Is colour composition phenomenal?[1]

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ABSTRACT: Colour composition divides colours into two types: unitary and binary colours. Colours which are not composed are said to be “unique” or “unitary” colours, whereas composed colours are always binary. Colour composition and the distinction between unitary and binary colours have played a major role in colour science and in the philosophy of colours. They have for example been invoked to introduce opponent-processes in the mechanisms underlying colour vision and have been used to criticize philosophers who defend a physicalist view on the nature of colours. Most philosophical or scientific theories suppose that colour composition judgments refer to the way colours appear to us. The dominant view is therefore *phenomenalist* in the sense that colour composition is *phenomenally* given to perceivers. This paper argues that there is no evidence for a phenomenalist view of colour composition and that a conventionalist approach should be favoured.

We can express a lot of judgments about the colours we perceive. Most observers judge for example that red is more similar to orange than it is to blue; that no shade of yellow is a shade of blue; or that red and green, orange and blue, and yellow and purple are pairs of maximally dissimilar colours. All those judgments express colour structural relations, i.e. relations that colours bear to each other. Among colour structural relations, colour composition has received tremendous attention by philosophers and scientists from fields

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as diverse as physics, physiology, psychology, artificial intelligence, linguistics, anthropology, etc.

Colour composition divides colours into two types: unitary and binary colours. Colours which are not composed (or unmixed) are said to be “unique” or “unitary” colours, whereas composed (or mixed) colours are always binary. According to the prevailing view of colour science there are only six unitary colours: red, green, blue yellow black and white. The remaining colours are all binary colours: for example orange is always said to be somewhat reddish and somewhat yellowish, whereas purple is at the same time bluish and reddish.

The goal of this paper is to investigate the nature of colour composition and the foundation of the unitary/binary colours distinction. Colour composition and the distinction between unitary and binary colours have played a major role in colour science and in the philosophy of colours. They have for example been invoked to introduce opponent-processes in the mechanisms underlying colour vision[2] and have been used to criticize philosophers who defend a physicalist view on the nature of colours.[3] As I will try to show in this paper, most philosophical or scientific theories suppose that colour composition judgments refer to the way colours appear to us. The dominant view is that colour composition is *phenomenally* given to all human “normal” human observers. To judge for example if orange is binary or unitary or to evaluate its reddishness, we must turn to our colour experiences. As I will try to show, there is little evidence for the “phenomenalist” view of colour composition. Unlike the dominant phenomenalist view, which relies solely on individuals’ colour experience, I will defend the idea that judgments about colour composition and the distinction between unitary and binary colours are essentially cultural and originate from communicational needs and constraints.

The paper will begin by a short overview of the historical background of the phenomenalist view about colour composition (§I). Then in §II and §III, I will argue that

[2] See Jameson & Hurvich 1955.
[3] See for example Cohen 2003, Hardin 1988, Thompson 1995.

there is not enough evidence to conclude in favour of a phenomenalist view of the binary/unitary colours distinction and of colour composition. By exploiting an analogy with the perception of temperature, I will show that the phenomenalist approach to colour composition gives an unsatisfactory account of colour experiences and that a conventionalist view of the unitary/binary distinction is therefore preferable (§IV).

I. A short historical overview of the phenomenalist view about colour composition

The publication in 1969 of Berlin & Kay's "Basic Colour Terms" has had a great impact on the scientific community in large part due to the fact that it helped linguists and anthropologists to give a scientific response to linguistic relativism. Linguistic relativism, which originated with the work of Herder [1772/2002] and von Humboldt [1820/1997] came to prominence through the work of Edward Sapir [1985] and his student Benjamin Lee Whorf [1956]. Linguistic relativism, today often referred as "the Sapir-Whorf hypothesis", is the thesis that the semantic structures of natural languages are incommensurable.[4] According to an extreme view of linguistic relativism, there is no way for speakers of different languages to have converging views on reality because each language structures reality in its own way.[5] In the challenge raised by linguistic relativism, colour naming has played a central role by providing linguists with abounding cross-cultural data. Because nothing in the physical reality can justify segmenting the colour spectrum into categories, the relativist assumption is that different languages deploy very

[4] Whorf tells us for example that: "We dissect nature along lines laid down by our native languages. The categories and types that we isolate from the world of phenomena we do not find there because they stare every observer in the face. [...] We cut nature up, organize it into concepts, and ascribe significances as we do, largely because we are parties to an agreement to organize it in this way - an agreement that holds throughout our speech community and is codified in the patterns of our language" [Whorf 1956: 214]

[5] According to Lucy, Whorf's view has been abusively assimilated to "a "prisonhouse" view of language in which one's thinking and behavior is completely and utterly shaped by one's language" [Lucy: 1992].

different systems of colour naming and that different cultures partition the colour spectrum in dramatically different ways.[6]

In 1969, Berlin and Kay argued, against the Sapir-Whorf hypothesis, that colour categories across different cultures are not incommensurable. Relying on an extensive data collection across ninety-eight languages, they claimed that colour categories converge universally to shared basic colour categories. Contrarily to the relativist assumptions, the comparative colour naming survey of Berlin and Kay showed that the partitioning of the colour space by linguistic categories could be accounted for by universal principles.

