

DEMOCRITUS' PERSPECTIVAL THEORY OF VISION

KELLI RUDOLPH
University of Oxford*

Abstract: Democritus' theory of vision combines the notions of images (εἰδῶλα) streaming from objects and air imprints, which gives him the resources to account for the perception of the relative size and distance of objects, not just their characteristics. This perspectival explanation of the visual theory accommodates important but overlooked evidence from Vitruvius. By comparing Democritus' theory with ancient developments in visual representation, my analysis provides a new approach to the evidence of atomist vision. I begin with the process of vision before turning to the Peripatetic objections, showing how a unified theory of vision takes into account all of the ancient testimony and provides possible atomist responses to the criticisms raised against it. I also identify the importance of vision via air imprints as an important metaphor for the conventionality of sensible qualities. Understanding these fundamental issues puts us in a better position to assess Democritus' place in the development of ancient optics and of atomist approaches to sense perception.

Democritus' theory of vision has been the subject of much controversy from the time of Aristotle right up to the present day. Aristotle dismisses key elements of the atomist theory, and Theophrastus' critical account in the *de Sensibus*¹ (*DS*) raises serious problems for a theory based on effluences and air imprints. Over the last 60 years a series of insightful studies² has confronted the difficulties presented by the doxographical sources, and yet, even modern scholars cannot agree about how to interpret the evidence for Democritean vision. Some scholars offer a two-theory explanation while others propose a single theory. Some believe Democritus' account includes a notion of a visual ray, others do not, and explanations of air imprints abound wherever Democritean vision is discussed. This is, in part, due to the damaged and fragmentary nature of our evidence. In all cases the consistency and reliability of the doxographical tradition, and particularly the report of Theophrastus, have been called into question partly because of the occasional difficulties with the text that has come down to us.

Ancient *testimonia* agree that Democritus believes vision occurs by means of the εἰδῶλα, images flowing from objects, which enter the eye.³ Diogenes Laertius (9.44) sums up Democritus' theory of perception with the incredibly succinct ὁρᾶν δ' ἡμᾶς κατ' εἰδῶλων ἐμπτώσεις ('we see by the impact of images'). Likewise, the Aëtian doxography often categorizes Democritus alongside Leucippus and Epicurus, drawing attention to the εἰδῶλα theory that is common to all three.⁴ The testimony of Alexander of Aphrodisias is particularly difficult to assess.⁵ In his

* krudolph@alumni.princeton.edu. My thanks to David Sedley and Dunstan Lowe for their generous help and insightful comments, and to James Warren, Pierre-Marie Morel, G.E.R. Lloyd and Nick Denyer for useful discussion. Any deficiencies are, of course, my own.

¹ Scholars debate the placement of the so-called *de Sensibus* among Theophrastus' works. Diels, following Usener, classified it as part of a larger work, the *Phys. op.* The most important editions and discussions known to me are: Diels (1879); Beare (1906); Stratton (1917); Baltussen (1992); (2000); (2005).

² von Fritz (1953); Guthrie (1965) 441–44; Baldes (1975); (1978); Burkert (1977); Sassi (1978); O'Brien (1984); Salem (1996) 129–32; Morel (1996) 224–40; Taylor (1999) 208–11.

³ DK68B123 preserves Democritus' term δεικῆλον for this 'effluence similar in kind to the object' from which it flows; our sources refer to the effluence as an εἰδῶλον.

⁴ DK67A29 and DK68A31. See Mansfeld and Runia (2009) 15, who make it clear that 'the roots of Aëtian doxography are for the main part in Peripatetic scientific inquiry and dialectic'. Cf. Cic. *ad Fam.* 15.16.1, who also correlates Democritus' theory with that of Epicurus.

⁵ See Avotins (1980). I disagree with his reading of Theophrastus and his overall conclusion about Democritus' visual theory, but his analysis of Alexander's critique of the atomist theory of vision is the most complete to date.

commentary on Aristotle's *de Sensu*, Alexander attacks the atomist position, grouping together Democritus, Leucippus and Epicurus in his critique of vision by emanations (24.18–21). Later in the same text he criticizes the theory of colour as an effluence (56.10–15), which he presents as the opinion of the followers of Leucippus and Democritus (περὶ Λεύκιππον καὶ Δημόκριτον). Although Alexander makes the generalizing statement, familiar from other *testimonia* that the atomists explain vision by means of the εἶδωλα, there is no clear distinction between the theories of Epicurus and those of the earlier atomists. Similarly in the so-called *de Anima Libri Mantissa*, Alexander presents the views of 'those who say seeing happens by εἶδωλα' (134.28–36.28). The details of the theories in these two works are clearly atomistic, but the position is presented in an indirect series of questions and criticisms, making it very difficult to distinguish the atomist position from Alexander's own conjectures. This problem, as we will see, is not as prevalent in Theophrastus' account. Even the atomist details that can be disentangled from Alexander's commentary cannot be definitively assigned to either Democritus or Epicurus. This is in part due to the scarcity of our evidence for atomist theories of perception, but is also the fault of Alexander's chosen method of presentation. He raises questions that are in keeping with Peripatetic concerns, including (1) why external objects are not used up by the constant flow of atoms, (2) how distance perception can be explained, (3) how objects larger than the pupil can be perceived and (4) how a theory of effluences can account for vision in mirrors and smooth surfaces; but Alexander's particular concerns seem better suited to a Hellenistic opponent than to a Democritean position.⁶ Thus, we cannot assume that these late descriptions, written within the context of very broad and cursory accounts of Democritus' theory of perception, are attempts to assign an εἶδωλα-only theory to him. If anything, these reports are concerned merely with the broadest general cause of vision, namely the image in the eye, and not the process by which that image itself is formed.

I. The image

Aristotle and Theophrastus, too, refer to Democritus' theory as one involving εἶδωλα, but it is in these earlier sources that we find a far more detailed approach to Democritean vision. Aristotle, in his critique of the 'image' theory, takes aim directly at Democritus.

TI Aristotle, Sens. 438a5–10

Democritus speaks correctly in that he says that the eye is water (ὕδωρ), but is incorrect because he believes seeing to be the image (τὴν ἔμφασιν). For this happens because the eye is smooth (λεῖον). Moreover, this image is not in the eye, but in the observer; for the phenomenon is only reflection (ἀνάκλασις γὰρ τὸ πάθος).

Aristotle considers the ἔμφασις a kind of reflection, due not to the wetness of the eye, as Democritus describes it, but to its smoothness.⁷ He argues that Democritus is incorrect to believe seeing to be the ἔμφασις, since Aristotle judges the phenomenon to be a case of mere reflection (ἀνάκλασις) or 'beaming-back'.⁸ For Democritus, the ἔμφασις is not the garden-variety reflection indicated by the term ἀνάκλασις; it is, as the verb ἐμφαίνεται implies, literally 'imaged in' the eye. Even in the Aristotelian corpus, ἔμφασις explains appearances, such as colours in mist, the way colours mix or impressions in dreams.⁹

⁶ Epicurus is an obvious target for Alexander's polemic, but Asclepiades of Bithynia was also a proponent of corpuscularian theories of the body. See Vallance (1990).

⁷ See also DK67A29.

⁸ See Arist. *Met.* 3.373b20–25; cf. *Met.* 1.345b9–25; *Pr.* 32.932b19–28.

⁹ See Arist. *Met.* 3.373a32–b34, 3.374a17–18, 3.377b14–26; *Col.* 792a5; *Div. Somn.* 464b5–18a. If, as Janko (1984) 202–03 suggests, ἔμφασις originally connotes appearances in need of interpretation, it would be fitting for Democritus, who considers the senses 'bastard' sources of knowledge (DK68B11), to play on this ambiguity.

An ἔμφασις also differs from an ἀνάκλασις because it appears in the eye, a specialized organ which transmits these images to the observer's reasoning faculty.¹⁰ Theophrastus preserves Democritus' detailed ophthalmological account (*DS* 50.6–11) in which he distinguishes the eye's surface and interior elements.¹¹ No important functional part is omitted from the report, which mentions both what facilitates vision and what impedes it. The most important element seems to be the eye's moist softness (ὕγρως) and, thus, its capacity to admit, retain and transmit the image entering the eye. The primary function of the physiological description is to explain the construction of the eye that allows the effluence and air imprint to pass through. Democritus describes no mechanism that would result in the kind of 'beaming-back' Aristotle mentions in T1. Surely Theophrastus, who was aware of Aristotle's criticisms and eager to point out difficulties with the theories of his predecessors, would have reported such evidence, if he had found it. Rather, the point of Democritus' ophthalmology seems to be that vision occurs because the eye allows the image *in* and its sponginess aides in transmitting the image to the rest of the body. Thus, it is the capacity of the ἔμφασις to move through the eye that distinguishes it from the 'beaming back' that Aristotle equates with ἀνάκλασις.

