I. GENERAL REMARKS

Introduction

The aim of this essay is to demonstrate that the ’grammar’ of our colour descriptions involves complexities that would fall outside the scope of any wholesale reduction of colour concepts to physical concepts. More accurately, colour descriptions involve several ’grammars’ that are, in characteristic ways, linked to other features of our lives in a three-dimensional and materially heterogeneous environment. Any one reductive account, if successful, could only reproduce the behaviour of colours in a specific context. There is room for accounts of colour in terms of physics, but then for purposes belonging to a scientific, not metaphysical, enterprise.

1 This draft is called ’a new try’ because my earlier attempt to address this topic was ’diverted’ to a discussion of Wittgenstein and Lichtenberg and published as ”Wittgenstein on Colour Geometry and Colour Perception” in Gefwert & Lagerspetz (eds), Wittgenstein and Philosophical Psychology. Essays in Honour of Lars Hertzberg, Uppsala Philosophical Studies 55, Uppsala 2009.
One might think that the reduction of colour into physical properties is at least under its way if law-like correspondences can be established between specific colours and specific physical properties. My point is that this would leave the main difficulty untouched. The difficulty about an all-embracing physicalist account is not one of identifying physical correspondences for individual colour samples, but that of isolating the general class of ‘colour phenomena’ that could be brought into law-like relations of correspondence with a specified class of ‘physical phenomena’.

Colour judgments occur in two main types of context, each involving its own kind of colour discourse. Colours are judged in colour samples – for instance, the chips of a colour chart viewed in standard light. Such samples may be matched and analysed both optically and in terms of their physical properties. The sample represents a certain colour, thus what is true of perceived colour relations between particular samples will be true of colours in general. We will not only be able to say, ‘this sample looks darker than this one’, but also, ‘this colour is darker than this one’. For instance, since saturated yellow is lighter than saturated red, then also a saturated yellow sample will be perceived as lighter than a saturated red sample in normal light. – In sum, the crucial feature about the role of the sample is that the relation between its colour and its appearance is regulated since the viewing conditions are controlled.

Colours also enter our lives as the colours of objects in a three-dimensional environment, interacting with differences of illumination, shadows and highlights, and they are assessed with the general character of the relevant object in mind. There the relation between the colour of the object and its appearance to the viewer is less clear-cut. Differences between these two types of discourse introduce characteristically interrelated ambiguities in central colour concepts – for instance, ‘the same’ vs. ‘different colour’, ‘lighter’ vs. ‘darker’, ‘real’ vs. ‘apparent colour’, and ‘normal viewing conditions’.

Experimental colour research deals in part with samples and in part with environmental impacts on colour perception. Colour scientists have been conscious for a long time of many ways in which data from research on isolated samples are at variance with colour perception in a natural environment.

In philosophical literature, the ambiguities of colour are in part glossed over because of the pre-eminence of the coloured image as the model for visual perception. Realistic colour images are treated as models of what meets the eye, or sometimes, of inner visual scenes. My argument is that the picture constitutes an interface between two ways of talking about colour. The picture can either be discussed in terms of the colour properties of the surface, or in terms of the colours of the objects that make up the scene depicted. For each
part of a painted canvas, an unambiguous colour value could be determined and its physical properties could be discovered. This may lead to the false impression that the samples discourse could serve as a blueprint for an eventual complete reduction of colour descriptions to physical descriptions.

The main text of this essay will accordingly fall into three parts. After some further introductory remarks there is a description of the samples discourse, including general comments on the empirical research on samples. Secondly, there is a discussion of colour judgments of objects in a three-dimensional environment. Finally, there is a discussion of the role of the coloured image.

**Basic Empirical Facts**

Surfaces are coloured – rather than pure white – because they absorb a considerable part of the visible incident electromagnetic radiation, unlike white surfaces that reflect a comparatively larger proportion of it. Surfaces have *chromatic* colours because they absorb radiation *selectively* while pure white, grey, and black absorb, and consequently reflect, the different frequencies in equal proportions. In comparison with an achromatic surface of the same lightness, the chromatically coloured surface absorbs more of those parts of the visible spectrum that correspond to the complementary of the surface colour: blue absorbs more orange, green absorbs more red, and so on.\(^2\) Generally speaking, surfaces thus have different colours because of their different spectral reflectance distributions, or the patterns according to which they absorb and reflect various frequencies of the radiation incident on them.

While the colour of a surface is a function of what parts of the spectrum the surface absorbs, the physiological explanation of our ability to see the colours of surfaces is made in terms of what parts of the spectrum the surfaces *reflect*, since that is the light that meets our eyes. Our colour perception is due to the sensitivity of our organs of sight to its spectral composition. The two variables are obviously connected, as reflected light is simply the part of the incident light that is not absorbed. The spectral composition of the radiation that a given surface reflects at a given moment will be the function of two variables: the composition of the incident light and the tendency of the surface to absorb certain frequencies more than others.