Soon enough Berlin and Kay's powerful linguistic theory of colour categorization has been linked to theories about colour perception, and in particular to Hering's colour opponency model. In 1878[7] Hering hypothesized that colour vision was based on four chromatic and two achromatic elementary, or unitary, colour perceptions (*Urfarben*) organized in two opponent processes (red vs. green and yellow vs. blue) and one non-opponent process (black vs. white). Hering's evidence for his opponent process model is essentially phenomenal in the sense that a colour is considered to be elementary if it is not experienced as a mixture[8] and colours are said to be opponent just in case they are mutually exclusive.[9] In 1978, Kay and McDaniel argued that the most basic universally colour categories distinguished by Berlin and Kay were identical with Hering's six primaries, while all other colour categories were supposed to be fuzzy set recombination of those six unitary hues. Except notable criticisms[10] and developments[11], current works in colour categorization continue to share Kay and McDaniel insights and consider Hering's primaries to be the most likely universal foundation for colour naming across

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[6] See e.g. Boas 1911; Hoijer 1954.
[7] Hering 1920/1964.
[8] According to Hering [1920/1964] and contrarily to Helmoltz [1924] trichromatic model, yellow for example cannot be a mixture because the sensation of yellow is elementary.
[9] For instance, blue and yellow are said to be opponent pairs because "Yellow can have a red or green tinge, but not a blue one; blue can have only either a red or a green tinge, and red only either a yellow or a blue one"
[10] See Saunders 2000; Saunders & van Brakel 1997; Jameson & D'Andrade 1997; Mausfeld 1997; Roberson, Davies and Davidoff 2000.
[11] See Regier, Kay & Cook 2005.

cultures. Whereas it seemed that segmenting the colour spectrum into categories could not be derived from the physics of light or coloured objects, human colour perception, and in particular Hering's model of colour vision, seemed to offer a straightforward explanation of the universality of colour categories. Contrary to the previous relativist tradition, colour naming was not supposed to result from arbitrary internalized categories, but rather to be caused by innate perceptual processes.

While much research has been conducted in order to provide empirical data to confirm Hering's opponency model[12], Hering's fundamental assumptions about colour experiences have never been closely scrutinized. What was presupposed by Hering, and what seems widely assumed to this day, is that colour composition and the distinction between unitary and binary colours are accessible through visual colour experiences and can therefore be exploited by observers to differentiate and categorize colours. In particular, if Berlin and Kay's distinction between basic colour terms and non-basic colour terms is supposed to be explained by colour vision, it is because linguistic colour categories are supposed to reflect some basic facts about colour *experiences*. For example, Hardin asserts:

> It should now be apparent that, far from language carving out categories from a structureless colour space, the basic linguistic categories themselves have been induced by perceptual saliencies common to the human race [Hardin 1988: 168]

Universalism about colour categories which emerged from cross-cultural studies in colour naming research has therefore been connected to Hering's opponent theory of colour vision through the following two assumptions:

[12] See Hurvich & Jameson 1957.

- universalism of colour categorization is explained by universalism of colour vision[13]
- Hering's opponent processes in colour vision are detectable through colour experiences.

To put it roughly, the traditional universalist view about colour categorization is that people categorize colours in almost the same way, because they perceive colours in approximately the same way.[14]

Contrarily to this general picture, and following recent studies in colour naming research and psychology, I will claim that there is no evidence for a distinction between unitary and binary colours *at the phenomenal level*. I will argue in particular that experiments in colour vision alone do not support Hering's distinction between unitary and binary colours and that it is only by using pre-established colour categories that colours are divided into unitary and binary colours. If this general approach is correct, then universal colour categorization, as well as colour lexical distinctions, is not directly supported by the structure of colour experiences but should receive a different explanation than the one provided by the phenomenalist view on colour categorization.

II. The phenomenal evidences for the unitary/binary colour distinction

Colour categories group together different colours and colour experiences. But according to the Berlin and Kay's tradition, colour naming does not rely on colour similarities only. Among the colour relations allegedly necessary to explain colour naming across cultures,

[13] The original view of universalism about colour categories, defended by Kay and McDaniel 1978, was that universals in colour naming could be explained by neurological properties of the visual system. Since several studies in neurophysiology [Abramov 1997; Abramov and Gordon 1994; Derrington et al. 1984] concluding that there is no evidence for a biological basis for Hering's oppency model, most universalists (see for example Kay and Maffi 1999: 746) take "universal constraints on colour naming to be based on presumed universals of colour appearance – for example, on opponent red/green and yellow/blue phenomenal channels – but on no specific neural substrate, retinal, geniculate, or cortical." [Kay 2005: 40].

[14] Or as Pinker put it: "The way we see colours determines how we learn words for them, not vice versa." [Pinker 1994: 63].

colour composition plays a major role. The term color composition refers to the assumption that some colours or colour experiences can be analyzed into combinations of other, more basic, colours. Oranges, for example, - according to the prevailing view - seem to be both reddish and yellowish and purples seem to be both bluish and reddish. In contrast, there are particular shades of red, green, blue, and yellow which appear not to be composed of any other colours, or so it is commonly assumed.. Talk of colour composition relies therefore on a distinction between the "pure" colours, called unitary colours, and all the other colours which are assumed to be composed and called "binary colours".

