Περὶ χρωμάτων (*Peri chrōmatōn*): Colour formation and investigation method.

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ABSTRACT

In this essay, the attention is focused on the method used to investigate colours, as produced in nature. This method was proposed by the author of the treatise *Peri chrōmatōn*, which has become part of the *Corpus Aristotelicum*. The colours are first divided into two large categories, simple and mixed, in accordance with other scientific and philosophical approaches. Simple (primary) colours are considered to be white and yellow, and are associated with the elements (air, water, earth, and fire/sun); black is also associated with the elements as they transform into one another. This division is new in comparison with previous theories based on two or four fundamental colours. The endless range of colours seen in objects, plants and animals, is connected to the mechanisms of mixing different qualities and quantities, inherent in what it comes into contact with, and in the consequent changes, in conditions and states of matter, in the incidence of light, qualitatively and quantitatively different. The heuristic reference scheme and the analogical model are represented by the dyeing process. The essentially phenomenological treatise contains historically significant insights: no colour can be seen in its purity; the reciprocal interaction of colours; the variability of conditions that determine the chromatic impression; light as a component of mixtures, and its diversity depending on the source; and the chromatic value of shade. In it, we can also see the formation of a classification of colours and a nomenclature, founded on the relationship of distinct chromatic notations with light and darkness.

KEYWORDS colours and elements, lights and pigments, shadow and darkness, *physis and technē*, dyers and painters.

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1. Introduction

The topic of perception, classification and naming of colours in Greek culture is at the centre of a lively debate, which started as early as antiquity. The bibliography on the subject is vast and includes studies in various fields (philological, anthropological, sociological, psychological, philosophical, artistic) and stimulating comparative investigations (Ferrini 1999; 2008; 2010; 2019; Gage 2001; Tiverios and Tsiafakis 2002; Cleland and Stears 2004; Rouveret *et alii* 2006; Carastro 2009; Grand-Clément 2011).

An essential work to capture some of the most salient aspects of Greek speculation on colour is Περὶ χρωμάτων incorporated in the *Corpus Aristotelicum*: this treatise is the only ancient work dedicated exclusively to colours (observed in objects, plants and animals) and has been preserved in its entirety, despite some textual corruptions.

2. Simple colours

In *Peri chrōmatōn*, colours are divided into two large groups, simple and mixed, in accordance with other scientific and philosophical treatises. These demonstrate the close link, in Greece, between the investigation of the cosmos and the origin of the existing, and the theory of colour. Simple colours (which we would call primary) are regarded as white (τὸ λευκόν) and yellow (τὸ ξανθόν): these are associated with the elements (air, water, earth, fire/sun); black (τὸ μέλαν), as a colour, is also associated with the elements, although when they change into each other: «Simple are those colours that are associated with the elements, i.e. fire, air, water, earth: air and water are white by nature, fire and sun are yellow. The earth is also white by nature but appears to be various colours because it is tinted. [...] The colour black is associated with the elements when they are transformed into one another. Other colours derive from these, as can easily be seen, by combining and mixing with each other. Darkness, in the end, is due to the lack of light» [1]. Defining black as a colour that is connected with the elements in their respective transformation has original characteristics in Greek literature; it derives from the observation of the phenomena described from time to time, in which processes that imply gradual changes over time take place: the appearance of black occurs *over time*. Furthermore, black is not only a colour but also a state of darkness or semi-darkness. It is particularly significant and original the passage which examines the three ways black can appear: as a positive colour, associated with the elements, and as a negative colour, in that it is the total *or* partial lack or absence of light, and is connected with a visual weakness or insufficiency. The black of black objects is distinguished from the black that is shown when an object reflects no or little light. In addition, terms connected with the noun that indicates shadow (σκιά, distinct from darkness, σκότος, which is deprivation of light) are used for the first time with a specifically chromatic value ('shadow colour'): «In three ways black appears to the eye. In general, what we do not see is black by nature (because all objects of this colour reflect like blacklight), or those objects from which no light reaches the eyes are black: what we do not see if the surrounding space is visible, determines the appearance of black; or, finally, all those objects from which light reflects poorly and very faintly appear black. This is why even shadows appear black; and so also does water, when it is disturbed, as when the sea ripples: since, due to the agitation of the surface, few rays fall on it and the light is diffused, what is in shadow appears black. The cloud also appears black for this same reason, whenever it is very dense. The same happens to water and air when light does not penetrate it completely [...]. It is not difficult to understand from many factors that darkness is not a colour, but deprivation of light, in particular from the lack of perception of how great the darkness is, and what its form may be, as is possible for other visible objects» [2]. Black, therefore, occupies a very special place: it is the only colour which, while having the function of a primary colour, can be produced and manifest itself over time. Even the definition of white and yellow as simple colours has new features compared to other and previous theories, in which white and black are considered simple, explicitly or implicitly, or four colours, white, black, red and yellow/green: red is the salient colour par excellence, while yellow and green are additional colours in many cultures, being able to integrate a triadic base, consisting of white, red, and black/blue. The four-colour painting, of which there is evidence in some ancient sources, is a matter of debate; in any case, it may have been influenced by conceptions of the cosmos and the elements. The relationship between colours and elements is theoretically investigated in other Greek sources, while in *Peri chrōmatōn* it is an accepted fact, instrumental to the discussion and a constant point of reference: each physical element is associated by its nature with a colour, as its inherent and characteristic, distinctive quality. Secondary and tertiary colours are obtained by mixing and in certain quantitative and qualitative [3] ratios. Few other colours are listed as ingredients in addition to the primary colours, while light and sun rays appear as fundamental components, quantitatively and qualitatively marked in their various gradations, intensities, and inclinations. Observations on light constitute one of the most significant aspects of this treatise. Even its opposite, darkness, has direct and concrete effects on the production and appearance of colours, as well as shadow, which has a chromatic value, and which can vary in intensity and be a