In philosophical shorthand, perceived colours are sometimes described as depending on ‘wavelengths’. However, there is no simple correspondence between wavelength and

\(^2\) Westphal, 101-106.
perceived colour. The perceived colour of light is a result, not of the prevalence of one wavelength in it, but of its spectral power distribution, i.e., of the overall distribution of the different parts of the spectrum in the light. For instance, a yellow surface usually reflects more 'red' and 'green' than 'yellow' wavelengths. A banana that exclusively reflects the 'yellow' part of the spectrum would normally be seen as black, not yellow, as it would absorb about 96% of normal daylight. Some yellow objects reflect no 'yellow' wavelengths at all.

The same visible colour may result from different spectral compositions of reflected light. This is called **metamerism**. The appearance of a coloured surface can be matched precisely by a variety of different pigment mixtures. The spectral power distributions of the light that they reflect may be markedly different but the samples will be indistinguishable to the eye. Physiologically, metamerism is explained by the fact that the normal human retina contains only three types of cone cells, each of which is sensitive to a specific range of radiation frequencies.

In principle, any visible colour may be matched by mixing from any three pigments (with certain restrictions) applied on a white surface. This is enormously important for the graphic industries, as the number of pigments and hence printing costs can consequently be kept low. Most of the colour reproductions we see in books, photographs, and computer and television screens are metameric reproductions.

Two coloured surfaces that are metamers of each other under one illuminant may not be so under another. This is because the quality of reflected light depends not only from the reflectance properties of the surface but also from the quality of the incident light. For instance, a makeup that matches a dress in daylight may not do so in incandescent light. A growing area of research consequently concerns the effect of viewing conditions. The task is to match the perceived colours of two samples in the light that approximates the likely viewing conditions.

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3 Westphal, 88. -- Obviously, a **wavelength** has a length but no colour. Thus, for instance, the expression 'yellow wavelengths' is shorthand for the wavelengths that constitute the yellow part of the spectrum; 'green wavelengths' constitute the green part, and so on.

4 See Rydefalk & Wedin, 3.5.2 (pp. 3-7 to 3-8). On the mixing of coloured light sources, see p 3-8: "every colour stimulus can be completely matched by a trichromatic observer by adjustment to suitable levels of three fixed colour stimuli, provided that none of the fixed stimuli can be matched by the other two. All stimuli must be incoherent (so that no interference phenomena such as speckle occur), and the observer is usually assumed to have normal trichromatic vision."

5 Colour prints usually apply the **CMYK system** where Cyan, Magenta, Yellow, and Black are used. The same principle applies for computer and colour-TV images where the picture is created directly by mixing coloured lights. Light of any colour can be matched with a suitable mix of three coloured lights. Computer and TV screens use the **RGB system**, where colours are reproduced by mixing Red, Green, and Blue.
Further Introductory Remarks: the Role of Reduction

The philosophical question about the status of colours concerns the relation between these facts and our colour descriptions. Should it follow that colours might in principle be reduced to underlying physical properties, having to do with the spectral properties of light and the reflectance properties of surfaces?

I take reduction to be an enterprise that pertains to relations between descriptions. The task facing the reductionist is to show that descriptions in terms of one property can be translated into descriptions in terms of the other without serious loss of meaning. In other words, a successful reductive theory should not imply consequences greatly at variance with the observed behaviour of the original phenomenon. Otherwise the reducing description does not individuate, or 'zoom in’ on, the same phenomena as did the original description.

It may be objected that reduction is a relation that obtains between properties, not between descriptions. Thus we should not expect complete correspondence between everyday colour descriptions and the reducing physical descriptions. The reducing description should not reproduce the inaccuracies and illusions that beset our pre-scientific understanding of physical reality.

My reply is that this would still leave the question open as to the relation between the underlying physical properties and colour properties as we normally know them. If we wish physics to tell us something about reality as we know it we must address the question how physical descriptions relate to the descriptions that we would naturally make. In particular, it should lie in the interest of physics that this relation is made clear, as the whole point of physics is to enhance our understanding of our environment as we know it.

An alternative to wholesale reduction is the possibility of establishing correspondences within a circumscribed domain. In the context of certain experimental settings, colour descriptions can at present be derived from descriptions of radiation. In a sense colours, in these settings, are spectral properties of radiation (see my description below). But this does not imply that the relation is the same outside those settings. On the contrary, much of the empirical work has focused precisely on ways in which this is not the case.

II. THE SAMPLES DISCOURSE

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6 According to philosophical usage, 'physical properties' are defined as properties that have an explanatory role in physical theories. In this sense, colour does not count as a physical property even if it is, obviously, in some sense a familiar property of middle sized physical objects.
The Colour Sample

By *colour sample*, I will mean either a coloured light or a surface of unitary colour exposed to uniform light. Most of my discussion will concern the properties of coloured surfaces, but a very similar argument could be formulated by using examples of coloured light.