Although the idea of colour composition is very old and can be traced back to antiquity, it is only with Hering that a consensus regarding the number and the choice of the unitary colours has emerged in the scientific community.[15] Hering justified the existence of six elementary colours by claiming that our visual system involves three opponent processes: one for red-green, one for yellow-blue, and a third, qualitatively different from the first two, for black-white. According to Hering and most colour specialists, the distinction between unitary and binary colours is primarily phenomenal.[16] But how do unitary colours appear in experience and is there any evidence for a phenomenal distinction between unitary and binary colours?

The distinction between unitary and binary colours has been approached in the scientific literature in basically two types of studies: colour naming and cancellation experiments. The colour naming approach to unitary colour determination relies on direct introspection and asks observers to describe colour samples by assigning a percentage of a limited set of colour terms. Cancellation experiments on the other hand rely on psychophysical measurements of Hering's opponent processes. As we shall see, these two types of studies mirror in fact the two major claims hypothesized in Hering's opponent colour

[15] See Dinah Gross (2009) and Martine Nida-Rümelin (2009) for an extended presentation of the various meanings of "primary colours" through history
[16] *Ibid.*

theory: first, there are only six colours that are perceived as “pure” or unitary; and, second, the six unitary colours organized in opponent pairs are sufficient to derive any other colour that we can experience. Contrary to what is usually assumed in the literature, I will claim that these experiments about unitary colours *do not show* that the unitary/binary distinction is a phenomenal distinction.

The colour naming test developed by Sternheim and Boynton [1966] is the most well-known psychophysical method for assigning uniqueness to a colour. Its goal is to identify the unitary colours by determining which colour terms are necessary and sufficient to describe the complete spectrum. In this test, the subject is asked to describe the appearance of coloured samples by assigning percentages from a specified set of colour terms. If a colour term appears to be both necessary and sufficient to describe a range of colour samples, the colour is classified as unitary. Thus, according to Sternheim and Boynton, the term ‘orange’ for example is unnecessary, since subjects are able to describe an orange-looking stimulus entirely in terms of yellow and red, whereas, on the contrary, stimuli appearing yellow cannot be described by any other term than “yellow”. With this method, ‘red’, ‘yellow’, ‘green’ and ‘blue’ were proved to be both necessary and sufficient for the description of any perceived spectral colour.

But as stressed by Saunders and van Brake [1997: §4.2] asking the observer to use specific words to describe perceived colours tells us more about his mastery of colour vocabulary than about the phenomenal content of his perception. The problem is that the task of describing colour appearances by using colour terms is constrained by the culture’s consensus about colour terms. Far from being a test about the phenomenology of colour perception, colour naming experiments can be considered as a test about our colour naming structure. More generally, it seems doubtful to use verbal reports to study the particular properties of colour experiences, because there seems to be no congruent correlation between the way subjects use colour terms and the way they perceive colours. Various studies[17] show that subjects who classify colours in similar ways can nonetheless have very different colour experiences. The most remarkable example is certainly the case of protanopes who can learn to use the term “red” even if they are quite insensitive to the red end of the spectrum. Although similarity tests show that protanopic colour experience differs dramatically from normal trichromatic colour experience, some protanopes exhibit a colour naming behaviour that would not distinguish them from normal trichromats. [18]

If colour naming technique cannot demonstrate the phenomenal reality of the unitary colours, is the cancellation method used by Hurvich and Jameson more promising? Hurvich and Jameson’s experiments are founded in Hering’s opponent process theory which states that the human colour vision system operates with three independent opponent processes: red-green, blue-yellow and white-black. The basic idea behind Hurvich and Jameson’s experiments is that opponency prevents both members of any opponent pairs to appear as “mixed” together: there are for example no reddish greens or yellowish blues.[19] When blue and yellow lights are mixed together they produce white and not bluish yellow, because blue and yellow cancel each other. If one starts with a mixed colour, like orange, it is therefore possible to mix orange with a unitary blue to cancel out the yellow component and obtain a pure red. This is the basic idea of Jameson and Hurvich’s cancellation experiments: the strength of the cancelled colour component is determined by the amount of the cancellation colour used to reach the equilibrium of the opponent system.

The cancellation method is used to obtain the curves representing the colour opponency system. The first step when using this method is to identify for each observer their unitary red, green, yellow and blue. Then monochromatic lights are presented one after the other and the observer is asked to cancel out one of the perceived colours if the wavelength is

[17] Cf. Shepard and Cooper 1992; Jameson and Hurvich 1978.
[18] Cf. Jameson and Hurvich 1978.
[19] It appears however that in the occidental population many people consider green as composed of yellow and blue.

not already a unitary colour. So, for example, when the observer is presented with an orange patch of light, he is instructed to cancel out the yellow component by using the unitary blue that has been formerly identified. The cancellation is total when the blue-yellow opponent system reaches the equilibrium, which is when unitary red is perceived by the observer. The amount of blue used to reach the equilibrium can then be taken as an indicator of the strength of the yellow component contained in the initial orange.

