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The Cultural Context Of Perception: On Colour, Representation, And Imaging

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THE CULTURAL CONTEXT OF PERCEPTION

— on colour, representation, and imagining

by

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Department of Philosophy

Submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy

Faculty of Graduate Studies
The University of Western Ontario
London, Ontario
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Abstract:

This work investigates some of the philosophical implications of current theories of the psychophysiology of perception. First, I consider the use of recent investigations into psychophysiological theories of vision, in particular, the perception of colour, and the important rôle assumed here for cognition and language. I conclude that a relation between colour perception and language has not been established, that consideration of spectral colours is too limited, and that the experimentation to date generates misleading results. I consider the interdependence of our psychophysiological response to the entire visual array, the world present to our fovea and its surround, and the manner in which this undercuts some standing notions of the assumed rôle of colour. Second, I consider the importance of this interdependence for limited visual experiences, with focus specifically on pictorial arts. I challenge the widely held belief, developed in a number of distinct ways, that the perception of two-dimensional representations requires a psychological immersion in the work at the expense of awareness of the work. I further conclude that a holistic approach, demonstrated through a series of practical aesthetic considerations, produces much more satisfying and useful results.

Keywords:

Basic Colour Terms
Colour Categories
Colour Language
Fallacy of Misplaced Concreteness
Imagining
Make-believe
Psychological Immersion
Psychological Participation
Psychophysiology
Realism
Representation

Brent Berlin
John Gage
Ernst Gombrich
C.L. Hardin
Michael Heim
David Hubel
Leo Hurvich
Dorothea Jameson
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Table of Contents

ii
CERTIFICATE OF EXAMINATION

iii
ABSTRACT

iv
DEDICATION

v
ACKNOWLEDGEMENTS

vi
TABLE OF CONTENTS

xi
LIST OF ILLUSTRATIONS

xiii
INDEX

xvi
PREAMBLE
INTRODUCTION

0. Intro
1. Colour and cognition
2. Psychophysiology
3. Picture perceptions
4. Perceptual holism

CHAPTER ONE:
COLOUR VISION

0. Intro
1. Neurons
2. The retina
3. The eye is not a camera
4. Colour space
5. Trichromacy and the Young-Helmholtz theory
6. The opponent: Hering

CHAPTER TWO:
COLOUR LANGUAGE

0. Intro
1. Reaction
2. Arbitrary or isomorphic
3. Two tactics
4. Boundaries, categories, and foci
5. Methodological difficulties
   1. Sample size
   2. Sample representativeness
   3. Aperture colours
   4. Reduction criteria
   5. Translation
CHAPTER THREE:
COLOUR AND PHYSIOLOGY

0. Intro
1. Receptor-neural linkages
2. Unique hues
3. An entanglement of tasks
4. The limits of physiology
5. A basic colour is not an aperture colour
6. The context of culture
7. Ethnocentrism

CHAPTER FOUR:
SOUND AND CULTURE

0. Intro
1. The analogy from sound: phonology
2. The analogy from sound: musical intonation

CHAPTER FIVE:
COLOUR AND CULTURE

0. Intro
1. Cultural determinants
2. Semantic shifts
3. Pigment and purpose
4. Aristotle's rainbow
5. From admixture to dispersion
6. Newton's rainbow
CHAPTER SIX: VISUAL PERCEPTIONS

0. Intro
1. The fallacy of misplaced concreteness
2. A fuller accounting
3. Higher-order cell activity
4. Luminance, colour, and the world before us
5. Parallels between the pathways
6. Yarbus and planar images
7. Considerations for research

CHAPTER SEVEN: WORLDS PERCEIVED

0. Intro
1. Picture environments
2. Two technical questions
3. Our place in the world
4. Immersion and virtual realities
5. Bigger versus smaller
6. Psychological immersion
7. Physiological participation

CHAPTER EIGHT: PSYCHOLOGICAL PARTICIPATION

0. Intro
1. The analogy from children's games
2. Analogous activities
3. Styles of realism: photography
4. Immersion and compensation
5. Different realities: Gombrich
6. Awareness
7. Appreciation
CONCLUDING REMARKS