The important thing here is that both the perceived colour and the reflectance properties of the surface can be determined in an unequivocal way. In a given illumination, a normal human observer will perceive *this* colour chip as, say, dark blue, with specifiable values for the three visual variables hue, saturation, and lightness. The spectral composition of the light reflected from it can also be measured exactly. When the spectral composition of the incident light is known, this gives us a specification of the absorption-cum-reflection pattern of the surface. With the two sets of values thus established, it will be possible to look for law-like relations between the percept (perceived colour) and the stimulus (physical phenomena).

The experimental research discussed in these sections concerns the question how perceived colour is a function of micro-level properties of the sample. For instance, the experiments have addressed the question which of two surfaces is perceived as lighter in standard viewing conditions, and how the physical properties of the one might be changed in order to make it look the same as the other. This research is generally concerned with colour reproduction. For obvious reasons, colour reproduction plays an important role in electronic, graphic, textile, and other industries. The task is, typically, to match two samples in an optimal way, striking a balance between degree of visual equivalence and production costs.

Experimental data on relations between spectral power distribution and perceived colour are the basis of standardised representations such as the *CIE 1931 Standard Colorimetric Observer*, which makes it possible to predict the perceived colour of a surface sample from the spectral composition of the radiation that it reflects.\(^7\)

However, metamerism implies that there is no one-to-one correspondence between perceived colour and the composition of radiation. While the *same* spectral power distribution always gives the same visible colour if the conditions are kept exactly the same, but the reverse is not true. In philosophical terms, these results indicate that colour is 'multiply realisable'. The results are compatible with describing visible surface colour as supervenient on certain physical properties as long as the viewing conditions are fixed.

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\(^7\) See Rydefalk & Wedin, 3.5.2 (p. 3-7) and 3.1 (p. 3-2).
Real Colour and the Role of Standardisation

However, these results are of a local character. They presuppose standard conditions. I would argue that the significance of these discoveries does not lie in their being first, imperfect approximations of some future comprehensive theory relating ‘colour’ to ‘physical properties’. They represent solutions to specific problems, important in their own right and capable of development without committing the inquiry to any ontological position about colour. The standard conditions applied here are obviously not the usual conditions for human colour vision. The research design for the study of samples is not even supposed to approximate the conditions that obtain in most natural settings – even less, to constitute a future model for all possible cases of colour perception.

The lawlike relations reported in the CIE 1931 Standard Observer result from the following test design and from others comparable with it. The sample should be something like a chip in a colour chart: an opaque, matt, flat surface of unitary colour. It should occupy two degrees of the visual field, framed by an area of standard grey. It should be viewed in indirect light with the composition known as D65, which approximates normal daylight in Northern Europe. On the whole, the point is to establish regularities that hold when the overall role of the sample in the general visual environment is controlled. The effect is that certain questions that emerge in more complex environments will not need to be asked.

What directly meets the eye in a physical sense is the radiation a surface reflects, not the radiation that it absorbs. But if the incident light is controlled, the one measure can be directly derived from the other since absorbed radiation is simply the part that is not reflected. Thus in the context of CIE 1931 Standard Observer, perceived colours of surfaces might in principle be described in terms of both reflected and absorbed radiation.

However, in a natural environment the illumination is not fixed. Not only is there a difference between indoors and outdoors illumination, but also between daylight at different times or even moments of the day, and between illuminated and shadowed parts of the visual environment. If our perception of the colours of objects were a direct function of the light that they reflect, we would perceive them as constantly changing in colour.

Philosophically the important thing here is to see the ways in which the colour concepts used are determined by the research design; how certain distinctions that we use in

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8 Rydefalk & Wedin 3.1 (p. 3-2).
9 Rydefalk & Wedin 3.1 (p. 3-2).
10 The CIE 1964 system uses a 10º field instead, giving slightly different results. See Rydefalk & Wedin, 3.5.2 (p. 3-9).
other contexts are not applicable because of it. In particular, this is true of the distinction between real and apparent colour.

In everyday situations, we recognise the risk that the perceived colour of an object may not always be its real colour. By this we mean that we should check the object in good light, such as indirect sunlight, and that we should not place it next to other strongly coloured objects. The concept of real colour is usually defined via the concept of good light and vice versa. This is implicit in philosophical definitions of colour in terms of normal conditions; for instance, when the colour red is defined as the surface property that appears red to normally sighted human observers in normal conditions.

These complications will not arise in the research design just described, because both the illumination and surroundings are standardised. The illumination used is, by definition, 'good light', because it is in that light that the samples are to be matched. Similarly, no problem arises about the disturbing effect of the surroundings, since the standard grey around the colour chip is, by definition, a 'neutral environment'. In this way, the standard conditions are designed to make the distinction between real colour and perceived colour disappear.

The philosophical interest of this lies in the fact that results obtained in research on samples are often falsely taken by philosophers to indicate that correspondences can be established between specific colours and specific spectral properties of light. 'Colour' is here understood as being independent of the context in which it is seen. But the sample is not free of context in this sense. The research on samples represents, instead, an attempt as far as possible to control the conditions in which samples are viewed and compared – not magically to make the context go away.

III. COLOURS IN A THREE-DIMENSIONAL ENVIRONMENT

Aspects of Colour Constancy

The concepts of real and apparent colour are connected with the set of phenomena generally known as colour constancy. Our colour judgments do not slavishly follow from the spectral properties of the light that meets our eyes.