When one examines the ἔμφασις in an observer's eye, it is immediately obvious that, unlike ordinary reflections, it represents the entire object in miniature; in this way too, it differs from a mere reflection. The physiology of the eye allows Democritus to explain how the image passes through the eye, but he still must explain how the ἔμφασις enters the observer's pupil and why it appears in miniature. This is where Theophrastus' detailed account comes into its own. Theophrastus notes (*DS* 35–36) that many Presocratics, including Anaxagoras and Empedocles, believed that the ἔμφασις was responsible for vision,¹² but it is Democritus' innovation in explaining the formation of this ἔμφασις that sets him apart.

T2 Theophrastus, *DS* 50.1–6

ὄραν μὲν οὖν ποιῆι τῆι ἐμφάσει· ταύτην δὲ ἰδίως λέγει· τὴν γὰρ ἔμφασιν οὐκ εὐθὺς ἐν τῆι κόρῃ γίνεσθαι, ἀλλὰ τὸν ἀέρα τὸν μεταξὺ τῆς ὄψεως καὶ τοῦ ὀρωμένου τυπούσθαι συστελλόμενον ὑπὸ τοῦ ὀρωμένου καὶ τοῦ ὀρώοντος· ἅπαντος γὰρ αἰεὶ γίνεσθαι τινα ἀπορροήν· ἔπειτα τοῦτον στερεὸν ὄντα καὶ ἀλλόχρων ἐμφαίνεσθαι τοῖς ὀμμασιν ὑγροῖς· καὶ τὸ μὲν πυκνὸν οὐ δέχεσθαι, τὸ δὲ ὑγρὸν διέναι.

He makes seeing happen because of the image, and he gives his own peculiar account of this. For the image, he says, does not come into being directly in the pupil, but the air between the organ of sight and the thing seen is impressed because it is compressed by the thing seen and the seeing subject. For all things are always producing some effluence. Then this air, being both solid and of a different colour, becomes imaged in the eyes, which are moist. The dense cannot receive it, while the moist lets it pass through.

Theophrastus' report begins with the 'peculiar' Democritean theory of air imprints, which posits the impression of air between the observer and the thing seen by effluences (εἶδωλα) flowing from all things.¹³ These effluences are one-atom-thick, three-dimensional copies of an object, flowing from its surface in a constant, near-limitless stream resembling a cinematic projection.¹⁴ According to Theophrastus, these εἶδωλα serve two functions: they are themselves

¹⁰ Or, as Theophrastus asserts (*DS* 54.6–8), to the 'rest of the body'.

¹¹ On the ophthalmological account, see Rudolph (forthcoming). Theophrastus seems to paraphrase Democritus; as with his report on vision from the *Timaeus* (*DS* 5.2–7, 86.1–8, 91.4–10), he may omit details in order to sketch Democritus' general approach. See Long

(1996); Baltussen (2000); Rudolph (2009) 4–32.

¹² See Warren (2007); Sedley (1992).

¹³ See *DS* 53.6–7.

¹⁴ The analogy with a film projector is not exact; effluences streaming from objects fast enough to provide continuous vision would need to move at incredibly high speeds.

imaged in the eye (*DS* 51.5–7), and also have a condensing effect in the visual process. Later he reports that sunlight plays a role in causing air to become imaged in the eyes.

Precisely how the Democritean visual process works, however, is controversial for two reasons. The first difficulty arises from the statement that ‘all objects are continually producing some effluence’. Some¹⁵ believe this suggests that Democritus has a notion of visual rays, others do not.¹⁶ The second problem is the apparent conflict in Theophrastus’ and Aristotle’s reports. Aristotle makes no mention of air imprints, rather, he reports Democritus’ view that ‘if the intervening space were empty, one would see acutely enough to see even an ant in the heavens’ (T7 below). This has led scholars to suggest that Democritus has two visual theories¹⁷ or to attempt to reconcile the disagreement.¹⁸ The rest of this paper is devoted to resolving these difficulties. I will discuss the evidence for the visual ray before turning to Theophrastus’ account of air imprints. Only after we have understood this material will we be able to account for the difficulties in our sources.

II. The visual ray

Those who maintain that effluences emerge from the eye and coalesce in mid-air with the object’s εἶδωλα to form the imprint are criticized for imposing an unwarranted addition on Democritus’ teaching in order to justify an unnecessary two-theory reading of the evidence.¹⁹ However, I believe critics have missed the point. Theophrastus’ language in T2 is clear; nothing in the grammar or placement of the statement ‘all things are always producing an effluence’ implies that it refers only to the object and not to the observer.²⁰ Introduced by an explanatory γάρ, this phrase immediately follows the description of the compressing of the air imprint by both the thing seen and the seeing subject (ὑπὸ καὶ τοῦ ὀρώοντος).²¹ The air imprint arises from the process of compression (συστελλόμενον).²² Whether this is Democritus’ own term cannot be determined, although it occurs alongside πυκνούμενον (which certainly means ‘condense’) in Anaximenes’ theory of the soul (DK13A1), and in Heraclitus’ account of the formation of earth

¹⁵ The most recent proponent of this theory is Burkert (1977) 99–100, who likens Democritus’ theory to that of Empedocles, arguing that the eye too produces an effluence, which together with the light and the effluence from the object ‘shrink’ (συστελλόμενον) the air. Cf. von Fritz (1953) 94; Guthrie (1965) 442–43; Kirk et al. (2005) 429. Sassi (1978) 108–09 believes that the perceiver makes some unspecified addition to the perceptual process, but does not think it is a case of the visual ray. Taylor (1999) 211 seems to concur.

¹⁶ Baldes (1975) provides the most detailed description of this position, taking aim at the notion that the eye contributes to vision via the air imprints. His argument is motivated by the difficulties found in Mugler (1959) and Guthrie’s (1965) summary of Theophrastus. He is over-hasty in his rejection of the idea that the visual ray cannot always be emitted, and his reading of ὄψεως, ὀρωμένον and ὀρώοντος is rightly corrected by Burkert (1977). Cf. *DG* 513, n.19; Beare (1906) 26–27; Bicknell (1968) 12, n.15; Barnes (1982) 308, n.9; O’Brien (1984) n.60.

¹⁷ See Guthrie (1965) 442–43; Burkert (1977).

¹⁸ Taylor (1999) 210–11; O’Brien (1984); Baldes (1975). Beare (1906) 26–27 mentions both pieces of evidence but not the inconsistencies. Kirk et al. (2005) 429 fails to mention the Aristotelian passage.

¹⁹ Baldes (1975) and O’Brien (1984). Baldes

attacks the visual ray, rightly arguing that ‘all things are always giving off effluences’ is not evidence that the eye has a *special* effluence. Relying on Guthrie’s (1965) 442 tendentious interpretation, he fails to consider Democritus’ interest in rays, which need not be particularly ‘special’ to do the job required of them.

²⁰ There is also no reason to follow Baldes (1975) 96 in assuming that the visual ray could not always be emitted because we do not always see. When the εἶδωλα are blocked by something (in Baldes’ example the eyelid of a closed eye) they presumably dissipate.

²¹ Diels (1879) tentatively suggests emending καὶ τοῦ ὀρώοντος to κατὰ τοῦ ὀρώοντος, only to eliminate the possibility of an active eye. Baldes (1975) again misrepresents the visual ray position. No ‘verbal acrobatics and shift of meaning’ are necessary to read ὀρωμένον as a reference to that which is seen (in both cases the effluence not the object) and there is no need to interpret ὀρώοντος as anything other than ‘eye’, as I have done.

²² Stratton (1917) 111; Guthrie (1965) 443; and Taylor (1999) 108 understand συστελλῶ to mean ‘compressing’ or ‘compacting’. Luria (1970) 326 translates it as ‘being produced’. Burkert (1977) 100, rightly suggests that it means that the air imprint not only is of greater density than the surrounding air, but also that it shrinks.