component of the mixture from which colours originate. These observations seem very important, if one thinks of the history of painting from antiquity to the present, the problem of the representation of shadow and the function attributed to it in theoretical speculation and practice.

3. The infinite variety of colours and the investigation method

The variety of colours is linked to mixing mechanisms of different qualities and quantities, which are inherent to what comes into contact, and to the consequent changes, to conditions and states of matter, to the incidence of light: «The multi-faceted aspect and the infinite variety of colours must not escape attention, no matter for how many reasons this may happen. We will discover the cause, either in their unequal and discontinuous reception of light and shadows [...], or in the fact that the mixed colours differ in quantity and vividness of the components, or that they do not have the same proportions. Violet, red, white and any other colour differ greatly according to the plus and minus, by the respective combination and purity. The colour mixed according to whether it is bright or shiny, or on the contrary dull and opaque, contributes to the difference. The brightness is nothing if not continuity and density of light; in fact, the colour gold shines when the yellow of the sun's light, which is very concentrated, shines through. Consequently, the neck of pigeons and droplets of water also appears gold-coloured if there is a reflection of light» [4].

3.1 *Reference Models*

Both the heuristic reference scheme and the analogical model are shown by the fabric dyeing process, extending to other phenomena. Each body is as if immersed in a dye: the image of a liquid flowing through the material is frequently used, conveying its chromatic qualities, spreading out along its path and permeating the parts that are porous enough to absorb it. To carry out the process, the following is necessary: a dye that penetrates the pores of the object to be dyed, water as a medium and heat. In particular, the development of different colours when dyeing with the murex illustrates what happens with fruits, which take on various colours, depending on their ripening stages: «When they crush the murex and drain the moisture away, and then it is poured into pots and boiled, initially no colour is distinguishable in the dyeing bath. This is because each of these colours gradually varies in many different ways; the more the liquid boils, the more the colours that remain are combined: you have black, white, brown, blue-grey, and then all the colours become violet once they have been boiled together, so that none of the other colours is distinguishable by itself, due to the mixture» [5]. Dyeing practices are used as experimental evidence and as an explanatory model of what happens in nature, according to parallels traditionally established between natural processes and *technē* procedures, and helpful for reasoning as the latter are useful for understanding and interpreting the former. Therefore, art can represent a model for the analysis of nature. However, in *Peri chrōmatōn*, it is noted that while the dyeing technique performs this function, the mixture of pigments by painters is not considered methodically valid for the investigation of colours. It is, in fact, the dyers who imitate nature, not the painters. On the contrary, the dyeing bath of fabrics soaked in the dyeing substance resembles how the liquids present in plants and animals affect and colour their various parts.