0. Intro
   1. The thesis

APPENDIX:
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BIBLIOGRAPHY

VITA
<table>
<thead>
<tr>
<th>Page</th>
<th>Section</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>1.1</td>
<td>Neurons</td>
</tr>
<tr>
<td>17</td>
<td>1.2</td>
<td>The eye</td>
</tr>
<tr>
<td>18</td>
<td>1.3</td>
<td>Cell layer connections</td>
</tr>
<tr>
<td>25</td>
<td>1.4</td>
<td>Cone sensitivities</td>
</tr>
<tr>
<td>26</td>
<td>1.5</td>
<td>Additive and subtractive colour mixing</td>
</tr>
<tr>
<td>27</td>
<td>1.6</td>
<td>Young-Helmholtz chart</td>
</tr>
<tr>
<td>31</td>
<td>1.7</td>
<td>Colour opponency chart</td>
</tr>
<tr>
<td>34</td>
<td>2.1</td>
<td>Evolutionary basic colour terms</td>
</tr>
<tr>
<td>44</td>
<td>2.2</td>
<td>The Munsell colour chart</td>
</tr>
<tr>
<td>45</td>
<td>2.3</td>
<td>Dani colour space</td>
</tr>
<tr>
<td>47</td>
<td>2.4</td>
<td>The devolution of evolutionary basic colour terms</td>
</tr>
<tr>
<td>60</td>
<td>3.1</td>
<td>Spectral hue coefficients</td>
</tr>
<tr>
<td>61</td>
<td>3.2</td>
<td>Spectral distributions</td>
</tr>
<tr>
<td>62</td>
<td>3.3</td>
<td>Linkages</td>
</tr>
<tr>
<td>65</td>
<td>3.4</td>
<td>Hue responses</td>
</tr>
<tr>
<td>68</td>
<td>3.5</td>
<td>Centre-surround cell structures</td>
</tr>
<tr>
<td>69</td>
<td>3.6</td>
<td>Eye cap</td>
</tr>
<tr>
<td>70</td>
<td>3.7</td>
<td>Hering's tool</td>
</tr>
<tr>
<td>86</td>
<td>4.1</td>
<td>Berlin and Kay: phonology</td>
</tr>
<tr>
<td>94</td>
<td>4.2</td>
<td>Comparison of Chinese pure fifths with European tempered scale</td>
</tr>
<tr>
<td>95</td>
<td>4.3</td>
<td>Comparison of tempering systems</td>
</tr>
<tr>
<td>116</td>
<td>5.1</td>
<td>Comparison of colour space</td>
</tr>
<tr>
<td>119</td>
<td>5.2</td>
<td>Three colour systems</td>
</tr>
<tr>
<td>123</td>
<td>5.3</td>
<td>Splitting and recombining light</td>
</tr>
<tr>
<td>132</td>
<td>6.1</td>
<td>Visual parallel pathways</td>
</tr>
</tbody>
</table>
134 6.2 Higher order receptive fields
135 6.3 Orientation-sensitive receptive fields
135 6.4 Movement-sensitive receptive fields
136 6.5 End-stopping
138 6.6 Overlapping receptive fields
141 6.7 Features of the parallel pathways
151 6.8 Yarbus' demonstration

167 7.1 The Treppenhaus with Tiepolo's ceiling
168 7.2 Tiepolo's Treppenhaus: Asia
175 7.3 Pozzo's St Ignatius from perspective point
175 7.4 Pozzo's St Ignatius off perspective point
THE CULTURAL CONTEXT OF PERCEPTION
— on colour, representation, and imagining

ANALYTIC INDEX
— being a brief sketch of the main argument

PREAMBLE

One occasion for this work is my reading of Basic Color Terms, the influential book of Berlin and Kay published in 1969. I identify two areas that are problematical with their work, and with its legacy. First, their claims directly and misleadingly impinge on social science research and theory. Second, their methodology exemplifies a pervasive methodological error in the social sciences, psychology, and perception. Though these issues intertwine, I am primarily concerned with the second, leaving the first for another volume.

INTRODUCTION

The bases of my thesis are recent theories in the psychophysics of perception. I investigate three specific and distinct domains of inquiry, each a subsection of and motivation of the next: colour vision and how it relates to colour language; visual perception in general; and the perception of limited (especially two-dimensional) arrays.
ONE.

COLOUR VISION

As background, I trace out a particular history of colour perception, with emphasis on the Young-Helmholtz additive theory and the Hering-Hurvich-Jameson opponent-process theory.

TWO.

COLOUR LANGUAGE

The most influential current account of colour language is that proposed by Berlin and Kay. Their methodological assumption was that colour perception could be studied in isolation. The conclusion was that all languages, and people, encode the world the same and that the development of colour vocabularies follows a tight and common evolution. The opponent-process theory of colour psychophysiology is often viewed as giving new credence to the Berlin and Kay theses.

THREE.