(DK22B5). Theophrastus uses συστέλλω almost exclusively to describe shrinking, and that is its primary meaning here.²³ Difficulty with the εἶδωλα compressing the air arises only when one assumes that it is the perceived object *alone* which emits such arrays of atoms. If we assume, however that the eye itself gives off εἶδωλα just as every other object does, then it too is involved in compression, since the object's εἶδωλα and the air have something against which to press. As the air is shrinking (συστελλόμενον), it is also impressed (τυποῦσθαι) or moulded (ἀποπλαττόμενον, T6 below) to form the image responsible for vision. This is all that can be said about the eye effluences functioning as visual rays from Theophrastus' evidence. As with most Presocratics, the less well-preserved theories are beyond irrefutable confirmation, but an analysis of other sources provides evidence that Democritus postulated visual rays is stronger than some have claimed.

Democritus was renowned in antiquity as a mathematician and a philosopher. He reportedly studied geometry in Egypt and spent time in Persia with the Chaldeans (D.L. 9.34–45), to whom Diogenes Laertius attributes a theory of air imprints (1.7). Most importantly for our purposes, he was famous among contemporaries and successors for calculating the volume of the cone and for raising a problem about dividing cones (DK68B155). Thrasyllus' list of Democritus' works includes a mathematical treatise, ἀκτινογραφίη. The other -γραφίη writings attributed to Democritus include οὐρανογραφίη, γεωγραφίη and πολογραφίη. The suffix, signifying 'drawing', may refer to geometrical diagrams or discussions. Whilst many topics in both Greek and English can be '-ologized', only subjects that involve writing and/or drawing are '-ographized'.

The ἀκτινογραφίη may well have been a geometrical charting or mapping of rays. The term ἀκτίς is generally used of light and fire in early Greek literature. Empedocles likens his theory of visual rays to light beaming from a lamp,²⁴ and Plato, writing within Democritus' lifetime, also theorizes light flowing from the eye toward the perceptible objects.²⁵ Thus, it is conceivable that Democritus' ἀκτινογραφίη included an account of a visual ray. The Suda records an ὀπτικά and an ἐνοπτ(ρ)ικά among the works of Philip of Opus,²⁶ and within a few generations Euclid had completed the formalization of Greek mathematics, which included an optical theory that applies simple geometrical principles to the straight lines that form the eye's cone-shaped field of vision.

Although Aristotle never explicitly calls Democritus a proponent of the visual-ray theory, he is a possible source for the unattributed theory of emanations from the eye mentioned in *de Sensu* (438a25–27): 'seeing occurs by something issuing from the eye; and it extends as far as the stars, or goes as far as a certain point and there coalesces with the object, as some think'. This passage directly follows Aristotle's discussion of Democritus' liquid eye (438a5–12) and segues into the analysis of light coalescing with light (438a30), almost certainly a critique of Plato's theory of vision.²⁷ At the very least, this suggests some similarity between the theories of the two thinkers.

In his commentary on Ptolemy's *Harmonics*, Porphyry explains why one sees lightning before one hears thunder: vision goes to meet the light, but hearing must wait to receive the sound. He cites Democritus as the authority for the second half of the proof concerning sound and he attributes the visual theory to 'mathematicians', which may include Democritus.²⁸

²³ Aristotle's usage varies more widely than Theophrastus', sometimes connoting collection (*Pr.* 1.862b33), confinement (10.897a23), contraction (26.940a6) or reduction (8.888a2). Cf. *MA* 701b15, 703a21, 22; Theophr. *CP* 1.8.3.6, 1.15.1.6; *Ign.* 14.5, 17.5, 67.3.

²⁴ DK31A90, B84.

²⁵ *Ti.* 45b–46a, 58c, 67c–d.

²⁶ D.L. 3.37 and Suda s.v. φιλόσοφος. Dillon (2003).

²⁷ DK68A157 only supports the notion of an emanation in general terms. One should not suppose, as Burkert (1977) 100 does, that the visual ray correlates to the 'fieriness of the eyes' (τὸ πυρῶδες τῶν ὀψεων) mentioned in this entry, since fieriness has a function in night vision. Cf. Salem (1996) 133.

²⁸ DK68A126a.

A final piece of evidence appears in the context of optical illusion. Vitruvius' *de Architectura* (DA) preserves valuable information about a Democritean treatise on scene-painting, but has often been dismissed by historians as retrojecting contemporary innovations in art and optics onto Democritus and Anaxagoras.²⁹ Even White, who argues convincingly that Vitruvius understands the details of perspective, leaves the question open: 'There is at present no way of deciding the extent to which Vitruvius may have been merely attempting to give ancient lineage to a relatively new invention'.³⁰ However, recent scholarship on vase-painting and sculpture has prompted a reassessment of early Greek theories of perspective.³¹ An analysis of which is important to our search for evidence of Democritean rays.

T3 Vitruvius, DA 7. Preface 11.5–13

namque primum Agatharchus Athenis Aeschylō docente tragoediam scaenam fecit et de ea commentarium reliquit. ex eo moniti Democritus et Anaxagoras de eadem re scripserunt, quemadmodum oporteat ad aciem oculorum radiorumque extensionem certo loco centro constituto ad lineas ratione naturali respondere, uti de incerta re certae imagines aedificiorum in scaenarum picturis redderent speciem et, qua in directis planisque frontibus sint figurata, alia abscondentia, alia prominentia esse uideantur.

First of all, in Athens, when Aeschylus was producing a tragedy, Agatharchus made the scenery and left a commentary about it. Informed by this, Democritus and Anaxagoras wrote upon the same topic, namely how a fixed centre should be established and the lines should correspond realistically to the sight-line of the eyes and the extension of the rays, so that on unclear evidence, clear images give the appearance of buildings in the murals of the stage, and things that are painted on flat, continuous façades seem to recede in some places and project in others.

Vitruvius tantalizingly places Democritus in the early Greek evolution of perspective-theory. Besides Lucretius' *de Rerum Natura* and Euclid's *Optics*, Vitruvius' is our only surviving ancient discussion of perspective. Lucretius shares the architect's concern for pictorial and architectural perspective (*DRN* 4.353–63, 426–31) and, like Euclid, Vitruvius addresses its theoretical aspects. However, these authors postdate Vitruvius' alleged origin of *scaenographia* significantly. Since the original pre-Hellenistic texts are lost, we must look for nascent awareness of perspective in visual materials.

Artefacts indicate that perspectival painting began as early as the sixth century.³² Black-figure vase-paintings from the late sixth century show a 'sustained attempt' to master the art of foreshortening in depictions of the four-horse chariot.³³ Similar representations of sails, shields and chariots date from the same period, although elementary foreshortenings (tables, stools and other cubic objects) only appear in the mid-fifth century. This does not necessarily reflect limited artistic abilities, but may instead indicate what the artists themselves found relevant and interesting. We must also remember that vase-painters worked on curved surfaces, which makes vanishing-point perspective particularly difficult. According to White, vases from the end of the sixth century (both red- and black-figure) 'seem to indicate that the leading artists were acutely conscious of the nature of the innovations they were making'.³⁴ Two amphorae in Munich, dated to the later sixth century, show definite foreshortening of the foreparts of the central pair of

²⁹ Thanks to Myles Burnyeat for drawing my attention to this passage and suggesting the possible connection between T3 and S.E. *M.* 7.140.

³⁰ White (1957) 257–58, n.6.

³¹ See Lephats (1998); Christensen (1999); Camerota (2002). Perspectival representation did not emerge fully developed. Partial or limited explanations or exhibitions

of perspective should be expected in the early Classical period.

³² Literary sources name mural- and panel-painters as famed innovators. Cf. Pollitt (1974) 242; White (1956) 9–10.

³³ White (1956) 11.

³⁴ White (1956) 24.

horses.³⁵ These parallel the intent, if not the skill, of the sculptor of the east frieze of the Siphnian Treasury at Delphi, who masterfully portrayed a Trojan charioteer and his team, using a full range of foreshortenings.³⁶ The Byzantine poet Tzetzes relates that Phidias, when competing with Alcamenes, corrected the proportions of a statue that was to be placed atop a column to ensure that it appeared perfect from below,³⁷ and it is well-known that the Parthenon itself utilizes entasis to make the building appear straight and symmetrical from below and from a distance. We cannot, of course, know how vase-paintings and sculptures relate to the large-scale paintings or stage designs of the period, but they provide undeniable evidence for the development of basic perspective in art immediately prior to Agatharchus' scene-painting for Aeschylus' tragedy.

