with greater skill than had theretofore been applied to it, but he did so without departing from the basic aims and criteria of visual theory established by [ibn al-Haytham] in the eleventh century’ (207). Mark Smith (2004) concurs, adding that in al-Haytham’s theory, ‘what actually radiates from the surfaces of visible objects is luminous color’ (183). W. W. Bryant (1920, 32) sums up Kepler’s limitations especially well: he ‘compared the mechanism of the eye to Porta’s ‘Camera Obscura,’ but made no attempt to explain how the image formed on the retina is understood by the brain.’ It is this failure of both Aristotle and the geometrical optics tradition that is covered up by Caston’s terminology of ‘transduction’ (discussed earlier).

How *does* the brain understand the retinal image? In particular, what conception does it form of colour? This is another iteration of the Problem of Perception—how does the eye turning blue give us an apprehension of the colour blue independent of its effect on the eye? It is here that we find Aristotle’s second and more persistent error. The question that we must now ask is: Is it appropriate to think of the eye as an apprehension of an external quality?

Here is the position that I would like to defend.

The retina is not sensitive to *colour*; cone-cells do not transduce colour. Colour is a classificatory system that colour *vision* creates.

###  Colour and Wavelength

Some contemporary philosophers hold that colour is a *physical* property, or (somewhat less boldly) that it is an objective property that can be identified independently of any perceiver or perceptual system. I want now to show why this form of objectivism is deeply mistaken. Colour properties are, as I shall show, identified by, and properly defined in terms of, a given perceiver’s response patterns—they are secondary qualities, as Locke called them. Notwithstanding this response-dependence, there is a sense in which colour vision can be accurate or inaccurate when it presents a distal object as possessing a certain subjectively defined colour—it is likely that colour objectivists have been misled by this.

Let’s begin with the quicksand basis for the objectivist position.

First, retinal cone-cells transduce light falling on them: that is, they respond to incident light by emitting a neural signal. Second, these cells respond differentially to different wavelengths of incident light: that is, light of one wavelength will produce a different-strength response from a given cone-cell than equally bright light of another wavelength. Finally*,* *colour* is the preponderance of some wavelengths in the visible spectrum over others—for example, *blue* is the preponderance of shorter wavelength light.

These three facts together have led some philosophers to identify colour-sensing with wavelength-sensing. They observe that, for example, some cone-cells respond more strongly to shorter wavelength light than to longer. They interpret this as a response that is partial to, and hence detects, light at the short wavelength end of the spectrum. Peter Bradley and Michael Tye (2001, 481), for example, say that the activation-level of a short wavelength cone indicates the “amount of low wavelength light” incident upon it. And they conclude, roughly speaking, that blueness is the physical property associated with short wavelength. This is the conclusion that I want to contest.

Let’s examine the cone-cells more closely. Vertebrate animals with colour vision—birds, old-world primates, many fish, etc.—possess several photoreceptor cell types, each differentially sensitive to light in a sub-region of the visual spectrum. Figure 1 shows the spectral sensitivity of the three human cone cells. Each place in the colour sensitive portion of the retina contains these three cone-cells. When light falls on a cone-cell, it responds according to its sensitivities to light of differing wavelengths.



Figure 1: Response curves of human cone cells. From the Wikipedia article on cone cells under the Creative Commons licence.

The cone-cells are sensitive to broad wavebands of light, but differently sensitive to different wavelengths within their bands. The L (or long wavelength) cone emits a response when light of just about any frequency is incident upon it, but if we pick a threshold of 25% of peak response, then it responds to light between 500 and 650 nm, or about half of the visible spectrum. It is maximally sensitive to light of about 580 nm. This means that light of 580 nm will evoke a response four times as strong as light of equal strength at 500 nm. And light of 500 nm will evoke the *same* response as light of 580 nm when the latter is only one-fourth as strong.