COLOUR AND PHYSIOLOGY

I here offer two accounts of the preceding. First, the claim that colour language is evolutionary is extremely under-determined and contrary to the internal evidence. Second, the related claims that the methodology elicits sufficiently complete colour vocabularies and that the opponent-process theory corroborates the colour space location of these vocabularies is based on an arbitrary (worse, specifically Western) understanding of colour itself.
FOUR.

SOUND AND CULTURE

Generally, the tactic for defending the Berlin and Kay theses has been to appeal to various physiological theories. I here critique the argument from analogy that claims colour perception and categorization is like the perception and categorization of sound. I consider two cases: that of phonology, which is raised by proponents of the Berlin and Kay theses, and that of tonality, which is an original application.

FIVE.

COLOUR AND CULTURE

I detail a number of historical cases that demonstrate how culture plays at least as active a role in the development of colour categories and terms as does physiology. Specifically, the categorizations of the rainbow and pigments follow theoretical beliefs and technological developments. The cultural and social environments of different peoples determine both colour terminology and categorization.

SIX.

VISUAL PERCEPTIONS

Recent electro and psychophysical research indicates that the visual system employs separate pathways for discrete tasks, resulting in interesting comparative functions between the pathways. I motivate the move from considering colour perception in isolation to a consideration of vision by giving account of the current understanding of higher-order cell activity in the visual system. I begin first with an overview of work on higher-order cell activity regarding form and movement. The tendency here has been to treat these features also in isolation. Given this history, the work will be reconsidered in relation to the whole visual system. Account will also be given of boundaries, illumination, and surrounds.
SEVEN
WORLDS PERCEIVED

The work of Livingstone and Hubel is intended to be further inclusive of physiological and psychological co-factors in visual perception. We in fact live in extensively manipulated worlds. I consider the relation of limited arrays to our natural environment. This is the corollary of the complaint raised against Berlin and Kay: in this domain limited perceptual functions may be testable and of interest. The extensive testing ground of these arrays is pictorial art. I take up the cases of Walton and Wollheim, both of whom have influential views on perception of pictorial art.

EIGHT
PSYCHOLOGICAL PARTICIPATION

Several aspects of Walton's theory are investigated to underscore the holistic nature of physiology and perception. Having argued that local perception must be placed within the whole context of perception, I here argue that the perception, contemplation, and appreciation of pictorial art is of the same kind.

CONCLUDING REMARKS

The methodological errors that permeate the erroneous conclusions about colour perception and categorization demonstrate a problem typically cast as between analytic and holistic approaches to philosophy and the sciences. These approaches should not be considered exclusive. Only when they are do we run the greater risk of the fallacy of misplaced concreteness. This work is intended to demonstrate the benefit of applying the holistic approach to the analytic approach.

BIBLIOGRAPHY
PREAMBLE

In 1969, Brent Berlin and Paul Kay published their book *Basic Color Terms*. The book arose from work done by Berlin and Kay and their students for a seminar at Berkeley in 1967. The working hypothesis of the seminar was that the claim that each language is semantically arbitrary relative to every other language, that extreme linguistic relativism holds, was false: "Our feeling was that color words translate too easily among various pairs of unrelated languages for the extreme linguistic relativity thesis to be valid."[2] In 1991, *Basic Color Terms* was published in softcover. With the exception of a one and half page introduction to the paperback edition and an incomplete bibliography of colour categorization research, the book is reproduced with all the errors and inconsistencies intact.

In 1989, I first read *Basic Color Terms*. It is both an important book and a source of frustration. It is important because it has been tremendously influential. Prior to 1969 the challenge was to disprove the extreme relativism thesis. Since 1969 the challenge has been to disprove the Berlin and Kay thesis. *Basic Color Terms* marks a shift in onus, both in the burden of proof and in the details of the nature of the debate. I have benefitted from reading and rereading it.

One obvious benefit is that it provides the first of two occasions for the present work. There are two areas that I find particularly problematic with Berlin and Kay's book, and with its legacy. First, the broad claims they make have directly impinged on and shaped social science research and theory. This, despite the fact that their claims are unsubstantiated, both in their book and in the subsequent literature and research. Nonetheless their claims have shaped social science on at least two levels. They have influenced the direction of much of the research in colour categorization and, more generally, has directed the thinking about relativism. Second, their methods exemplify a pervasive methodological error in the study of the social sciences, psychology, and perception. This error is what A.N. Whitehead termed the Fallacy of Misplaced Concreteness:

In so far as the excluded things are important in your experience, your modes of thought are not fitted to deal with them...[1] It is of the utmost importance to be vigilant in critically revising your modes of abstraction.[59]
It is possible, then, to fallaciously assume these conclusions to be, or treat them as, concrete and non-abstract. Berlin and Kay erred in thinking that a test of responses to a limited portion of the visual colour world counted as a test of our responses to the entire colour world. As I will demonstrate in the first half of the following work, a test of psychophysiological responses to spectral and aperture colours is not a test of the cultural determinants of, for instance, surface colours. The patterns of cross-cultural consistency in colour naming mis-ascribed by Berlin and Kay were induced by the categories of analysis they imposed.