This early evidence for the development of perspective supports Vitruvius' reference to Aeschylus and Agatharchus. Vitruvius calls Agatharchus the first to paint and document perspective 'when Aeschylus was producing a tragedy'.³⁸ This places the introduction of scene-making in the mid-fifth century, prior to Aeschylus' death in 456/455 BC. Pollitt believes this refers to a revival performance of Aeschylus in the 430s, citing Agatharchus' patron-artist relationship with Alcibiades to support this later dating.³⁹ If true, this anecdote situates Agatharchus in Athens in the 420s; it does not rule out his working for Aeschylus in the 450s, even if, as Pollitt argues, it gives Agatharchus an 'unusually long career'. Anaxagoras was expelled from Athens as early as 450 BC,⁴⁰ while he might have had access to Agatharchus' commentary shortly before his death in Lampsacus around 428/427 BC, it seems more likely that he encountered Agatharchus while in Athens. Even if we assign his *floruit* to the 420s, Democritus, a younger contemporary of Anaxagoras,⁴¹ could have easily been influenced by Agatharchus.

According to Vitruvius (*DA* 1.2.2), *scaenographia* 'is the sketching of the front and of the sides in the background, and the correspondence of all the lines to the centre of a circle' (*ad circinique centrum omnium linearum responsus*). *Scaenographia*, as the term suggests, signifies stage-painting, but it also comes to mean perspectival drawing. Camerota argues that it is a form of optics related to geometry and the plastic arts, not specifically painting.⁴² Thus, *scaenographia* refers in particular to the proportionality of the buildings and ornaments painted in the scene, not necessarily the painting itself; Vitruvius makes this clear in referring to the buildings that appear to recede and project in the painting.⁴³ Christensen argues that this convention acknowledges the central role of stage design in the development of centralized perspective,⁴⁴ and Camerota rightly infers that these texts were concerned not with vanishing-point perspective (which is only fully developed in the Renaissance), but with reproducing the visual proportions of buildings correctly. Correct perspectival representation of three-dimensional objects on a flat surface is easily accomplished by observing relative distances and by positing a cone with rays emanating from observer to object in order to determine the correct proportions. If Agatharchus, Democritus and Anaxagoras formulated ideas about how architectural scene-paintings could be correctly proportioned by drawing lines that converge on the eye, it should come as no surprise that such elements play a role in visual theories.

³⁵ For example, see Attic black-figure amphorae, Munich, Museum Antiker Kleinkunst, Inv. 1376 and 1391.

³⁶ Textual evidence and stylistic elements date the frieze securely to around 525 BC.

³⁷ Tzetzes, *Chiliades* 8.340–46. Cf. Pl. *Soph.* 235d–36a.

³⁸ Vitruvius' reliability is debatable. He offers 'infinite thanks' to compilers of earlier authors, acknowledging them as his sources (*DA* 7.10, 14). Obviously, Vitruvius is only as reliable as these sources.

³⁹ Pollitt (1974) 245; Plu. *Alc.* 16.4.

⁴⁰ See Kirk et al. (2005) 362–64 on Anaxagoras' expulsion from Athens.

⁴¹ D.L. 9.41. See Stella (1942); de Ley (1968), who argue for the Eusebian dating (*ca.* 500–400); Ferguson (1965) for the Apollodoran dating (*ca.* 400–360); O'Brien (1994) for the Thrasyllan dating (470/469–380/379). Cf. Davison (1953).

⁴² Camerota (2002) 121.

⁴³ When introducing proportion in building (*DA* 6.2.1.9), Vitruvius advises the architect to alter the design so the optical adjustments are correct. He illustrates the deceptiveness of vision with examples of a scene-painting and the familiar illusion of the 'broken' oar, which sends back 'images flowing from their own bodies' (*DA* 6.2.2–3). See Büssing (1984).

⁴⁴ Christensen (1999) 165.

The description in T3 provides important details about how Agatharchus' *scaenographia* influenced Anaxagoras and Democritus.⁴⁵ The first part of the account (*quemadmodum... respondere*) is a description of the process of vision, and has been presumed to apply Euclid's geometrical analysis of visual perception.⁴⁶ This, however, as White clearly articulates, requires a very weak interpretation of *respondere* (and *responsus* in DA 1.2.2), which is inconsistent with 28 of Vitruvius' 29 uses of the term. In 26 cases *respondere* and its derivatives represent an exact 'correspondence', usually a precise mathematical relationship. In the other two, Vitruvius explains that relieving arches in a wall must have all their joints and voussiors *ad centrum respondententes* for maximum support.⁴⁷ This use of *respondere* makes it highly unlikely that in T3 Vitruvius can mean anything but the convergence of all lines towards a single point. Thus, *ad aciem oculorum radiorumque extentionem* refers to the point where all lines of sight converge, i.e. the pupil. Most scholars believe this is a further application of the Euclidean visual cone to art, and thus find the entire description to be anachronistically misattributed.⁴⁸

Euclid however, writing within a generation of Democritus, already appears to have a developed notion of perspective. In *Optics* (Definitions 2 and 4) Euclid explains the connection between apparent magnitudes of the visual angle, the apparent diminution of distantly viewed objects, and how the two interrelate. He also writes that planes and lines converge towards the eye (planes above slope downwards and those below upwards; lines on the left slant rightwards, those on the right leftwards). These principles seem rather obvious and, as the material evidence suggests, were well-known to artists before his time. Euclid's analysis of vision may thus utilize notions developed previously. He is our earliest source for the theory of a visual cone with its apex at the eye and its base at the object seen, but this does not mean that it originates with him. Democritus could very well have written a treatise that utilized some of these nascent forms of perspective. We can then, with some assurance, conjecture that Democritus' interest in cones and rays was related to his perceptual theory.

We can infer that Democritus' visual theory utilized his knowledge of cones and rays, but what would constitute visual rays? Admittedly, proof for the presence of the visual ray in Democritus' theory is not conclusive, but the evidence is not as negligible as some would have us believe. Theophrastus tells us that the seeing subject helps shrink the image, and by way of explanation he merely states 'all things are always producing some effluence' (T2). Thus, we are certain only that the air between the object and observer is compressed by the effluences flowing from both, ultimately resulting in the image in the eye (ἔμφασις). Details about the observer's contribution are presumably elided, but given what we know about Democritus' interest in cones and rays, we may assume that as the effluences emitted from the circular eye travel away from the observer, they move outwards in a conical pattern. As effluences, these films would have a similar compressing force to the εἶδωλον of the object. At a distance, these eye-effluences would be more diffuse, whereas those closer to the observer would be denser (Fig. 1 [below, p.79]). This would allow whatever compressing effect these eye-effluences have to increase as they approach the observer. I will call eye-effluences 'visual rays', by which I merely mean effluences that flow outward from the eye in a conical pattern; after all, the powers of peripheral vision alone suggest that we see not only things at which we glance, but also objects at the margin of our gaze. An explanation of how these visual rays help transmit information to the eye will become clear in the following discussion of air imprints.

⁴⁵ My analysis is based on that of White (1956) 47–51.

⁴⁶ See Knorr (1991); Lefhas (1998).

⁴⁷ DA 6.8.3–4, 10.12.2; White (1956) 45–48.

⁴⁸ See Tybout (1989).

III. Air imprints

Having established the likelihood of visual rays in Democritus' theory, I now turn to the difficulties presented by air imprints. Theophrastus alone preserves evidence of the atomist air imprint theory,⁴⁹ leading scholars to question the consistency of his report with the evidence we have from Aristotle and the later tradition.⁵⁰ Theophrastus himself raises the problem of the superfluousness of the theory (*DS* 51.5–7): why should Democritus posit air imprints when he already explains vision by means of the εἶδωλα? To this we may add, how are these air imprints produced?

I will begin with an explanation of how air imprints form. Many of the details Theophrastus preserves about them are embedded in his criticisms.

T4 Theophrastus, DS 51.1–3

First, the making of an impression (ἀποτύπωσις) in the air is absurd. For it is necessary for what is impressed (τὸ τυπούμενον) to have density (πυκνότητα) and not to be fragmented (μὴ θρύπτεσθαι), just as he himself says in comparing the making of this sort of impression (ἐντύπωσιν) to pressing something in wax (ἐκμάξειας εἰς κηρόν).