The cancellation experiments cannot however provide any empirical evidence for the phenomenal reality of the unitary/binary distinction because they rely on a *a priori* choice of the unitary colors. In order to be able to conclude for example that the yellow component of a perceived orange has been cancelled out, one must first acknowledge the existence of a unitary red which guarantees that the equilibrium has been reached. For this reason, it is unwarranted to say that the existence of Hering's opponent systems has been confirmed by Jameson and Hurvich's cancellation experiments.

The mere fact that there is a systematic pattern in the way colours change cannot support the hypothesis that there is a phenomenal distinction between unitary and binary colours or the fact that apparent colours are generated by Hering' antagonistic processes. In fact, there are as many different systematic patterns in additive colour mixtures as there are choices about what lights are first singled out and then used to perform the experiment. Take for example a green patch of light projected onto a white surface. If one add a blue light to a green light it turns into cyan. One could therefore argue from this experiment that green is a binary colour and that adding a blue light cancels its yellow component out yielding the coloured beam of light to appear cyan. One could also argue, as pointed out by Abramov and Gordon, that cancellation experiments show opponent processes to be chartreuse-violet and teal-cherry:

> hue cancellation studies demonstrate that hue is organized in opponent fashion: any stimulus that elicits some sensation of G can be added to one eliciting R in order to cancel R…However, there is no obvious a priori justification for these precise axes; the axes might be chartreuse-violet and teal-cherry. [Abramov & Gordon 1994: 468]

What is problematic about the cancellation tests is the preliminary choice of certain hues used for cancellation. What these experiments really show is that Hering's distinction between unitary and binary colours is compatible with the way we perceive additive colour mixing.[20] But this is of course true of many alternative theories, including theories which deny that there is any phenomenal difference between unitary and binary colours. According to a theory that denies the theoretical distinction between unitary and binary colours, the cancellation experiments only show that systematic changes in the spectral composition of lights can be correlated with systematic changes in the colours perceived by a given observer. In other words, the cancellation experiments presented above shows that by adding a light perceived as blue in isolation to a light perceived as orange causes the perceived orange light to shift from orange to red and conversely that adding a light perceived in isolation as orange causes a blue light to shift from blue to red. But if cancellation experiments do not provide any decisive evidence for the claim that there is some yellow component in orange, why is this way of talking abundantly used in colour science and in every day life? Is the difference between unitary colours and binary colours not obvious?

One can argue that although there are no uncontroversial empirical evidences for the unitary binary distinction, the phenomenal evidences are undisputable: the way unitary colours look to me is different from the way binary colours look to me because when I

[20] In fact, as noted since 1907, Hering's opponent processes are not satisfactorily confirmed by spectral mixtures. It has been observed in particular that canceling unitary red with a green light always produce yellowish appearance instead of a whitish appearance as predicted by the theory.

have an experience of unitary colour I can only distinguish one component whereas when I have an experience of a binary colour I can distinguish two components. However, introspection has been criticized for not being a reliable source of evidence for phenomenal facts.[21] One could therefore argue that the fact that most people are willing to describe their own colour experiences in terms of the unitary/binary distinction does not necessarily imply that the unitary/binary distinction is anchored in the phenomenology of colour.

It seems, moreover, that the evidences based on introspection are not as uncontroversial as they appear at first sight and that a careful examination of the character of one's own experience shows that the appearance of binary colours does not really differ from the appearance of unitary colours. The claim that a colour is binary seems to imply that a binary colour is complex in the following sense: when in a unitary colour we can distinguish only one component, in looking at a binary colour we can differentiate two components. The experience of a binary colour would therefore seem to be more complex than the experience of a unitary colour. But, contrary to this supposition, it seems difficult to hold that experiences of binary colours are somewhat more complex than experiences of unitary colours

Consider an analogy with shapes.

[21] See Hurlburt and Schwitzgebel 2007.

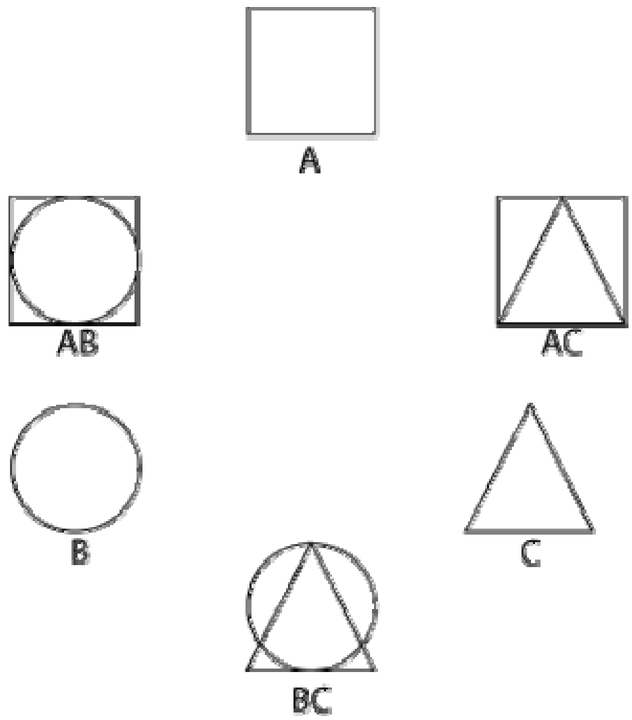

Fig.1

Although there is nothing in common between A, B and C, they share a phenomenal “simplicity” that is not present in AB, AC and CB. Inversely, AB, AC and CB share a phenomenal “complexity” which A, B and C lack. Notice that each “composed” shape bears also some resemblance relations with the “simple” shapes. AC, for example, resembles both to A and C.