Colour constancy means that we are able somehow to discount the changes of illumination typical of most visual environments. The question is how this is possible. How does the changing radiation that meets the eyes give us information about unchanging features of objects? In part, this is a matter of identifying physiological adjusting mechanisms. But it also requires understanding the behaviour of our colour concepts.

Three kinds of phenomena are at work here.
(1) The perceived visual scene remains to some extent constant because of physiological adjustments. This involves the adjustment of the eye to lighting conditions. This always takes some time, hence we may initially experience difficulties when we move from outdoors to indoors and vice versa. (More dramatically, afterimages are unexpected side effects of physiological adjustment). This is a fairly uncontroversial class of phenomena that might be called *physiological colour constancy*.

(2) Secondly, when the visual scene as a whole has perceptibly changed, we are still able to recognise colours in the new situation. For instance, Dominic McIver Lopes prefers to speak here of *colour recognition*, not colour constancy, since we perceive *both* a general change and, simultaneously, the permanence of colours in the changed environment.\(^\text{11}\)

(3) Thirdly, when there are local changes, we distinguish between the real colours of objects and various effects of highlights, shadows and other modifications of lighting. This is an aspect of our general familiarity with three-dimensional visual environments.

Purely physiological adjustments should not be confused with the two other phenomena that should perhaps not be called adjustments at all – neither physiological nor even mental.

*Colour Recognition*

Importantly, our recognition of the constant colours of objects does not require perceptual constancy. It is possible for us, at the same time, both to recognise the original colours in new lighting conditions and to see that they look different because of the lighting. As an analogy, Lopes points out that the recognition of the permanence of physical objects does not require that objects should have the same appearance regardless of distance and perspective. On the contrary, it is important that we should be aware both of their permanence and of the ways in which their visible shapes vary when seen from different angles.\(^\text{12}\) (The concept of looking the same has ambiguities that may cause some confusion. The visible shapes of objects change as we move in relation to them. But in another sense the objects do not look changed at all. On the contrary, we see their visible shapes changing exactly because the objects do not change. If their visible shapes did *not* change as we move this would indicate that the objects are moving as well.)

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\(^{11}\) Lopes (2005) distinguishes between colour constancy and colour recognition. In his terminology, the items (2) and (3) here would count as instances of colour recognition.

\(^{12}\) Lopes 2005, 426.
When coloured light is selectively directed at a white spot, we may be fooled to think that the spot is coloured. But a general coloured illumination does not have this effect. For instance, as Jonathan Westphal points out, blue illumination in a room does not make white objects seem blue. Even under a blue illuminant, white objects will appear less blue than blue ones would do in the same conditions. In fact, blue illumination enhances the whiteness of most white objects since it cancels out the yellowing typical of many white objects.\textsuperscript{13}

What we see here is a degree of constancy in colour relations within the visual scene throughout the changes of illumination. The light reflected from each individual object displays a regular pattern in how it deviates from the colour of the general illuminant. A coloured object darkens the incident light by absorbing parts of it.\textsuperscript{14} The absorbed parts of the spectrum correspond to the complementary of the colour of the object. Thus, for instance, blue objects absorb a disproportionate amount of orange. To see the colour of an object is, from this point of view, to see the under-representation of its complementary. To express this schematically, ‘blue’ means ‘bluer than …’ (or perhaps rather ‘less orange than …’). And the general illumination gives us the point of comparison.

Lopes’ specific discussion concerns the representation of colours in realistic painting. In certain ways, our recognition of colours in a picture works analogously with colour recognition under modified lighting conditions. For various technical reasons, a painting typically cannot reproduce the full colour range of outdoor scenes. Pictures are usually hung indoors and will not be as brightly lit as the original scenes. Moreover, pigments – especially in watercolour – mostly have a narrower range of available hues than those represented in the visual environment. Pictures can rarely reproduce both the tone (brightness), hue, and saturation of the original. Instead, they tend to reproduce relations between the original colours on a narrowed-down scale. Different colouring styles opt for different ways of striking a balance. For instance, in the very usual shadowing style technically known as \textit{chiaroscuro}, the colours of surfaces are toned up with white to represent the lighter parts of the scene. Thus saturation is sacrificed for brightness. In Impressionism, shadowed parts of surfaces may instead be represented with mixtures of the surface’s complementary, thus preserving saturation but sacrificing contrasts of brightness.\textsuperscript{15} Within each style of colouring, we are still able to see the result as realistic. We judge the colouring, not through one-to-one comparisons between individual parts of the canvas and the corresponding real objects, but

\textsuperscript{13} \textsc{REFERENCE WESTPHAL.}
\textsuperscript{14} See Westphal 1991, 2, 101-108. Westphal describes colour as a certain kind of ‘shadow’ or darkening of light.
\textsuperscript{15} Lopes 2005, 421 – 422.
by comparing colour relations between real-life objects with relations that obtain within the
general colour situation of the picture.