T5 Theophrastus, DS 52.1–2

But if this [sc. air imprinting] does happen, and the air is impressed (ἀπομάττεται) like wax by being pressed (ὠθούμενος) and condensed (πυκνούμενος), how does the image (ἡ ἔμφασις) come about, and what kind of image is it?

T6 Theophrastus, DS 54.1–4

But perhaps the sun makes the image by also, as it were, bringing light to vision (τὸ φῶς ὥσπερ⁺ ἐπιφέρων ἐπὶ τὴν ὄψιν), as he apparently wants to say. For it is absurd, at any rate, to describe the sun pressing (ἀπωθοῦντα) the air away from itself and condensing (πυκνοῦν) it as it is moulded (ἀποπλαττόμενον), as he says; its nature is, rather, to separate it.

Theophrastus prefaces each set of questions with a statement about Democritus' theory. In some cases, he repeats information from his report, but, as in T4–T6, he also provides new evidence. In *DS* 51–54, the frequency with which Theophrastus tells his reader what 'Democritus says' increases dramatically; he uses a verb of speaking seven times in his 35-line criticism of Democritus' visual theory. This is, on average, as frequent as his use of speaking verbs in his critique of Plato's *Timaeus*, where passages introduced by such verbs contain a higher proportion of technical or author-specific terminology than we find elsewhere.⁵¹ This predominance in the critique of Democritus' theory bodes well for any interpretation attempting to take full account of his theory of air imprints.

Democritus' stipulation that what is impressed must be dense, unfragmented and condensed (T4–T5) provides the reasoning behind his explanation of the sun as an agent of condensation (T6). In these three passages forms of ὠθέω and πυκνόω describe the compression and condensation of the air necessary to form the continuous mass of particles (T4). No agent of condensation is stipulated in T4 or T5, but in T6 it is the sun that condenses the air. Theophrastus states that Democritus says this (φησίν), before giving his own opinion to the contrary.⁵²

⁴⁹ One ought not assume Diogenes' ὁρᾶν δ' ἡμᾶς κατ' εἰδῶλων ἐμπτώσεις refers to this process. ἔμπτωσις is a late term used by Epicurus (*SV* 24) to refer to the way in which dreams appear.

⁵⁰ See Beare (1906) 26–27; English (1915) 218–21. Guthrie (1965) 442–43 posits a two-theory solution, but brings them together by suggesting κενόν is used loosely in T7. von Fritz (1953) 95, n.50 says the 'inconsistency cannot be explained away by any possible inter-

pretation'. Burkert (1977) 104 also concludes that the air-imprint theory is incompatible with εἶδωλα, suggesting that εἶδωλα are parapsychological rather than visual entities (see also Bicknell (1968); (1969); (1970)). Baldes (1975) and Taylor (1999) argue for a single theory, the latter follows Beare, suggesting that the imprints are responsible for visual distortion.

⁵¹ Cf. *DS* 73, 80, 84, 86, 90, 91.

⁵² Cf. Theophr. *Ign.* 46.

Burkert suggests that the sun serves a twofold purpose in Democritus' theory, by condensing the air to receive an imprint and transporting the imprint along the cone to the eye. However, taking ὁ ἥλιος... καὶ τὸ φῶς together with ἐπιφέρων (T6) strains the Greek. It is much better to omit Diels' comma after τὸ φῶς and thus render the sentence as I have done. After all, light need not be brought to the eye to see. Someone in a dark room does not have the sun bringing light directly to the eye, and yet he is able to see the sunlit scene outside the doorway because the outside air has been prepared by the sun for vision.⁵³

If, instead of the sun being a conduit for images, we consider it bringing light to the visual process (ὄψιν, T6), it plays an auxiliary role in ἔμφασις formation by preparing the air for the moulding (ἀποπλαττόμενον) by the εἶδωλα. Theophrastus does not explain how the sunlight, itself an atomic aggregate, achieves this condensation. Nevertheless, by drawing on other elements of Democritus' physics we can make certain inferences about what this process may entail.⁵⁴

Sunlight is presumably, like fire, composed of small, swift-moving round atoms.⁵⁵ In *de Caelo* (3.307a31–b5), Aristotle reports the general theory that fire combines and connects rather than separates things.⁵⁶ From the atomist's perspective such combinations occur as the particles that compose sunlight filter among the air particles, simultaneously increasing its density and brightness. Conversely, if too few light-making particles intermingle with the air, then the amount of void between the particles of air would make the medium difficult to manipulate, since it would not form a continuous body capable of being imprinted. This may explain the loss of vision in darkness.⁵⁷

For the object to be continuously seen, the impressing of air must continue for as long as the ἔμφασις remains visible in the eye. Thus, not only are the air imprints simultaneous with the compressing process, but they *must* be simultaneous for the ἔμφασις to remain visible.⁵⁸ Avotins argues that this cannot be, since 'the act of imprinting wax by means, for instance, of a signet ring would normally be pictured by Democritus and his audience as a momentary act rather than one signifying extended continuous pressure'.⁵⁹ His objection presupposes that this action is a single event and that the wax hardens. However, air, like soft wax, remains malleable because sunlight intermingles with it. Imprinting must continue in order to prevent the air from returning to its unimprinted state. If the consistency of the air is not uniform then the imprinting will be distorted or incomplete.

Now that we understand the individual elements that form air imprints, we can speculate about the role they play in Democritus' visual theory.

- (1) An object's εἶδωλον flows toward the eye. (T2)
- (2) The air through which it moves, infused with light particles from the sun, is condensed, i.e. ready for imprinting by εἶδωλα. (T4–T6)

⁵³ Lucr. *DRN* 4.337–52; cf. 2.741–47, 795–816, 4.230–33, 271–78. See also Plut. *adv. Col.* 8.1110c–d, which raises difficulties with seeing colours in the dark.

⁵⁴ Evidence for Democritus' theory of temperature is extremely fragmentary, but, like many Presocratics, he associates density with temperature: cf. DK13B1.2–8; see Rudolph (2009) 64–92. Aristotle (*Metaph.* 7.1078b19) suggests that Democritus attempted to define temperature, and Democritus identifies soul and heat because they consist of spherical atoms (DK68A106). Theophrastus too suggests that Democritus correlated spherical shapes with heat (*DS* 63.4–6, 65.1–4, 67.1–4, 75.1–9).

⁵⁵ DK68A1, DK68A101.

⁵⁶ For the opposite view, cf. Arist. *GC* 2.336a3; n.52 above.

⁵⁷ *DS* 53.8–11. Although unlit and cooler air (adopting Wimmer's emendation of ἐμψυχότερος to ἐμψυχρότερος), like cold wax, would better retain imprints, the continual process of forming new ones is greatly diminished at night. This explains why the owl (DK68A157) is described by Democritus as having 'fiery warmth about its eyes which is very sharp and cutting and divides and mixes up its sight', since additional light from nocturnal eyes, like light from the sun, would help form imprints by preparing the air. See n.27.

⁵⁸ The grammar and syntax of T2 bear this out.

⁵⁹ Avotins (1980) 443–44.

- (3) As the εἶδωλον presses the condensed air, eye effluences (i.e. visual rays) supply a simultaneous compression. The action of these two effluences moulds the air and results in an impression. (T2)
- (4) As the εἶδωλον and newly formed air imprint approach the eye, the air density grows due to the increased density of the eye effluences. This continues the compressing process, making the εἶδωλον and imprint small enough to be 'imaged in' (ἐμφαίνεται) the pupil as an ἔμφασις.⁶⁰ (T2; see also Fig. 1)
- (5) As the imprint and εἶδωλον enter the observer, the soft, moist eye lets the image pass through the ducts. (T2)

Although this explains how imprints are produced and how they enter the eye, we still do not know why air imprints are necessary for Democritus' theory.

This vision-via-imprints theory suggests that the further the object is from the percipient, the more compression and contraction must take place between the εἶδωλον leaving the object and reaching the eye.⁶¹ And yet, Theophrastus insists (*DS* 54) that Democritus' 'attempt' to explain the imaging of size and distance was unsuccessful. He gives no explanation for this critique, but he may have Aristotle's own criticism of distance vision in mind.