In the case of the above geometrical example it seems correct to say that there is a phenomenal difference in complexity between A, B and C, on the one hand, and AB, BC and AC on the other hand. It seems clear however that there is no equivalent difference in complexity between binary hues and unitary hues in the case of colours. With respect to simplicity, colours seem in effect to be all alike. As often stressed by philosophers, all colours appear to be “simple” and “unanalysable”. [22] Colours can be said to be unitary or

[22] See Locke 1689: Bk II, Ch. II, par. 1. See also Hume 1739/1983: Bk. I, Pt. VII, footnote.

binary, but introspection does not seem to confirm a corresponding distinction at the level of colour experiences. Of course, it could be argued that the distinction between unitary and binary colours does not imply any difference with respect to the complexity of colour experience, but such a claim would require a clarification of the notion of colour composition at issue in order to make it understandable in what sense one can say that a composed colour is not more complex than a pure colour.

III. The phenomenal evidences for colour composition

We have seen so far that there is no evidence for a phenomenal difference between unitary and binary colours. In other words, it appears that there is no evidence that observers can distinguish on the basis of their colour experience alone which colours are unitary and which colours are binary. What I would like to examine now are the possible phenomenal evidences in favour of colour composition itself. In other words, I would like to investigate the reasons given to say that a given colour is said for example to be composed of blue and red instead of violet or orange. I would like in other words to consider in what way colour composition is supposedly given in colour experience. However, to address this issue, we must first ask: what is “phenomenal colour composition”?

“Composition” is generally used in mereology to express the relation between the components and the whole they compose; where “components” are the parts available as individual units, regardless of their interaction with the other parts of the whole”.[23] A heap of rocks is for example composed of rocks and a sentence is composed of words.

If we follow this practice, colour composition should be understood as the relation between a binary colour and its chromatic parts. But as stressed for example by Hardin,

[23] Varzi 2003.

there is no clear sense in which we can say that a binary colour has parts. To circumvent this difficulty Hardin proposes to understand colour composition not in terms of mereological relation, but in terms of a vector:

> There seems to have been tendency to think that if colours are analyzed they are analyzed into parts, whereas we might better think of them as being, like vectorial quantities in physics, analyzable into components. A component of a vector is not part of a vector. [Hardin 1988: 43-44]

The image of vectorial decomposition is different from parthood relations, but it is not clear how talk about vectors can help us to have a better understanding of colour composition and how it is accessible in colour experience.

Colour composition is expressed in terms of relative proportion: a given composed colour Cc is equivalent to a certain amount of colour C1 and colour C2. A common way to express colour composition is to give the relative proportion of a shade's components (a given shade of orange can be for example 60% red and 40% yellow) or to express colour (di)similarities by comparing the amount of a shade's components: a given chip of orange can have for example, more "red" or less "yellow" than another. What these examples show is that colour composition seems to involve quantity. But, as expressed here by Byrne & Hilbert, talking about the quantity of a property seems quite problematic:

Red, yellow, green, and blue are properties, and it does not make any sense to say that one object has more of a property than another object, or a relative amount of a property. An object either has a property or it doesn't. [Byrne & Hilbert 2003: 14]

Assigning quantities to colours becomes more plausible if colour composition is considered as some kind of mixture. Unlike composition, mixture involves transformation and quantity. When one adds some milk to a cup of black coffee, one gets a cup of coffee-and-milk. Coffee-and-milk is not black coffee plus milk, it is a new beverage obtained by mixing black coffee and milk. Coffee-and-milk is no longer black coffee and no longer milk. By mixing the ingredients, one transforms the initial ingredients and obtains some new substance. Quantity plays an important role in mixture because the result directly varies according to the relative proportion of the ingredients. A mixture can be, for example, a medicine or a poison according to the relative proportion of the active ingredient it includes.

Many authors have tried to explain colour composition in terms of mixture. Michael Tye for example proposed to give an account of colour mixing in terms of physical colour mixing:

> As for the binary-unitary distinction, it can be preserved as a basic truth about colour mixing. Orange, for example, is the colour you get when you mix red and yellow pigments. These facts are arguably facts we have learned from training, not facts given to us in our colour experiences and extractable from them without any basic lessons or art classes on the various colours and their relationships. [Tye 1995: 148]

Colour composition accounts in physicalist terms have been strongly criticized because predictions based on such accounts are wrong.[24] According to the physicalist account, green is a mixture of blue and yellow in exactly the same sense in which orange is a mixture of red and yellow. But this result clearly contradicts the fact that most observers consider green to be a unitary colour. Conversely, some colours which can be obtained by mixing different pigments are not considered to be composed in a similar way. Painters for example can mix orange and green pigments to get yellow or blend green and red pigments to get grey, but neither yellow nor grey are considered to be composed of green. Lack of parallelism between physical colour mixing and colour descriptions in terms of colour composition has favoured a phenomenalist interpretation of colour

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[24] Cf. Hardin 1988: 43; Byrne 2003: n.38.

composition which claims that the way colours are described is not anchored in the way colours are physically generated, but in the way they appear in colour experiences.