Here, then, is a central fact about cone-cells. They do not sample the intensity, or strength, of light in a waveband; their read-out is, rather, the sum of intensity at each wavelength *weighted by their own sensitivity* at that wavelength.The S-cone, for example, is sensitive to light of wavelengths between 390 and 540 nm. As we saw, Bradley and Tye say that it responds to the amount of “low wavelength light” incident on it. But this is wrong. The S-cone is variably sensitive to light at different parts of its sensitivity-range, and so, it doesn’t give us the *amount* or *total energy* of light in the short-waveband. What it actually gives us is the following quantity: [], where λ stands for wavelength, and Sensitivity is the sensitivity of the cone’s response at . *Note that the cone’s physical characteristic is a factor in this expression.*

This is not just a quibble. Bradley and Tye base their objectivist argument on the premise that the readout of each cone is a function of a subject-independent variable, the intensity of light in a certain waveband. But in fact, it is a function of two variables, the strength and also the sensitivity-profile *of the* ***subject’s*** *S-cone*. The second of these is (obviously) subject-dependent. If the cone-cell’s sensitivity was more or less flat across its range, we could ignore this, but as Figure 1 shows, this is not the case. And, as we’ll see, the visual system *does nothing at all to recover information about total intensity* from the output of the S-cone.

This undermines the idea that cone-cells measure a purely physical property. However you look at it, the front-end response of the visual system is dependent upon the characteristics of that visual apparatus. To the above, add the further complication of the shape and limits of sensitivity curves vary among species and even among individuals of the same species. The same signal will evoke a different response in different individuals, though any one individual will respond similarly to physically similar signals.

###  Colour and Opponency

This brings me to a second point about colour and the cone cell system. We noted in the previous section that there are three cone cells. External objects emit light, normally a mixture of wavelengths with varying brightness at each wavelength. When this emission of light, or *signal*, reaches the eye, each cone cell responds. Accordingly, any given signal S will generate three responses, which we can label SL, SM, and SS. One of the visual system’s tasks is to mine these responses for wavelength-based differentiators of both incident light and of distant objects.

One difficulty that the visual system faces in performing this task is that cone-cell response is a function not just of wavelength, but also of intensity. The brightness of a signal influences all three cone cells—they all respond weakly at night and strongly in bright sunlight, and this has nothing to do with colour as such. There is a strong correlation here: a weak response from one cone predicts a weak response from the other two (and conversely). A second difficulty is that (as illustrated in Figure 1) there is overlap among the cones’ sensitivity ranges. This overlap is strongest between the L- and M-cone sensitivity profiles. So, a signal that activates L strongly will also activate M strongly, and conversely one that activates L weakly will do the same for M. Wavelength discrimination is hindered by these two sources of correlation among the cones.

Given these positive correlations, the significant colour-related information is the *difference* among cone-cell responses. A *red* object, for example, is one that gets the strongest response from L-cone and, relative to this response, a weaker response from the other cones. But this L-cone response may be weak in the dim light of evening, strong in the brightness of the noonday Sun. And given a strong response from the L-cone, a strong response from the M-cone might also be expected, though one would expect it to be weaker than the L-response. The significant quantity is, therefore, not the absolute value of the L-response, but the amount by which it exceeds the other cones. Accordingly, the colour vision system is interested in *differences* between cone-responses to signals.

These differencing operations are collectively known as opponent processing. They do not *add* information to the outputs of the cone cell; they merely discard the correlations. As Lee et al (2002) write:

Color opponency . . . is an attempt to remove correlations in the signals of different cone cell types that are introduced by the strong overlap of the cone spectral sensitivities. [As well] naturally occurring spectra are known to be fairly smooth . . . and therefore may contribute substantially to redundancies in the cone signals. (*ibid*, 2085)

Opponent processing provides the visual system with input that is relevant to making distinctions among objects on the basis of their wavelength-determined properties, while discarding the effects of brightness and cone-overlap.

Let’s summarize this as follows: every signal that reaches the eye is encoded in terms of differences among cone-responses. This encoding is wavelength-dependent, but only in an oblique way. This encoding is the basis of colour.

###  The Subjectivity of Colour Schemes

With these two facts—cone-dependeny and opponency—firmly established, let me now present four consequences that undermine the subject-independence of the essence of colour.