T7 Aristotle, de An. 1.419a13–17

For Democritus is wrong in stating the opinion that if the intervening space were empty one would see acutely enough to see even an ant in the heavens (εἰ γένοιτο κενὸν τὸ μεταξύ, ὀρᾶσθαι ἄν ἀκριβῶς καὶ εἰ μύρμηξ ἐν τῷ οὐρανῷ εἴη); for that is impossible.

Scholars often assume that Theophrastus' report of Democritean air imprints contradicts this passage. However, air imprints may be the very things drawing these opposing testimonies together. If we read T7 as a thought-experiment rather than as evidence for a theory, the apparent conflict is resolved.⁶² If, hypothetically, there were no air, εἶδωλα from objects and perceivers would have nothing to compress. The object's εἶδωλα would continue to transmit information about its size, shape and colour when it fell upon the perceiver's eye. No air imprint would form, so the size of an ant εἶδωλον would remain the same as it flowed from the heavens to the perceiver, leading to a visual distortion, since the ant up close and the ant far away would be the same size. Contrary to Aristotle's analysis, positing acute vision under the condition that void alone separates the viewer from the ant does not mean denying that air is the medium necessary for normal vision. Rather, it emphasizes the air's capacity to reduce the size of εἶδωλα. If there were an ant in the heavens and its εἶδωλα travelled through the air towards the eye, so much compression and reduction would occur over the distance that the image would be invisible when it reached the percipient. However, if there were no air to compress, the ant's εἶδωλα would be visible because, unshrunk, they would be the right size to enter the eye. The same could not be hypothesized for an elephant in the heavens because its undiminished εἶδωλα would be far too large to fit into the human eye.

Maintaining consistency in vision requires spatial relationships between objects to be demarcated from a fixed point. Thus, the image of an object ten feet from the perceiver will appear larger than the image of the same object 100 feet away, because less shrinking takes place between the nearer object and the perceiver than takes place between the further object and the perceiver (Figs 1 and 2). Avotins argues that if Theophrastus had known that Democritus posited

⁶⁰ Beare (1906) 27 incorrectly claims that the imprint alone is imaged in the eye.

⁶¹ The apparent deterioration of images over distance is attributable not to parts of εἶδωλον being knocked off, as the Epicureans suggested, but to the shrinking

effect of air, which can distort the object's appearance.

⁶² Thought-experiments occur elsewhere in Democritus' physics (most notably when discussing possible worlds); we ought not be surprised to find hypothetical suggestions here as well.

a shrinking air imprint to account for the size of an object seen at a distance, he would not have grouped this theory with the other ‘reflection’ theories; however, as we have seen, this is no ordinary reflection, and it is precisely by analogy with a wax imprint that this becomes clear. Gem carvers often engraved images of things – for example, amphorae, animals and people – onto a stone which, when pressed in wax, produced an image that was not only a replication of the original engraving, but also a miniature mimetic image of a real object, similar to Democritus’ ἔμφασις in the eye.

How are εἶδωλα directed toward a fixed point? One may argue that on this model Democritus must posit εἶδωλα moving from objects at such high speed and in such great quantities that they could shrink toward every conceivable point in three dimensions around the object in order for the perspective to remain undistorted. One possible answer is that the compressing force of the visual rays (i.e. eye effluences which disperse in a conical pattern from the eye) acts as a kind of channel down which the εἶδωλα move toward the perceiver. This need not be an active guiding; the eye effluences need only alter the density of the air to play a role in transmitting the image to the eye. As the εἶδωλα and air imprint approach the eye, the density of the air is altered due to the increased density of the eye effluence itself (Figs 1 and 2). In this way, the eye becomes the reference point toward which the image shrinks and from which all objects and their relative distances from one another are perceived. This is precisely the point Vitruvius makes in T3, providing further confirmation of the applicability of his testimony to Democritean optics. This perspective-via-imprint theory eliminates the redundancy Theophrastus sees in Democritus’ theory (*DS* 51.5–7) and accounts for the apparent inconsistency in the doxographical evidence. Moreover, it offers a plausible explanation for how eye effluences in the form of visual rays help transmit information to the eye and aid in the formation of the ἔμφασις.

Opponents of the perspective-via-imprint theory may protest that such an explanation strips Democritus’ theory of vision of its epistemic interest, since the air imprint is no longer a source of visual distortion. Taylor is the most recent proponent of the interpretation that Democritus’ air imprints account for the interference of the environment in the visual process.⁶³ However, as von Fritz rightly argues, air imprints are not necessary for distortion; mentioning the blurring effects of air itself is enough to suggest such a scenario.⁶⁴ Baldes argues that Theophrastus’ account describes what happens at or in the percipient. He suggests that the air imprint is formed when the air near the eye is trapped and compressed against it by the momentum of the image,⁶⁵ but he never makes it clear precisely what role the air imprint has in the visual theory. The explanation I put forward above provides a more coherent account than other reconstructions, and it has the benefit of allowing for the perception of distance.⁶⁶ Democritus may be emphasizing that the ἔμφασις, being composed of an effluence and an imprint like wax, *appears* to be a precise copy of the thing being imprinted. My reconstruction makes the wax analogy a far more compelling metaphor for sense perception and particularly for vision, because a wax impression bears a direct relationship to its intaglio: the hollow image engraved on stone appears in relief in the wax, and letters and images are reversed on the wax surface.⁶⁷

⁶³ Taylor (1999) 209–10.

⁶⁴ *Contra* Beare (1906) 26–27, von Fritz (1953) 94 criticizes air imprints as a mode of visual distortion, suggesting instead that the air imprint makes the image hard, so that it can be imaged in the soft eye. This too seems unnecessary.

⁶⁵ Baldes (1975) 100–01.

⁶⁶ Burkert (1977) 100 and Furley (1987) 132, n.24 suggest that air imprints may be responsible for the

perception of the size of objects, proportionally reduced according to the distance the εἶδωλα travel to the eye, but neither provides arguments for this observation. Cf. O’Brien (1984).

⁶⁷ This method of mechanical reproduction is the only ancient imprinting process that did not require a specialist skill; as such the process would have been familiar to Democritus’ readers.

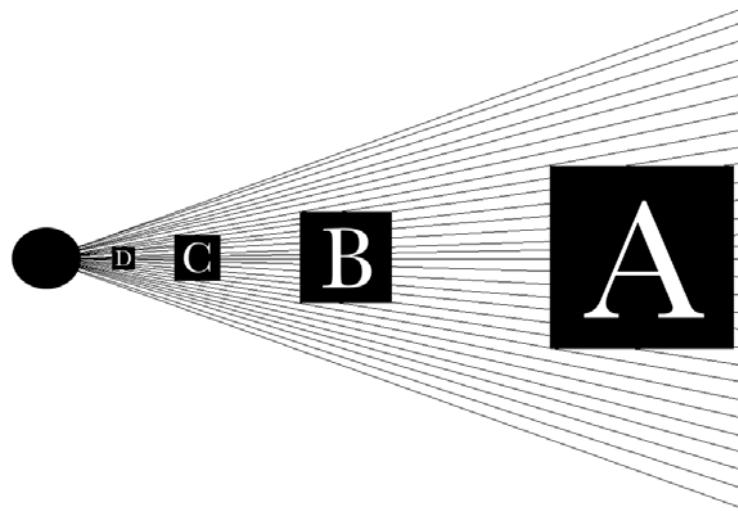


Fig. 1. Visual rays guide the object's εἶδωλον as it approaches the eye

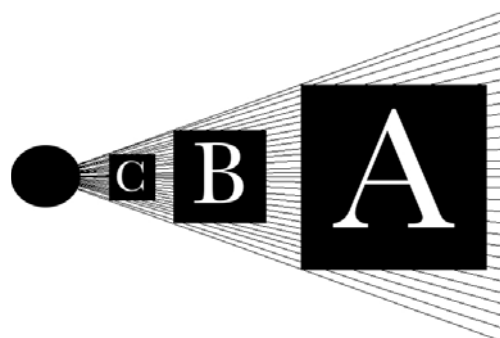


Fig. 2. An object nearer the eye, with the same εἶδωλον as in Fig. 1, shrinks less

Theophrastus raises two objections to air imprints themselves (*DS* 52.1–6): first, he argues that if air were impressed like wax the imprint would be facing the thing seen and, second, that it would be impossible for the image to be reversed unless the imprint were turned around. These objections mistake Democritus' point. The image impressed in wax only 'faces' the object on the surface; the 'back' of the wax would have an image exactly as it appeared on the stone (albeit not in intaglio). The same explanation works for vision: the ἐμφασις in my eye will only appear in reverse to someone looking at the reflection in my pupil, but it will appear forward-facing to me because I am, in a sense, seeing the 'back' of the image.