The phenomenalist is right in stressing the fact that colour composition cannot be accounted for by physical colour mixture. However, from the fact that colour composition cannot be equated with physical mixture, one cannot conclude that colour composition is phenomenal. It is possible for example to home colour composition in language rather than perception. And in fact a lot of empirical evidence seems to point in this direction. First, contrary to what has often been claimed, there appear to be many inter-linguistic as well as intra-linguistic discrepancies about colour categorization. If access to colour composition was essentially perceptual, one would expect those distinctions to be universally shared. Take for example, the blue and green categories. If blue and green are unitary colours, one expects blue and green to be categorized in different categories because blue and green enter as components of different colours. If the quadripartite division of colours is valid, lime contains green but no blue and violet contains blue but no green. Recent works[25] show however that on the contrary many languages do not have separate terms to designate “blue” and “green”. In Berinmo for example green and blue are grouped under a GRUE category called nol. If colour composition characterizes the way we perceive colours, we must conclude that the Berinmo lack the linguistic tools to describe their phenomenology, while English speakers are better equipped. But there are also notable differences among English speakers which seem to undermine a phenomenalist view on colour composition. According to colour-naming studies, many English speakers consider green to be a combination of yellow and blue[26], whereas brown is rarely considered to be a combination of yellow and black. Those cases of course do not constitute a devastating objection to the phenomenalist view on colour composition, because the phenomenalist could claim for example that there are phenomenal differences among subjects or that observers can be wrong about their own experiences. However, I would like to show that there is a different approach to colour composition which is

[25] Jameson 2005a; Roberson, Davies & Davidoff 2000; Kay & Regier 2003.
[26] One famous example is Brentano who defended the view that green is phenomenally composed of yellow and blue against his contemporaries. For a careful and critical presentation of Brentano’s arguments, see Schnetzer 2005.

worth exploring because it has the advantage of explaining many of the difficulties and the controversies related to the question of colour composition and the selection of unitary hues.

I have argued that there is no phenomenal evidence for colour composition or the distinction between unitary and binary colours. However, it appears undisputable that describing orange as a mixture of yellow and red is acceptable, while talking about a shade of red as being a mixture of purple and orange is not. As stressed by Broackes, the use of any alternative colour system appears impracticable:

Is the choice of red, green, yellow, and blue as unitary and basic terms of classification an arbitrary one? Could we have done just as well, for example, with lime, purple, orange, and teal?
Suppose we imagine a colour classification system based on those four. What would be involved? Some shade of orange would need to strike us as unitary and pure – containing no hint of red or yellow, or any other colour. Similarly, teal would have to seem free of any hint of blue or green. What we now see as unitary blue we would have to see as containing purple and teal. We would need to be able to understand instructions like this: “Take this yellow patch of light, cancel the orangeness in it with as much teal as it takes, until you are finally left with the pure lime that is its other component.” It is, I think, no mere accident of the 20th-century American English that we find it hard to imagine using these four hues in the way described. We might write the specification of a language for talking of colour in this way, but is it a language we could learn to speak? [Broakes 1997: 183]

If there is no reason other than conventions to categorize colours, why does an alternative colour system appear to be wrong and even impossible? Is the apparent naturalness which goes with our use of Hering’s colour system not evidence in favor of the view that Hering’s unitary colours are rooted in our colour experiences?

Even though there is a strong tendency to assimilate the feeling of the “naturalness” of our colour system with the fact that it is rooted in experience or in our biological makeup, I would like to argue that internalized conventions can provide the same feeling. My claim is that the apparent appropriateness or naturalness of colour descriptions in terms of Hering’s unitary hues is not incompatible with a conventionalist approach to colour categorization.

To illustrate this view, I will present an analogy with temperature perception. The analogy is designed to fulfil two purposes: it should make the thesis intuitively clear and it should also provide some intuitive support. Like temperature experiences colour experiences cannot be differentiated by their complexity. Like in the temperature case, the recognition of amounts of redness cannot and should not be explained by the assumption of the presence of redness as a phenomenal component in the perceived colour. The temperature case will help to understand the view I propose about how particular colours are singled out and used as landmarks in colour identification. It will also clarify the role played by mixture in colour categorization and it will illustrate how arbitrary colour categories can be internalized. Furthermore the analogy will illustrate that we cannot conclude from our capacity to recognize a certain amount of redness and a certain amount of blueness in a particular colour that red and blue are somehow phenomenally ‘contained’ to a specific degree in the resulting colour.

IV. Mixing water and mixing colours

Imagine you are diving in a tropical sea. The water is clear and you can admire wonderful fishes and colourful coral reefs. Continuing your descent, you dive deeper. Slowly, light diminishes and the colours vanish until there is only darkness surrounding you. You’ve left the visible world…

What are your perceptual experiences in the darkness of the abyss? We can suppose there is not much to be seen, heard, tasted or smelled. Your perceptual experiences are reduced to the awareness of your body and the perception of the water enwrapping you. Now, your skin is your only sense organ and the water the only external reality to be sensed. As poor as it can seem, your perceptual universe is not empty. Your perceptual experiences can vary according to the changes of the water's temperature, current or viscosity.