Applying the point to colour perception in general, the constancy that we recognise in
the colours of objects is not that of their absolute colour values but that of constant relative
values. Perhaps analogously, our judgment of the size of an object is not based on the
absolute size of the area that it covers in our visual field but on its size relative to other
objects we see.

**Illustration: Coloured Shadows**
The context-dependent character of colour recognition is nicely illustrated by *coloured shadows.*

The first scientific experiments on coloured shadows were reported by Otto von
Guericke (1602—1686), physician and the burgomaster of Magdeburg, who described what
is today known as the Guericke phenomenon. Goethe discussed the phenomenon in his
*Theory of Colours*, having been made aware of it in a letter sent to him by Lichtenberg. He
includes examples of his own experimental designs.

You will easily find instances of coloured shadows in your surroundings once you
know where to look. But you can also produce them at home, quite industrially if you like.
The main principle is that two light sources of different colour should illuminate the same
area; for instance a candle (orange) and sunlight (neutral) indoors on a cloudy day. (For
variation, you can substitute electric lights, using colours of your choice). Place the candle
close to a white wall that receives indirect sunlight from the window. Place your hand
between the candle and the wall and project a shadow. Now place another hand on the other
side of the candle to cast another shadow. The two shadows should now be differently
coloured. On areas where natural light but not candlelight is blocked, the shadow will be
tinted orange, obviously due to the orange illumination from the candle. Where candlelight is
blocked but natural light is unimpeded, the shadow will be blue. Where both lights are
blocked the shadow is black.

One of the shadows thus always takes the colour of the coloured illuminant while the
other takes the colour complementary to it. What may make the result seem puzzling is that
the latter – the blue shadow in this case – represents a physical stimulus, or spectral power
distribution, that the viewer would identify as grey under a neutral illuminant. However, the

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16 An excellent modern description is included in Scientific American 1986 (Brou et al. 1986).
17 Goethe, Sämtliche Werke, 17. §§ 64 – 70 (pp 59 – 60).
orange general illumination makes the viewer expect a brownish shadow. In relation to the illuminated parts of the wall, the shadow has an under-representation of orange. Under-representation of orange equals over-representation of the complementary colour, i.e., of blue. Thus the shadow is blue because it is less orange than grey objects should normally appear in candlelight.

In a sense, this is a case where two different colour environments are superimposed on one another in an unexpected way. There are illuminants of two colours, which renders the concept of ‘ambient’ illumination ambiguous. However, the effect is simply a by-product of the general principles of colour recognition. – In an important empirical study of the topic, Brou, Sciascia, Linden and Lettvin call coloured shadows the ‘obverse’ of colour constancy.

In both phenomena the color attributed to a light is different from what it “really” is – different from what the physical properties of the light would lead one to predict. In colored shadows the identical spectral distribution (that is, the same spectral stimulus) has different colors. In color constancy different distributions have the same color.18

Thus coloured shadows and colour constancy are illustrations of the same general point. Perceived colour depends on comparisons:

the perceived colors of things in the visual world do not depend slavishly on the light from each object, sensed independently of all other things in the world, but on a comparison of the lights from an object and its surroundings.19

However, we should be aware that the blue shadow experiment is not an empirical confirmation of what has here been said about colour recognition. That point is a point about the meaning of colour descriptions, and it is fully demonstrated already in the fact that the colours of objects do not change with changes of illumination. Light of the same physical composition will be classified differently depending on the general colour situation. The blue shadow experiment is instructive, however, because it is an unexpected reminder of what is constantly before our eyes.

Does the blue shadow experiment create an illusion? Goethe includes them in his description of “physiological colours”, thus suggesting that they are caused by the eye’s

18 Brou et al. 1986, 85.
19 Brou et al. 1986, 80.
physiological adjustment. Westphal, who gives a good description of the phenomenon, similarly calls it a “physiological effect” and equates it with afterimages.\textsuperscript{20} This might suggest that the shadow is somehow not really coloured. That would downplay an important difference between the cases. Any vision obviously involves physiological adaptation. But unlike afterimages, the blue shadow does not involve a specific adaptation and hence is not to be explained in terms of it. It is an aspect of the same discounting of the general illumination that makes it possible for us to recognise blue \textit{objects} in orange light.

Brou \textit{et al.} apply the word “illusion” – in quotation marks – to both coloured shadows and colour constancy in general. But this is just their way of saying that, in these cases, we are made to see one colour although in some sense we ‘ought to’ see another.\textsuperscript{21} Such cases may simply show the limitations of received ideas about colour vision.\textsuperscript{22} Thus, colour constancy counts as illusion if colour concepts are falsely taken to apply to spectral power distributions of light regardless of the surroundings.\textsuperscript{23}

Usually, we call something a colour illusion if it makes us see (or think we see) a colour that is not there; for instance, afterimages can be colour illusions in this sense.