When we realise that a wax impression is an isomorphic copy of the original, but never an exact replica, the analogy becomes problematic for two reasons. Firstly, as Theophrastus notes, a wax impression is a positive inverse image of the negative depiction on the stone.⁶⁸ Secondly, the impression is mimetic and thus epistemically and ontologically constrained. Democritus, the first philosopher to liken sense perception to wax imprinting, seems aware of these difficulties and may have even embraced them.⁶⁹ Democritus' analogy differs from those of Gorgias, Plato

⁶⁸ See Platt (2006).

⁶⁹ See S.E. *M.* 7.135–40.

and Aristotle⁷⁰ in that air, and not soul, is imprinted: the impressing process is thus one step removed from the perceiver, which may accommodate the notion of epistemic uncertainty in the images we see.⁷¹ Despite, or maybe because of, these limitations, wax imprints are a powerful metaphor in Democritus' philosophy for the relationship between the external world and our perception of it.

IV. The problem of multiple impressions

Theophrastus concludes his critique by raising four pertinent objections concerning multiple impressions that create serious difficulties for the explanation of vision via imprints.⁷² However, many of the difficulties Theophrastus finds in Democritus' theory can be alleviated by accepting that things at a distance shrink more than things seen up close. These four criticisms, paraphrased below, form the culmination of Theophrastus' argument against the imprint theory.

- (1) *DS* 52.6–8: When several things are seen in the same place, how can there be several imprints in the same air?
- (2) *DS* 52.8–10: How can we see one another without the imprints colliding, since each is face to face with its source?
- (3) *DS* 53.1–5: Why do we not see ourselves, since imprints from ourselves would be imaged to our own eyes as much as other people's, especially when two people are face-to-face with each other: there would be a visual equivalent of an echo.
- (4) *DS* 53.6–8: From what Democritus says, all bodies are necessarily imprinting themselves and a great number are crossing one another's paths, which impedes sight and is impractical for other reasons as well.

Objection (1) is a further complication of Theophrastus' claim that images imprinted on air would face the object rather than the perceiver. As we have seen, the problem of backward-facing imprints is not a difficulty. If by 'in the same place' Theophrastus means objects grouped together so that parts of them overlap, it may be that the effluence and imprint of the unseen part of one object is obstructed by the visible portion of another. We can only speculate about the fate of these 'blocked' atoms; presumably the particles dissipate upon collision with another object.⁷³ Objection (1) may also express the potential problem of how one sees two objects side by side. Democritus may have replied that the visual field as a whole, not just individual objects, is imaged in one's eyes or that one sees two objects beside each other because the atoms which form those objects are already arranged in close proximity. As the images and imprints of each object are contracted, those belonging to each condense into two relatively dense aggregates, which are then imaged in the eye. In conjunction with objection (1) one may also ask how continuous vision is possible if the air is constantly imprinted by different effluences. However, if the air is itself continually being compressed and moulded, the movement will allow whatever air is used for one image to be replaced in time for a second imprint to be made. This requires very rapid movement, but is not impossible.

The account of distance and size may also alleviate Theophrastus' concern (3) that on Democritus' theory we should see ourselves. We may conjecture that effluences move away from

⁷⁰ Plato and Aristotle both use the wax-imprinting analogy in their discussions of the knowledge of perceptibles. Aristotle employs it in *de An.* 2.424a19 to explain how one can receive perceptible forms without their matter; Plato likens memorization to imprinting in wax in his second definition of knowledge in *Th.* 191c–d. Gorgias (DK82B11.13, 15) too speaks of the imprinting of the soul through sight. See also Pl. *Phil.*

39a–b; Arist. *de An.* 3.425b23, 3.434a29; as well as the Stoic usage (*SVF* 2.53, 55, 56).

⁷¹ See von Fritz (1953) 96–99; Burkert (1977) 103; Baldes (1978); Rudolph (2009) 154–59.

⁷² Alexander raises similar difficulties in his *in Sens.* 24.18–21, 56.10–15 and *Mantissa* 134.28–36.28, but he focuses on large buildings and images in mirrors.

⁷³ Cf. Alex. *in Sens.* 57.1–11.

objects and the same must be true of our own. Initially, they will be larger than our visual cone and much too large to fit into our eyes, which is why we do not see our own εἶδωλα. As our image moves away from us, the density of the effluences of our eyes will be diminishing and our own image will thus escape our sight.

Objection (2) and its extension (4) are by far the most difficult to answer, and serve as the climax of Theophrastus' critique of Democritus' 'absurd' theory. The doxographical tradition preserves no information about the way Democritean effluences and air imprints from different objects interact with one another. One possibility is that they pass through one another, being arranged and contracted enough to retain their configuration, but loose enough to allow other images to pass through them.⁷⁴ For example, when two projectors are shone at one another the image emitted from one is not blocked by the image emitted from the other. On the contrary, the whole image from projector one passes through the beam of projector two and is visible on the opposite wall. The same can be said of light from lanterns, and Democritus may have something similar in mind.

Theophrastus' final difficulty with air imprints stems from the problem of dissipation.⁷⁵ In *DS* 53 he suggests that if an image remains, one ought to see even when the bodies are not visible or near, if not at night when the images remain due to the coolness of the air, then at least during the day. In a sense, this criticism is related to (4), since it relies on multiple imprints, but whether Democritus actually suggested that air imprints remain is unclear. This may be Theophrastus' own assumption; there seems little reason for it. If they did remain, it may be that they become so small as to be invisible. It seems more likely, however, that air imprints dissipate. Theophrastus' criticisms of Democritus' visual theory raise important questions about the viability of perception via εἶδωλα;⁷⁶ it may be in response to challenges of this sort that the Epicureans abandoned the theory of air imprints.

Theophrastus' remarks, as we have seen, present further Democritean evidence, but also allow us to see his Peripatetic methodology at work. At T4 he criticizes Democritus' view that 'what is impressed must have density and not be fragmented', pointing out that one should thus be able to see better in water than in air because it is denser.⁷⁷ By delaying this piece of evidence, Theophrastus makes Democritus' theory seem self-refuting.⁷⁸ Likewise, postponing the wax analogy to the critique allows Theophrastus' questions to seem more pertinent. When read together, Theophrastus' objections also form a coherent argument that builds to the conclusion that Democritus' theory is 'absurd'. It is impossible to know whether these concerns were or could have been answered by the Democritean source material at Theophrastus' disposal, but he clearly did not feel the need to extend the principle of charity to his predecessor. That in itself does not make Theophrastus a bad source for early Greek philosophy, if anything, it makes it easier for us to separate the Democritean material from Theophrastus' own conjectures. Unlike Aristotle, who mentions earlier philosophers in order to dismiss them or to show how his own theories supersede theirs, the *DS* includes the details of earlier theories as the basis for Theophrastus' own detailed criticisms. While he shows some interest in grouping philosophers into explanatory categories (those who say perception is like-by-like and those who say it is by

⁷⁴ See Baldes (1975).

⁷⁵ This final criticism seems to bear some relation to the scanty evidence for Democritus' theory of dreams. Aristotle refers to Democritus obliquely in *Div. Somn.* 464a5–17 and Plutarch also records what may be Democritus' theory (DK68A77). Cf. Cic. *de Div.* 2.67.137.

⁷⁶ Cf. Alex. *in Sens.* 57.21–29.

⁷⁷ To Theophrastus' suggestion that vision would be better in water, Democritus might reply that water is not

affected by sunlight to the same degree because it is already a continuous body of the wrong consistency. He might suggest that the particles or arrangements that compose water are not as suitable for seeing through, being too large, or too incorrectly shaped or aggregated, to be imprinted by εἶδωλα.

⁷⁸ If one reads Theophrastus' συμβάλλειν ἑαυτοῖς at *DS* 52.9 as 'self-defeating' with Baldes (1975) 101–02, his interest in self-contradiction is even more apparent.

opposites), he does not attempt to press Democritus into either category, preferring to offer him as a counter-example to these prevailing points of view. Whether this is a sign of dialectical motives on his part or a reflection of his interest in going further than his teacher is best left to a discussion of the *DS* as a whole.⁷⁹ Nevertheless, we are able to see that Theophrastus' evidence is not as untrustworthy as some scholars have suggested.