Suppose now that you want to order your different experiences according to the temperature of the water that you perceive. It would be quite natural, I suppose, to graphically represent their ordering using a straight line extending from the coldest to the hottest experiences. The ordering is apparently easy and straightforward. However, to order experiences of temperature one must be able to compare the experiences at issue and this comparison can be quite difficult according to the circumstances. Suppose for example you took a warm bath yesterday and wondered if it was the same temperature as the bath you took a week ago. How can you make this comparison? It seems quite difficult because your memory is not perfectly reliable and the absence of an external standard makes the comparison uncertain. Suppose now that the plumbing of your house is archaic and that the only way to have tepid water is to mix a certain quantity of cold water at a fixed temperature C with a certain quantity of hot water at an invariable hot temperature H. Although not very convenient, this plumbing system provides an unexpected way to measure the temperature of the water in your house. With time and practice, you would know the relative proportions of hot and cold water needed to obtain water at a given temperature. In this manner comparing the temperature of the bath you took yesterday and the temperature of the bath you took last week could be performed through the comparison of the relative proportions of cold and hot water needed to obtain the temperature of both baths.

Although the tepidity of your bath is the result of mixing hot and cold water of determinate temperatures C and H, the exact same temperature of your bath could be obtained by mixing water of different temperatures. The practical choice of choosing C and H as the external reference should therefore not hide the arbitrariness of the choice. Water temperature could in effect be measured in the same manner by using reference temperatures other than H and C. Despite the arbitrariness of the measurement method, one can, I believe, easily imagine that this method, if regularly used, could be internalized and become a second-nature for estimating the temperature of water. Now, let's leave the abyssal darkness and let's surface to the world of colours.

Experiences of colours, like experiences of temperatures, can be ordered. But the task seems much more complex. Unlike experiences of temperature, there is a multiplicity of similarity relations between each pair of colours. Two colours can resemble each other according to their lightness, saturation, hue, glossiness, fluorescence, etc. I will defend the view that the complexity of colour similarity relations explains why some colours are singled out as unitary colours. I will maintain in particular that the distinction between unitary and binary colours result from the way we refer and classify colours and colour experiences and that the way we refer to colours and order them is not constrained by the nature of colours or colour experiences only. Contrary to what has been widely assumed, the fact that orange is steadily said to be both reddish and yellowish in not rooted in the phenomenology of colour experience, but in the fact that a given shade of red and a given shade of yellow can be used as references to locate orange in the complex web of colour similarity relations. To understand better how some colours can be used as referential landmarks, I propose to return to the analogy of the bath given above.

Suppose for example that the temperature of the bath has been obtained by filling the bathtub with 25% of hot water at a temperature H and 75% of cold water at a temperature C. It certainly makes sense to say that we could judge that the temperature of the bath corresponds to 25% of water at temperature H and 75% of water at temperature C, but it is very doubtful to say that, by touching the water of the bath, we experience the two quantities of water initially added to obtain the water of the bath. The tepid temperature of the bath T does not appear to be composed in any way. When I immerse my body in the water at T, I do not have a phenomenal access to the water at C and the water at H used to fill my bathtub. What I feel is simply the temperature T of the result of mixing some water at C with some water at H. Phenomenally, the temperature of the water of the bath does not appear more complex than the temperature of the water used to fill the bath initially. The felt temperature of the water of the bath and the felt temperature of the water used to fill the bath are different only in degree.

My proposal is to describe colour composition in a similar way. Judging that a given orange patch is 25% red and 75% yellow is not determined by the phenomenal presence of any red and yellow component. An orange patch does not look in any way more complex than a pure red patch or any other coloured patch. Like in the water example, red and yellow are not phenomenally given in the perceptual experience itself but can be used as references to describe actual experiences of orange. Yellow and red are not therefore contained in orange or in the experience of seeing an orange patch as suggested by the phenomenalist view of colour composition. They are stored in memory and used to locate colours, like orange, in the colour spectrum. Referring to some arbitrary colours can greatly simplify the task of ordering colour experiences and identify colours. We can in effect discriminate around ten million different shades of colour, but we are almost unable to reidentify a particular colour shade.[27] Our inability to directly identify or reidentify colours among the tremendous richness of possible colour experiences can be partly overcome by comparing our colour experiences with some particular colours used as landmarks. This is the reason paint companies provide colour charts of various shades. The fact that those colours are externally accessible like in Pantone® colour charts for example or internally accessible like in memorized experiences of “pure” red, yellow, blue, green, black or white does not make any relevant

[27] Raffman 1995.

metaphysical difference. Being able to identify and reidentify colours by comparing them with some particular colour used as references is certainly remarkable. However there is no good reason to consider those referential colours to be metaphysically or phenomenally different from the other colours. Their distinctiveness among the plethora of colours is essentially linked to the role they play in our cognitive access to colours and colour experiences. Like in the bath example, the fact that we can use water at temperature C and H to compare temperatures does not make the temperatures C and H ontologically, phenomenally or biologically different. Other colours could have been chosen to play the referential role played by yellow, blue, green, white and black in our colour system, but it does not imply that the choice is fully arbitrary. It could be the case that the colours chosen to play this role have some specificity.[28] However, the fact that some characteristics could have guided the choice of those particular colours does not imply that no other colours could have played the cognitive role at issue.