1. *Subject-Relative Essence* Colour is an idiosyncratic family of properties that cannot be defined except by reference to visual system characteristics. Aristotle was wrong to think that the visual faculties receive a property that has an essence that is independent of subjects. Contemporary colour realists such as Bradley and Tye repeat the error.
2. *Higher-Order Dissimilarity* There is no *higher-order* similarity structure that the colours share with any physical properties. You cannot, for example, say that red is dissimilar to blue in the same way as long wavelengths are dissimilar to short. The reason is that physical similarities are erased first by the peaked shape of the cone-response curves—close-by wavelengths get very different cone responses—and second by the differencing operations that system performs on these outputs. Because of these factors, the colour *properties* stand to each other in different similarity *relations* than those of any supposedly physical correspondent properties. For example, *red*, which is associated with the long-wavelength end of the visible spectrum, is sensed as more similar to *blue*, at the short end, than it is to *yellow* or *green* in the middle.
3. *Perceiver Variability* Different perceivers generate different colour properties. For example, the surfaces I see as saturated green may be different from those that you see as such. Moreover, two surfaces that trichromat humans see as having the same colour might be seen by a tetrachromat bird as differing in colour. Similarly, a dichromat dog is unable to distinguish certain surfaces by colour that trichromat can distinguish. On a view like Aristotle’s, this implies a deficiency in humans relative to birds, and in dogs relative to humans. There is, however, no deficiency; the avian-colour family is simply different from the human-colour family and the canine-colour family. Both are systems by which subjects differentiate certain groups of surfaces and assimilate other groups to one another. There is nothing objectively *wrong* with any of these systems of classification—each reveals something about the differences among objects, and that is all one can say. There is, therefore, no one family of colours on which visual faculties of different sensing subjects must converge and relative to which one can make judgements of right and wrong (Matthen 1999).
4. *Physical Heterogeneity* There is no physical property shared by things that have the same colour, neither a colour-generating property such as chemical composition nor an optical property such as a wavelength or reflectance profile. This, once again, implies that groupings by sameness or similarity of colour fail to reflect groupings based on physical sameness or similarity. This may not be obvious at first glance, but the following examples may help make the point.
5. Consider your face and an excellent colour photograph of your face. The pigment that gives your face colour is quite different from the combination of inks that is used in the photograph. They are the same colour, but chemically very different. Colour does not predict chemistry.
6. Equally, colour-matching does not imply a shared subject-independent *optical* property. Light, for example the light emitted by your computer monitor, can match reflectance. A printed photograph is reflective; on a computer, the same photograph is luminous.
7. Finally, think of metameric matching. Very simply, a 650 nm signal of high intensity can evoke as strong a response from the L-cone as a low-intensity signal of 600 nm. Thus, very different mixtures of wavelengths can get the same response from the eye. Colour does not predict optics.

We may sum up these facts about colour in the following way:

*Sensory Ordering Thesis* Sensory systems sort and assign sensed objects to sensory classes; they create graded relations of similarity and dissimilarity among these classes. (cf. Matthen 2005, 13 and 96.)

In certain cases, these graded relations of similarity closely match certain physical similarity relations among the corresponding objects and classes. In other cases, when the information available is sparse and the use made of the sensory classes does not depend on it, the relations of similarity may be subject-relative. Colour is an example of the second kind.

###  Two Kinds of Correspondence

I have argued that colour properties are perceiver-dependent because they reflect a system of sensory classification that depends on the characteristics of her colour-vision system. This undermines Aristotle’s idea that the *accuracy* of colour sensing is correspondence between the state of the colour-sensing system and a subject-independent property of an external object. Does this mean that we should abandon his second intuition?

I2. Sensory states are *accurate*, or *true*, only if their structure mirrors the state of the external object from which the sensing starts.

Not entirely. I’ll now argue that I2 can be retained in a somewhat different form.

Let us distinguish between two types of subjective property. One type—call it type-1 subjective—depends on the relationship that sensed substances bear to a sensing subject but is relatively constant given the intrinsic properties of both sensing subject and sensed object. When the intrinsic properties of both the subject and the object stay the same, type-1 subjective properties will also stay the same, regardless of what else changes. Let’s say that a knife is *dangerously sharp* if it cuts the skin on slight accidental contact. This is a subjectively defined category since it depends on the properties of the skin, but if a particular knife is dangerously sharp to my skin, then another knife with an equally hard and well-honed blade will also be dangerously sharp to my skin. This is an example of a type-1 subjective property. It is defined relative to a subject, but supervenes on subject-independent properties.