3.2 *Colour mixing in nature*

The author of *Peri chrōmatōn* proposes a method of investigation of colours, just as they are produced in nature, referring repeatedly to certain criteria that essentially derived from a series of observations arranged and supported by rules, from specialised knowledge, and based on the conviction that in nature lights and not pigments are mixed. «We must examine all this without mixing these colours as painters do, but by comparing the rays that are reflected by the colours we have been talking about: this is the best way to investigate the mixtures of colours according to nature. Also, the evidence and basis for comparison must be derived from cases where the origin of the colours will be clear. This is particularly true of sunlight and firelight, air and water: their mixture in greater or lesser proportion gives rise to almost all colours. […]. Other colours must then be observed in the processes of ripening since they are produced in plants, fruits, hair, feathers and so on».[6] The skill of painters, who mix pigments, is opposed to the recommended research method, which is to observe colours in nature. The emphasis is placed on the concept expressed by the nexus *kata physin theōrēsai* [7]. The passage was usually compared with the statement of Aristotle, in the *Meteorologica* (372a 5 ff.), about the three main colours (red - φοινικοῦν, green - πράσινον, violet - ἀλουργόν) of the rainbow, which cannot be artificially produced by painters: in both cases, it seems that the authors distinguish between two systems, which we define respectively as an additive, where coloured lights are mixed, and subtractive, where pigments are mixed.

3.3 *Origin and change of colours*

Careful observation and correlation of the phenomena would be more fruitful in cases where colours' origin is clear (those in which sunlight and fire, air and water interact): then they can be valid as proof and as a basis for comparison. The reference to a colour of clear origin, the

comparison of reflected rays and the effects of light on different objects, the transition from one colour to another, and again (as the author says in the section on the formation of colours in the vegetable and animal world) the connection between colour in living organisms and ripening represent the basis for the study and understanding of chromatic phenomena. In this way, everything can have a permanent colour and a transitory colour, an original colour and a colour that is formed over time, again starting from the original, linked to the element of which a substance is predominantly made up. The only distinction that the author invites us to make is between the colour based on observation, or presupposition, and the colour that occurs in successive phases of growth (plants and animals reach their own colour as they *mature*), or in dyeing processes, or following mechanical phenomena, for example, the rubbing of stones and metals, physical (and chemical) actions due to light and heat. We can, therefore, observe initial colours, intermediate colours, final colours; light is a fundamental variable for their formation and their manifestation, even transitory. There is a colour naturally linked to things, as they are mainly formed by an element, but we do not always see it; therefore analysis and interpretation focus on the visible and very mutable colour, on the colour that appears at the beginning of a process, for example, green in plants. The evidence (πίστις) that proves and confirms the validity of the statements once again comes from observation and experience. The simultaneous reference both to arguments that can be adduced as evidence and to a criterion by which relationships between things are identified (the criterion of similarity) is significant. In collecting data, attention is paid to the analogy of the phenomena and the causes that produce them. The necessity to observe and correlate the phenomena, underlined many times, is associated with an attempt at experimentation in the passage in which reference is made to the iridescent neck of the pigeons, an example that is added to the chromatic changes of the air and water, due to the different incidence of light on a surface: «[...] the air sometimes takes on a purple tint to the east and west, when the sun rises and sets: then its particularly weak rays hit the dark air. The sea also tends towards the purple when the waves rise and the part of the wave that arches is in shadow, for the sun's rays strike this inclined part lightly, and cause the violet colour to appear. This is also observed in the plumage of birds: under a certain angle of light, it has a violet colour. If a lesser amount of light hits it, it is of that dull colour which is called brown; whereas plenty of light, mixed with the original black, produces red. If it is bright and glittering, the colour changes into the red of the flame» [8]. The orientation of the feathers in the direction of the light, almost skimming, has several effects that depend not only on the quantity and quality of the incident light but also on the angle of incidence. It is significant that the plumage of birds, traditionally a symbol of colour variation, is colouristically defined as the iridescent seawater. The iridescent colour of pigeons' neck, in the sun, was one of the well-known arguments in favour of relativism of knowledge and optical illusions (today we would speak of colouring by interference). Each qualitative and quantitative change corresponds to a change of colour and a step to characteristics that from time to time are opposite or intermediate, with respect to the completion of a process and the time it takes. The processes and actions that influence the various production of colours are heating, combustion, liquefaction, melting, boiling (in the case of artificial dyeing, for example), cooling, maturation/cotion (in plants and animals), correlated with nutrition and assimilation. Precise qualities, positions and dispositions, characteristics and states of matter are just some of the variables that determine colour: density and compactness, rarefaction and thinness, porosity or continuity, smoothness or roughness. Different conditions related to light and shadow, depth, distance, surface or interior vision, direct or through a medium, permanence or movement, space or time, add to the list of factors to which reference is made several times. The various causes of colour change are therefore attributable to physical (or chemical, in some cases, from our point of view) characteristics and processes, and to optical phenomena of light reflection, sometimes superimposed.