What, then, are we to make of the very different explanations of Democritean optics that we find in Theophrastus' *DS* and the other doxographical sources, which tend to privilege the εἰδῶλα over the imprints? Unfortunately for those looking for nascent theories of cognitive processing, Theophrastus does not explain how Democritus' account of the eye and his theory of vision function as a whole. There is no hint as to how the eye processes or transmits the images it receives, so we must set aside such questions. However, it has become clear that Democritus' theory of vision requires none of the special pleading required for a two-theory visual account. From the evidence we have determined that Democritus' theory of vision is not nearly as simplistic and passive as some would have us believe. The imprint theory supplements rather than contradicts the notion of vision by εἰδῶλα, by explaining the miniature size of the reflection in the eye. Moreover, this perspective-via-imprint theory vindicates Vitruvius' testimony and shows Aristotle's troubling passage about vision through void to be a thought-experiment that helps prove rather than refute Democritus' theory. More importantly, however, if the interpretation presented in this paper is accepted, it follows that Democritus, by combining empirical observation and mathematical theory in an explanation of perspectival vision, was a much more innovative and sophisticated theoretician than has been suggested previously. This is all the more interesting because an explanation that utilizes air imprints, which necessarily constrain and alter vision, lays the groundwork for Democritus' larger epistemological claims about the value of sense perception.

Bibliography

- Avotins, I. (1980) 'Alexander of Aphrodisias on vision in the atomists', *CQ* 30, 429–54
- Baldes, R.W. (1975) 'Democritus on visual perception: two theories or one?', *Phronesis* 20, 93–105
- (1978) 'Democritus on the nature and perception of "black" and "white"', *Phronesis* 23, 87–100
- Baltussen, H. (1992) 'Peripatetic dialectic in the *De Sensibus*', in W.W. Fortenbaugh and D. Gutas (eds), *Theophrastus: His Psychological, Doxographical, and Scientific Writings* (New Brunswick) 1–19
- (2000) *Theophrastus Against the Presocratics and Plato: Peripatetic Dialectic in the De Sensibus* (Leiden)
- (2005) 'The Presocratics in the doxographical tradition: sources, controversies and current research', *Studia Humaniora Tartuensia* 6, 1–26
- Barnes, J. (1982) *The Presocratic Philosophers* (London)
- Beare, J.I. (1906) *Greek Theories of Elementary Cognition: From Alcmaeon to Aristotle* (Oxford)
- Bicknell, P.J. (1968) 'The seat of the mind in Democritus', *Eranos* 66, 10–23
- (1969) 'Democritus' theory of precognition', *REG* 82, 318–26
- (1970) 'Democritus' parapsychology again', *REG* 83, 301–04
- Burkert, W. (1977) 'Air-imprints or eidola: Democritus' aetiology of vision', *ICS* 2, 97–109
- Büssing, H. (1984) 'Optische Korrekturen: Vitruvs Empfehlungen verglichen mit der attischen Architektur des 5 Jhs. v. Chr.', in H. Knell and B. Wesenberg (eds), *Vitruv-Kolloquium des Deutschen Archäologen-Verbandes* (Darmstadt) 27–40
- Camerota, F. (2002) 'Optics and the visual arts: the role of σκηνογραφία', in J. Renn and G. Castagnetti (eds), *Homo Faber: Studies on Nature, Technology, and Science at the Time of Pompeii* (Munich) 121–41

⁷⁹ See Long (1996); Baltussen (2000); Rudolph (2009) 4–32.

- Christensen, J. (1999), 'Vindicating Vitruvius on the subject of perspective', *JHS* 119, 161–66
- Davison, J.A. (1953) 'Protagoras, Democritus, and Anaxagoras', *CQ* 3, 33–45
- de Ley, H. (1968) 'Democritus and Leucippus, two notes on ancient atomism', *AC* 37, 620–33
- Diels, H. (1879) *Doxographi Graeci* (Berlin)
- Dillon, J. (2003) *The Heirs of Plato: A Study of the Old Academy* (Oxford)
- English, R.B. (1915) 'Democritus' theory of sense perception', *TAPhA* 46, 218–21
- Ferguson, J. (1965) 'On the date of Democritus', *SO* 40, 17–26
- Furley, D. (1987) *The Greek Cosmologists* (Cambridge)
- Guthrie, W.K.C. (1965) *A History of Greek Philosophy Vol. 2: The Presocratic Tradition from Parmenides to Democritus* (Cambridge)
- Janko, R. (1984). *Aristotle on Comedy: Towards a Reconstruction of Poetics II* (Berkeley)
- Kirk, G.S., Raven, J.E. and Schofield, M. (eds) (2005) *The Presocratic Philosophers* (Cambridge)
- Knorr, W.R. (1991) 'On the principle of linear perspective in Euclid's *Optics*', *Centaurus* 34, 192–210
- Lephas, P. (1998) 'On Vitruvius' concept of scaenographia', *NAC* 27, 261–71
- Long, A.A. (1996) 'Theophrastus' *De Sensibus* on Plato', in K.A. Algra, P.W. van der Horst and D.T. Runia (eds), *Polyhistor: Studies in the History and Historiography of Ancient Philosophy Presented to Jaap Mansfeld on his Sixtieth Birthday, Philosophia Antiqua* (Leiden) 345–62
- Luria, S.R. (1970) *Democritea* (Leningrad)
- Mansfeld, J. and Runia, D.T. (eds) (2009) *Aëtiana: The Method and Intellectual Context of a Doxographer, Vol. 2: The Compendium, Part 1* (Leiden)
- Morel, P.-M. (1996) *Démocrite et la recherche des causes* (Paris)
- Mugler, C. (1959) 'Les theories de la vie et la conscience chez Démocrite', *RPh* 33, 7–38
- O'Brien, D. (1984) 'Théories atomistes de la vision: Démocrite et le problème de la fourmi céleste', in L. Benakis (ed.), *Proceedings of the First International Congress on Democritus* (Xanthi) 27–57
- (1994) 'Démocrite d'Abdère', in R. Goulet (ed.), *Dictionnaire des Philosophes Antiques* (Paris) 649–715
- Platt, V. (2006) 'Making an impression: replication and the ontology of the Graeco-Roman seal stone', *Art History* 29, 233–57
- Pollitt, J.J. (1974) *Ancient View of Greek Art* (New Haven)
- Rudolph, K.C. (2009) *Reading Theophrastus: A Reconstruction of Democritus' Physics of Perception* (Ph.D. Diss. Cambridge)
- (forthcoming) 'Democritus' Ophthalmology', *CQ*
- Salem, J. (1996) *Démocrite: Grains de poussière dans un rayon de soleil* (Paris)
- Sassi, M.M. (1978) *Le teorie della percezione in Democrito* (Florence)
- Sedley, D.N. (1992) 'Empedocles' theory of vision and Theophrastus' *De Sensibus*', in W.W. Fortenbaugh and D. Gutas (eds), *Theophrastus: His Psychological, Doxographical and Scientific Writings* (New Brunswick) 20–31
- Stella, L.A. (1942) 'Intorno all cronologia di Democrito', *RFIC* 70, 21–46
- Stratton, G.M. (1917) *Theophrastus and the Greek Physiological Psychology Before Aristotle* (Amsterdam)
- Taylor, C.C.W. (1999) *The Atomists: Leucippus and Democritus* (Toronto)
- Tybout, R.A. (1989) 'Die Perspektive bei Vitruv: Überlieferungen von *scaenographia*', in H. Geertman and J.J. de Jong (eds), *Munus non ingratum: Proceedings of the International Symposium on Vitruvius' De Architectura and the Hellenistic and Republican Architecture* (Leiden) 55–68
- Vallance, J.T. (1990) *The Lost Theory of Asclepiades of Bithynia* (Oxford)
- von Fritz, K. (1953) 'Democritus' theory of vision', in E.A. Underwood (ed.), *Science, Medicine and History: Essays on the Evolution of Scientific Thought and Medical Practice Written in Honour of Charles Singer* (Oxford) 83–99
- Warren, J.I. (2007) 'Anaxagoras on perception, pleasure and pain', *OSAPh* 33, 19–54
- White, J. (1956) *Perspective in Ancient Drawing and Painting* (London)
- (1957) *The Birth and Rebirth of Pictorial Space* (London)