A second type of subjective property—call it type-2 subjective—characterizes relationships between sensing subject and sensed object that depend not only on the intrinsic properties of these objects, but also on other circumstances. *Pleasant* is notoriously a property of this sort; in tense times, one might not enjoy a book that one finds pleasantly diverting in easier times. (We can allow that the distinction between types 1 and 2 are not all-or-nothing but a matter of degree: a sensed quality can be *more or less* *invariant* with factors other than the sensing subject and the sensed object.)

I have been arguing that colour is a subject-generated quality—an object-classification scheme that depends on certain characteristics of the subject’s visual system, and which varies from subject to subject. Yet its application to objects by individuals is remarkably consistent. Physically similar things generally get seen as having the same colour from occasion to occasion (except, of course, when they change colour). The point I want to make here is that this is compatible with the essence of the colours (i.e., *blue, red,* and so on) being subject-dependent. What the consistency of its instantiation from object to object shows is, at most, that it is type-1 subjective, not type-2. Though colour is defined in a subjectively, colour supervenes on purely physical properties.

Let’s say, then, that a type-1 subjective property *S* is one that has a supervenience-base: a set of physical properties P, such that (necessarily) an object *O* is *S* if and only *O* possesses some member of P. Then we could define accuracy as follows:

I2\* A sensory state that attributes a type-1 subjective property *S* (such as colour) to *O* is accurate, or true, only if *O* has a property that belongs to the supervenience-base of *S*.

###  Concluding Remark About Theoretical Knowledge

In her book on Aristotle’s theory of sensing, Anna Marmodoro (2014) writes:

One of the cornerstones of Aristotle’s theory of perception is that the world is truly as colorful as it looks to us, as noisy as it sounds to us, etc. . . Aristotle holds that we perceive the world through the senses *as it is . . .* (*ibid*, 3)

In this paper, I have argued that this is not as straightforward to evaluate as it sounds. Aristotle held that the essence of colours is independent of subjects. I have argued that he is wrong about this. The visual system does not passively receive a physical quantity; rather, it works with information that is available to it, to construct such categories as it can advantageously use. In some domains, a faculty of sense might have relatively a lot of information, or the categories it constructs may need to correspond quite closely to qualities that are defined independently of the subject. Some have argued that in the case of *shapes* and *motion*, both these conditions are satisfied. *Neither* condition is satisfied in with colour. Available information is sparse; constructed categories are relatively superficial but still useful to the subject because they make contact with physical properties in the manner sketched in the preceding section.

As mentioned at the start of this essay, Aristotle extended his assimilation model to the intellect: ‘As sense is to sensibles, so thought is to thinkables,’ he wrote (*de Anima* III 4, 429a17-18). How should we evaluate this claim? Suppose that the universe has a complicated but unified structure, *S*. A scientific realist would hold that ‘the theory of everything,’ *T*, is fully adequate only if it exactly reproduced *S*. Even if *T* was quite useful, it would not be fully correct if it failed to capture every last detail of *S* faithfully. Aristotle was firmly committed to scientific realism in this form. What he failed to appreciate is that in this respect, thought is different from sense; the aim of science, in distinction to the biological function of sense, is (at least according to the scientific realist) faithfully to capture truths that are essentially independent of the thinker.

But Aristotle makes another claim here—that the thinker *assimilates S*. Here, he may have been misled by another analogy with sense. Suppose that it looks to me as if a particular sapphire is blue. Suppose further that it really is blue. Suppose, however, that my visual state is a lucky hallucination; it looks to me as if the sapphire is blue, but this is a self-generated state, not one that comes about by the influence of the sapphire. In such a case, my sensory state is deficient. Aristotle may have thought that the same goes for knowledge. If the scientist’s theory *T* is self-generated, not received from *S*, it is deficient.

I think it is clear that here Aristotle is, once again, in the grip of a misleading analogy. First, scientific theorists do not passively assimilate objective structures; scientists create categories that are useful for understanding nature. A second point is perhaps less obvious. The senses too are active constructors of categories. This is what I have tried to demonstrate in this paper. [[4]](#footnote-4)

## REFERENCES

Balme, D. M. (1962) ‘Development of Biology in Aristotle and Theophrastus: Theory of Spontaneous Generation,’ *Phronesis* 7/1: 91-104.