It is also important to notice that once a particular referential system has been established, it becomes so “natural” that any other referential system seems impracticable. Once again, imagine you’ve learned to estimate the water temperature in terms of the relative proportion of water at temperature C and water at temperature H. It would seem impossible for you to estimate the water temperature in using completely different referential temperatures. In the same way, to use any other referential colours to describe or identify colours can seem impossible.

It appears that the example of the bath exhibits many resemblances with the way we use referential colours to identify and classify colours. However, we can question how far the analogy goes. In particular, we can wonder if colour “composition” could be derived from

[28] Recent studies offer a new perspective on cross-cultural colour categorization and naming. Rather than founding universality of colour categorization on pan-human colour vision mechanisms, they argue that universality in colour categorization and naming emerges from cognitive universals and socio-cultural evolutionary processes. Jameson [2005c] argues for example that universality in colour categorization can be accounted from a purely pragmatic approach based on individual cognitive strategies (explaining, for example, how dichromat observers can communicate with the majority of trichromatic individuals) and social constraints aimed to optimize interpersonal communication.

some physical mixture. Remember that in the example of the bath, mixing water at given temperatures allows the subject to build a temperature scale expressed in terms of the relative quantity of water at temperature C and H needed to obtain water at temperature T . In the colour case, one can wonder if some similar colour mixing can explain our ability to judge the relative proportion of “pure” yellow and “pure” red needed to obtain a given shade of orange. One can wonder in particular if the relative proportion of red and yellow identifying a particular shade of orange by a given observer can systematically be correlated to the relative proportion of a given yellow paint and red paint necessary to obtain this particular shade of orange. It should be noticed here that most objections against the assimilation of colour composition with physical colour mixture do not affect the present account. The fact, for example, that some particular shades of grey can be obtained by mixing red and green has been alleged[29] to refute accounts of colour composition in terms of colour physical mixing, because, unlike its physical composition, a given shade of colour, like grey, never looks to be composed of green and red. As discussed earlier, the present proposal denies that colour composition is phenomenal. It cannot therefore be affected by the claim that grey is phenomenally composed of black and white and not of red and green. According to the present account, we simply do not see whether some particular shade of grey is or is not composed of red and green, what we see is just a particular shade of grey.

But why is grey described as being whitish and blackish and not reddish and greenish? If colour mixture plays a role in classifying colours, why is green and red not used to identify shades of grey? I have claimed that the choice of primary colours is not only rooted in colour phenomenology but that linguistic conventions and pragmatical constraints play a major role in the way we refer to colors. According to this analysis, the way a particular shade has been obtained by colour mixing is irrelevant to the way we refer and describe the colours we perceive. And if the present account is correct, the choice of red, yellow,

[29] *Cf* Nida-Rümelin & Schnetzer 2004.

blue and green is partly arbitrary and could be replaced by other colours, like for example, cyan, magenta, yellow and black.[30]

However paint mixing can provide a method for comparing colours. Like with the example of the bath, variations of colours can be captured in an economical way by referring to the relative proportion of the ingredients entering a mixture. We learn to compare shades of orange by the way we combine red and yellow paints. We say that a shade of orange is more reddish than another, because we know that to obtain that particular shade by using red and yellow paint, we should add more red paint. It is however not necessary once we've learned this way of identifying colours, that the shade we perceive is actually obtained by the mixture of the colours used for its identification. As with the bath example, once we have learned how to estimate the temperature of a liquid by reference to a relative proportion of water at C and H, it is possible to use the same method to estimate the temperature of a liquid whatever its actual mixture is. If the present account is correct, the role of paint mixing is therefore restricted to setting up a comparison scale and learning how to use it.

The unitary/binary distinction has raised various philosophical controversies. Philosophers and scientists have fought over the number of primary colours or the question whether green is unitary or binary.[31] If the present account is correct, all these controversies miss the point, because the unitary/binary distinction does not concern colour phenomenology, nor colour ontology. The unitary/binary distinction is an epistemological tool built to identify and describe the variety of colours. As a tool, the only thing that matters is its effectiveness. As long as its efficiency is guaranteed, variations among subjects can be tolerated. If some people take green to be a unitary colour, whereas others consider green to be a binary colour, it's probably because it does not

[30] The present proposal predicts that people working in the printing industry who daily use four inks - cyan, magenta, yellow and black to reproduce the whole colour spectrum, will be disposed to describe colours in terms of the relative proportion of those four inks. An interesting experiment would therefore be to determine if red, which can be obtained by mixing magenta and yellow inks, is "perceived" as a primary colour by printer and graphic designers.

[31] *Cf* Schnetzer 2005.

affect their capacity to identify colours. Using a thermometer whether in Celsius or Fahrenheit can both help us to select the right temperature of our bath, provided we have some familiarity with the scale we use.

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