Brou \textit{et al.} present also an effect that \textit{would} count as illusion in the proper sense. They consider a figure where grey pigment is applied to different parts of a non-figurative picture.\textsuperscript{24} We perceive the pigment quite differently depending on the colouring of the area immediately surrounding it. For the viewer, it is almost impossible to see that the same

\textsuperscript{20} Westphal, (1991, 109-10). Nörretranders (REFERENS) thinks the experiment shows that \textit{all} colours are illusions.

\textsuperscript{21} Brou \textit{et al.} 1986, 80.

\textsuperscript{22} Brou \textit{et al.} 1986, 80.

\textsuperscript{23} Brou \textit{et al.} say “the \textit{perceived} colours of things” depend on comparisons. But is the point about the mechanisms of perception or is it about the meaning of our colour concepts? In other words: do the authors mean we perceive colours in ways that falsely suggest their independence, or do they say that colours \textit{are} to a degree independent of the light reflected from the objects? Brou \textit{et al.} do not quite specify their position. Tellingly, they call colour constancy and coloured shadows ‘illusions’, but yet consistently use the word inside quotation marks.

\textsuperscript{24} Brou \textit{et al.} 1986, \textit{passim}. 

Thus, do they think the shadow in then experiment is coloured, or just that the illumination falsely makes us think it is, despite the fact that it is ‘really’ grey?

The question whether the shadow is \textit{really} coloured is a typical conceptual question. It is not settled by collecting more data; rather one will need to specify one’s concept of ‘real colour’. In the case of tangible, three-dimensional objects we typically distinguish between their real and apparent colours. The reason is no doubt the fact that you can study such objects in various kinds of illumination. A bit of blue cardboard in orange light would look the same as the blue shadow in the candle experiment. They would also have the same colour in a photograph. But you can move the cardboard outdoors, or move a neutral light closer to it. You cannot move the shadow or study it in better light. Thus there is no ‘real’ colour of the shadow to be discovered independently of any specific illumination.

But this is obviously not the case. The spectral power distribution that represents grey in one visual environment may represent blue in another.\textsuperscript{24} Brou \textit{et al.} 1986, \textit{passim}. 

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pigment is used in the one corner where it is surrounded by orange and the other corner where it is surrounded by blue.

Brou et al. point out that also this illusion is an effect of colour constancy. One way to describe the connection is, perhaps, as follows. Looking at the nonfigurative coloured surface, we tend to understand large coloured areas occupying its different corners as coloured shadings or films laid over entire surfaces. We tend to judge the colour of the grey speck in it in terms of how it stands out from its immediate surroundings.

In this particular case it is quite correct to speak of a colour illusion, because we are made to think we see two or more different pigments instead of just one. The result is an illusion, not simply a case of recognising colours in different environments, because there is a conflict between our natural way of understanding colour relations in the picture and the implicit task that we are expected to perform.

The task is to compare different samples of pigment. In this case, the *colours* of the printed areas should be identified with the *pigments* used in printing them, not with the colours of any depicted objects. This would not be the case with a naturalistic representative picture. If we perceive two objects located in different parts of a naturalistic picture as differently coloured, despite the fact that they are rendered by using the same pigment, this is not an illusion but belongs to the ordinary exercise of colour judgment. We would not identify the colours of the objects depicted in a naturalistic picture with the pigments used in the picture.

(i.e.: we tend to look at the figure as if it was a depiction of something, i.e., of coloured objects in different kinds of illumination. But as a matter of fact it is an arrangement of pigments and the task is not to recognise the colours of depicted objects but of pigments.)

*Colour Judgment*

Colour judgment is an aspect of our general ability to distinguish between constant and transient elements of a visual scene. For instance, we can tell the difference between a shadow and a stain. When we read a book in strong daylight, the perceived difference of lightness between the parts that lie in light and the parts that lie in shadow is 9:1. This is more than the difference between black and white areas of the printed page in uniform daylight.25 In one sense of the word, the 'perceived colour' of the different parts of the page are different. We might even say that the shadowed part looks darker, but we would not expect

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25 REFERENCE BAXANDALL.
anyone to be fooled to believe that its real colour is darker. Optically (in terms of spectral power distribution of reflected light) a grey object, a white object in a shadow, and a highlight on a polished black surface are the same colour. (Technically speaking, they have the same 'aperture colour' – see below.) In another, more familiar sense they are different colours.\(^{26}\)

It would be possible for someone to dye the page – or, for instance, part of a wall – in such a way that we think we are seeing a shadow on it. This is the principle of Trompe d’oeil paintings. We recognise our mistake if we are allowed to move in the setting or to manipulate the object. Trompe d’oeil paintings do not deceive us unless we are stuck in one place.

Colour judgments of the kind that dominate in everyday life presuppose implicitly the concept of an individual object, in other words, an understanding of parts of the visual environment as relatively constant and detachable. Roughly, colour that moves together with the object is the colour of that object. Colour variations that move (to an extent) independently of the object on which they are seen, are variations of lighting conditions. Shadows and highlights indicate the shape and position of the object, but the object has its own colour, which can be studied independently of any particular lighting.

Our ability to make these judgments demonstrates that we do not, in a natural context, judge the colours of objects by seeing whether they match a timeless model where a given spectral power distribution always corresponds to the same colour. We judge the colours of objects in a context of illumination and shadows.