Bradley, Peter and Tye, Michael (2001) ‘Of Colors, Kestrels, Caterpillars, and Leaves,’ *Journal of Philosophy* 98: 469-487.

Bryant, Walter W. (1920) *Kepler* London: Society for Promoting Christian Knowledge.

Caston, Victor (2015) ‘Perception in Early Greek Philosophy,’ in M. Matthen (ed.) *Oxford Handbook of the Philosophy of Perception* Oxford: Oxford University Press.

Chirimuuta, M. (2015) *Outside Colour: Perceptual Science and the Puzzle of Color in Philosophy*. Cambridge MA: MIT Press.

Clark, Austen (2000) *A Theory of Sentience.* Oxford: Clarendon Press.

Coates, Paul (2015) Review of Mark Kalderon, *Form Without Matter*. *Philosophy* 91: 600-605.

Gregoric, Pavel (2007) *Aristotle on the Common Sense*. Oxford: Clarendon Press.

Ierodiakonou, Katerina (2016) Review of Mark Kalderon, *Form Without Matter*. *Notre Dame Philosophical Reviews* 2016.01.32.

Johansen, T. K. (1998) *Aristotle on the Sense-organs.* Cambridge: Cambridge University Press.

Kalderon, Mark Eli (2015) *Form Without Matter: Empedocles and Aristotle on Color Perception*. New York: Oxford University Press.

Lee, Te-Won, Wachtler, Thomas, and Sejnowski, Terrence J. (2002) ‘Color opponency is an efficient representation of spectral properties in natural scenes,’ *Vision Research* 42: 2095-2103.

Lindberg, David (1975) *Theories of Vision from Al-Kindi to Kepler* Chicago: University of Chicago Press.

Marmodoro, Anna (2014) *Aristotle on Perceiving Objects.* New New York: Oxford University Press.

Matthen, Mohan (1999) ‘The Disunity of Colour,’ *Philosophical Review* CVIII: 47-84.

Matthen, Mohan (2005) *Seeing, Doing, and Knowing: A Philosophical Theory of Sense-Perception*. Oxford: Clarendon Press.

Smith, A. Mark (2004) ‘What is the History of Medieval Optics Really About?’ *Proceedings of the American Philosophical Society* 148: 180-194.

Surridge, Alison K., Daniel Osorio, and Nicholas I. Mundy (2003) ‘Evolution and selection of trichromatic vision in primates,’ *Trends in Ecology and Evolution* 18: 198-205 doi:10.1016/S0169-5347(03)00012-0.

Turner, R. Steven (1994) *In the Eye’s Mind: Vision and the Helmholtz-Hering Controversy* Princeton: Princeton University Press.

Tye, Michael (2006) ‘The Puzzle of True Blue,’ *Analysis* 66: 173-178.

1. A referee observes that the skin becomes hot or cold when in contact with something hot or cold—and suggests that Aristotle could have taken this too to confirm his definition. In fact, this is not exactly correct. Though the observation that the skin becomes warm is not wrong, Aristotle thought that it was impossible to sense by contact, and as a consequence he held that the flesh (and, presumably, the skin also) is a *medium*, not an *organ*, of touch. He might have held that the organ of touch, buried deep in the body, becomes warm when the skin touches something warm, but he has as little reason for affirming this as he does for thinking that the organ of taste becomes sweet when the subject puts honey in her mouth. [↑](#footnote-ref-1)
2. How exactly does the transparent medium change when it is in contact with a coloured body? I am not convinced that Aristotle has a coherent answer, and so I will set the question aside. See, however, Marmodoro (2014, 141-153) for a nuanced discussion. [↑](#footnote-ref-2)
3. Gregoric somewhat unfortunately calls this the problem of ‘cross-modal binding.’ This neglects that in contemporary psychology, (a) feature-binding is thought to be governed by location, not by a substance, and (b) that it is essentially a sub-personal operation. Aristotle was certainly not aware of the problems that arise from either clause. [↑](#footnote-ref-3)
4. Warm thanks to James Allen, Anna Marmodoro, and two anonymous referees for comments and discussion. [↑](#footnote-ref-4)