3.4 *No colour is seen in its purity*

Attention is constantly drawn to the infinite variety of colours [9]: this part is extremely interesting for its modernity. There is a clear awareness of characteristics, colour attributes, distinctions and phenomena, to which we give precise names (hue, saturation, brightness, contrast of tone, simultaneous contrast of colours, influence of the field) and which we define with different parameters, based on acquisitions and new settings, methodical experimentation and instrumental measurements, but in their intuitive essence are present in the mind of our author. No colour can be seen in its purity: all are to some extent modified by mixing if not with other colours, certainly with light and shadow. In fact, light and shadow appear to be the main factors of chromatic alteration: they can vary in intensity, quantity, regularity and interact differently with things that have a different composition, structure, consistency, surface, position, exposure and inclination: «We do not see any colour in its purity, as it is in reality, but all mixed with others: and even when they are not mixed with another colour, they are at least mixed with the rays of light and shadows; so they appear different, and not as they are. For the same reason, the same objects appear to us of a different colour when observed in the

shadow, in the light, when there is the sun, under intense or dim light, according to inclinations and different positions, and other different factors. The same happens with objects exposed to the light of a fire, the moon, or lanterns because each of these lights is different; and again in the case of the combination of colours, because they acquire their colour as one passes through the other. When light, falling on something, is coloured, and becomes, for example, red or grass green, and then the reflection falls on another colour, it takes on a different chromatic mixture as a result of this new intermingling. Undergoing these continuous but imperceptible modifications, the light sometimes reaches the eyes already mixed with many colours, but in such a way as to determine, among the prevailing colours, the perception of only one. This is why objects observed underwater come closer to the appearance of water, and objects observed in mirrors have similar colours to those of the mirrors themselves. The same must be thought to happen with the air. In conclusion, all colours are a combination of three components: light, the medium through which it is seen, for example water or air, and finally, the basic colours from which light is reflected. » [10].

4. Conclusion

There are many historically significant findings in this treatise, which is essentially phenomenological: no colour can be seen in its purity; the mutual interaction of colours; the variability of conditions that determine the chromatic impression; light as a component of mixtures, and its diversity depending on the source; the chromatic value of shade. Likewise, the attempt at a classification of colours and nomenclature, based on the relationship of distinct chromatic notations with light and darkness, emerges in it.

5. Conflict of interest declaration

No potential conflict of interest

6. Funding source declaration

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7. Short biography of the author

Maria Fernanda Ferrini is Associate Professor of Greek Language and Literature at the University of Macerata. Her principal monographies are focused on the technical and scientific treatises of the *Corpus Aristotelicum* (*De coloribus, Problemata, Physiognomonica, De audibilibus, Mechanica, De plantis, Rhetorica ad Alexandrum*). Among her most recent publications is ΧΡΩΜΑΤΑ *(Chrōmata). Lessico dei termini greci di colore. I: alpha* (2019)

Notes

[1] Col. (= De coloribus) 791a 1-12. The Greek text of the treatise is quoted according to my edition (Ferrini 1999), for which I revised the manuscripts collated by Bekker (1831) and by Prantl (1881), and I used other manuscripts that were not examined by the other two editors.
[2] Col. 791a 13-b 6.
[3] Col. 792a 4-5; 792 a 32-b 2. For some derivatives colours, components and quantity are given, but this is only vaguely indicated with 'a lot' and with 'a little', 'more' and 'less'; in every case, the author does not give formulae (his treatise is not an investigation for practical purposes) which we find in a list of instructions for the composition of colours, destined for painters and dyers, which was very common from late antiquity until the modern age, as a jealously guarded secret of every workshop, painting school, and alchemy and weaving studio.
[4] Col. 792b 33-793a 16.
[5] Col. 795b 11-21; cfr. 797a 3-8.
[6] Col. 792b 16-32.
[7] Col. 792b 20 κατὰ φύσιν θεωρῆσαι, 'investigate according to nature'. The method proposed is the best and most effective for explaining the variety of colours, even according to the more general principle, typical of ancient science, of studying phenomena as they appear in nature.
[8] Col. 792a 17-29.
[9] Col. 792b 33-34: τὸ πολυειδὲς καὶ τὸ ἄπειρον τῶν χρωμάτων.
[10] Col. 793b 12-794a 2.

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