The same stimulus (the same quality of reflected light) is produced both by a grey object in good light, a white object in shadow, and a highlight on a polished black object. Ludwig Wittgenstein addresses this and similar cases in his Remarks on Colour, where he notes the ambiguity of speaking of 'the same colour'.

The ambiguity can be resolved with the introduction of the concepts of surface colour and aperture colour.\(^{27}\) An aperture colour appears when some part of the visual environment is viewed through an opening, or aperture. For instance, we may look at some part of the surface of a white cube through a tube of grey cardboard, which makes the object unrecognisable and blocks out any cue about the ambient light. The part of the cube that lies in shadow will have the same aperture colour as a grey wall that lies in good light. The two surfaces have different surface colours (white vs. grey) but the same aperture colour (grey).

\(^{26}\) Reference Wittgenstein.

\(^{27}\) Reference John Hyman, … .
In a conventional realistic painting or a colour photograph, the two viewed areas would be rendered with the same grey pigment. A different painting style, such as Egyptian art before the Ptolemaic period, would represent the surface colours of each object depicted, representing white objects with white and grey objects with grey.²⁸ It takes a special effort not to do this in painting.

In all judgments based on visual perception, [the elements of] judgment and perception are completely amalgamated, so that later in life we find it impossible to pull them apart again; we believe at each moment that we *see* what is really just an *inference*. This is the reason why bad portrait painters smear the faces all over with flesh colour. They can’t imagine that a human face may have blue, green, yellow, and brown shadows. And the cuffs are painted in such a spotless manner that only their placement and outline betrays that the stain of chalk that the artist has thrown there is meant to be a cuff.

Lichtenberg contrasts ‘judgment’ and ‘perception’. The homogeneity or *sameness* of two samples of white in “judgment” is contrasted with the *difference* of “perception” when we see the two samples without preconceived notions. The successful realistic painter must abstract away from his or her “judgment” and just try to see a visual pattern.

In principle, an artist could reproduce a three-dimensional scene by matching, point by point, the aperture colours of its each individual part with the colour of a pigment applied to the appropriate part of the canvas.

John Hyman (REF) argues that realistic colour images involve the matching of the aperture colours of the scene with the pigments used. As a result, the aperture colours seen on the canvas should be the same as the aperture colours in the scene:

[W]hen shading is used, the aperture colours of depicted objects are the same as the aperture colours of the parts of the painting that depict them, as long as the aperture is small enough to prevent us from seeing the ambient light in the depicted scene, and the painting itself is uniformly and adequately lit.²⁹

²⁸ Hyman, p. 675.
This principle may have to be modified in real life, because, as we have seen, a painting typically cannot reproduce the full colour scale of outdoor scenes.\(^{30}\) There is some dispute here. But the important thing is that this is the implicit ideal when colour images are treated in philosophy as the paradigm of visual perception.

IV. THE COLOUR IMAGES AS AN 'INTERFACE' BETWEEN THE SAMPLES DISCOURSE AND THE COLOURED OBJECTS DISCOURSE

(This part is not quite finished and I would very much like the discussion at the seminar to devote some time to it.)

The distinction between discourses relating to colour samples and to three-dimensional settings is in part obscured because of the role of coloured images as philosophical models for the visual environment (and for the inner visual scene when such is part of the argument). The confusing philosophical model involves the implicit or explicit assumption that each spot of the scene that we see – of what is before our eyes and could be painted or photographed from the place where we stand – could be treated as a colour sample and compared with a colour chart.

For instance, a sample taken from a spot in the picture occupied by the image of a grey chair would have the colour value 'grey’. A sample containing a white sheet of paper lying in shadow would also have the colour value 'grey’. Their colour values could also be given in terms of spectral power distributions of light.

Philosophical ideas of colour vision are thus conditioned in part by the fact that we have pigments, i.e., by the existence of painting. Any given part of a painted canvas could be detached and analysed optically and chemically. Two samples from different parts of the canvas may turn out to have the same colour. What is on the surface came from the same pot, they could be shown to have the same chemical analysis. A key point of dispute is: What role should such things play in our understanding of 'the real colour’?

For, in the usual sense of this expression, the two objects depicted on the canvas – the grey chair and the white sheet of paper – are obviously not the same colour. Sometimes we would say they look the same colour, but not even this is usually true unless we mean that someone might be deceived to think they are the same colour.

In his Remarks on Colour, Wittgenstein highlights the contrast between the samples discourse, where colours are treated as independent of each other, and normal colour

\(^{30}\) REFERENCES. Newall, Lopes.
perception where the colours of individual spots are defined in relation to the whole of one’s surroundings. In this context, Wittgenstein considers the question of how the colours of a natural visual scene are reproduced in paintings. A discussion of painting illustrates the contrasts between the two ways of identifying colours and talking about them.

Ideally speaking, as coloured samples, it is true that white is the lightest colour. On a flat surface in homogeneous illumination – as in the French Tricolour – white will be the lightest part of the surface. But it does not follow that white objects are always the lightest parts of a picture. Wittgenstein imagines a painting where a white sheet of paper receives its illumination from a blue sky. The sky will have to be painted lighter than the piece of paper (I.2).

The painted canvas can be called an interface, a point of transition from colour geometry to the natural perception of colour. An artist’s palette consists of colour samples. Colours are placed there, in good order against a neutral, flat surface. But when the artist dips his brush in paint and places a speck of colour in the right place the effect will depend on where on the canvas the pigment is placed. What, in terms of the samples discourse, is defined as grey will perhaps become a white area placed in a shadow, blue placed in orange light, or a highlight on a polished grand piano (cf III.95). The question what colour this spot in the painting is, will be ambiguous. One can think of ‘colour’ either as the specific pigment placed on a piece of fabric (i.e., grey) or as the colour of the object depicted in the painting (white, blue, black, etc) (cf III.77-78).

Wittgenstein remarks that Rembrandt did not use gold paint in his Man with a golden helmet (III.79).31 (This famous painting in Dresden was then attributed to Rembrandt and said to be a portrait of Rembrandt’s brother. Later studies have identified the real painter as one of his students.) The colour of ‘this spot’ is in one sense brown and, in another sense, gold. The painter has created the impression of gold by means of a combination of various brown, black, and yellow pigments. In this journey from the palette to the canvas, yellow – or brown or black! – turns to gold.

Wittgenstein’s interest in the transition from the palette to the canvas may have been stimulated by his reading of Lichtenberg. Lichtenberg writes about the difficulty of distinguishing between ‘judgment’ and ‘sensation’ in colour judgments:

31 Lee (2005) also discusses this remark by Wittgenstein, and the related theme of depicting ‘unconventional’ colours – e.g. gold – with the help of pigment. A naturalistic painter will not use gold paint in order to depict gold.
In all judgments based on visual perception, [the elements of] judgment and perception are completely amalgamated, so that later in life we find it impossible to pull them apart again; we believe at each moment that we see what is really just an inference. This is the reason why bad portrait painters smear the faces all over with flesh colour. They can’t imagine that a human face may have blue, green, yellow, and brown shadows. And the cuffs are painted in such a spotless manner that only their placement and outline betrays that the stain of chalk that the artist has thrown there is meant to be a cuff.

Ordinary colour judgments are not about spots in the visual field but about the colours of objects. This is why realistic painting is so difficult. We naturally tend to paint objects in the colours we know them to be, not to reproduce the interplay of light and shadow that produces the visual impression. – Hence, Lichtenberg says:

For the same reason, the technique of colouring is studied more easily from the works of great masters rather than from nature, because the colour is already there on the canvas, divorced from judgment, and it can be studied like any other piece of coloured fabric, in all kinds of light and in all kinds of angles against it. But here judgment must first be divorced from perception, which not everyone can do.

Wittgenstein’s remark in I. 60 of the Remarks on Colour might be directly inspired by Lichtenberg’s discussion.\(^{32}\) He imagines that we actually cut up a painting in pieces and use the pieces as a pointillist jigsaw puzzle. The position of a given fragment in the jigsaw puzzle will decide whether it will be seen as part of a grey object, or as a piece of a white object in shadow, or as a highlight, or still something else (also see III.53).

The realistic coloured image constitutes ’an interface’ between two systems of colour determination: the samples discourse and the visual environment discourse. The image can be studied both in terms of the colours of its surface and in terms of the colours of the objects depicted.

Wittgenstein notes that Rembrandt did not use gold paint in his picture of a man in a golden helmet. This is different from the practice, e.g., of icon painters who used gold liberally for analogous purposes. Rembrandt realised that the colours of the individual spots

\(^{32}\)Also see the previous entry (I. 59), where Wittgenstein speaks of painting the view from his window. Cf III.265-6.
of the picture do not necessarily need to match the colour of the depicted materials. Different parts of the helmet are rendered with yellow, brown, black, and so on. The spectral value of each individual spot could be determined. But we see the helmet as uniformly golden because we recognise it as a shiny three-dimensional object.

Our idea of colour is conditioned in part by the fact that we have pigments, i.e., by the existence of painting [and dyeing]. What is on the surface came from the same pot, would be shown to have the same chemical analysis. (It is, also, perhaps, conditioned – though less directly in our normal life – by the fact that we can measure wavelengths of light [spectral power distributions]. A key point of dispute is: What role should such things play in our understanding of 'the real colour'. 33

This should give pause to those philosophers and philosophically minded colour scientists who would treat the experimental results as local blueprints for future all-embracing reductionist accounts of colour. While law-like relations between physical facts and perceived colour can be established in conditions especially designed for matching purposes, questions remain about what we can say about the status of colour judgments outside those conditions.

LITERATURE
I haven’t composed a proper literature list as yet. Central works include:

Baxandall, …. Shadows and enlightenment (CHECK TITLE & DETAILS)


Hyman, John …. 


33 This is a formulation by David Cockburn, in a commentary to my earlier paper.