The second occasion for my writing is the recently published work by Kendall Walton, *Mimesis as Make-Believe*. Though billed as a study of the representational arts, the work has much to say about the philosophies of mind and psychology. In his discussions of psychological participation with representations (both verbal and visual), Walton assumes a theory of psychological immersion that has precedents with art historian Kenneth Clark and art theorist Ernst Gombrich. In attempting to demonstrate the consequences of Whitehead's fallacy for perception, I turn to a consideration of limited visual arrays, bounded (usually) surfaces which we treat in abstraction from the whole visual field.

The present work is primarily intended as a corrective to the fallacy of misplaced concreteness as it arises in both Berlin and Kay and Walton.
INTRODUCTION

This work investigates some of the philosophical implications of current theories of the psychophysiology of perception. The discussion of these implications focuses on three specific domains of inquiry. First, I consider the use of recent investigations into human response to spectral colours, and the importance accorded to this response for cognition and language. In particular, I discuss the theory of universal colour categorization, initially articulated by Brent Berlin and Paul Kay. Second, I consider the interdependence of our psychophysiological response to the entire visual array, the world present to our fovea and its surround, and the manner in which this undercuts some standing notions about the role of colour in cognition and language, recently articulated by C.L. Hardin. Hardin follows Berlin and Kay in thinking that a psychophysiological description of one aspect of our visually perceived colour world is adequate as a causal explanation of language formation and categorization. Third, I consider the importance of this interdependence for limited visual experiences, with focus on the modern visual pictorial environment — which includes some aspects of art.

Since the early part of this century increasing support has been given to the theory of colour opponency, according to which our visual apparatus determines sharp divisions on the visible electro-magnetic spectrum with four unique wavelengths or hues (the familiar red, green, blue, and yellow). This opponent-process theory has recently been used to support a variety of arguments within psychology, philosophy, and anthropology. For example, it provides support for subjectivist accounts of colour, while undercutting objectivist theories and has more general implications for philosophical and epistemological objectivism and relativism. Generally it has been assumed that the priority of this response to spectral colours bears directly on, among other things, cognitive psychology and language: that biology strongly influences semantics. In this work I address the supposed implications of opponency for current theories of language and cognition as these are directly related to perception. Next, I reject the assumption of the psychological (and subsequent linguistic) primacy of spectral colours on two counts: primarily on the basis of the very psychophysiological evidence which stands behind to the opponent-process theory, but also on the evidence of our basic intuitions about
(responses to) our environment.

The colour information received from the cones in the eye, in according to the opponent-process theory, is processed by higher-order cells. The processing of colour signals is only one task performed by higher-order cells. In a complex of interrelations these cells are sensitive to absolute and relative information about colour, texture, shape, movement, and illumination. I reject the treatment of spectral colour in isolation from other psychophysiological factors; this treatment, in turn, is the result of accepting the work of Berlin and Kay on colour foci and categorization, which I also reject.

The problem that arises in Hardin and elsewhere is the impasse between proponents and opponents of the Berlin and Kay theses and the real differences documented in colour categorization and response. The rôle of spectral colours, as well as the rôle of each of these other visual components, must be re-evaluated within the context of higher-order activity. Such a re-evaluation, in light of the recent understanding of the integration of colour vision with our complete visual experience, better accounts for much of the anthropological and psychological evidence. Two corollary conclusions may be drawn here: perception of spectral colours is a component of physiological activity (and hence a relatively minor activity) which need not underlie language and cognition, and perception of entire arrays is a major physiological activity. By distinguishing between minor and major activities I mean to indicate the current recognition that different visual tasks are essentially connected in the higher visual pathways, so that a task as specific as the perception of spectral colours, while experimentally testable, works in conjunction with other visual tasks to enable us to practically negotiate the world. As with other perceptual tasks, colour perception is causally complex, involving other perceptual (and psychological) tasks. (This latter conclusion will come as no surprise to Land, Gibson, and Marr.)

The colour opponent theory stipulates that there are four physiologically salient hues or wavelengths. It is argued that this physiological feature in turn has specific implications for the development of language and the formation of colour
categories based on a specific cognitive psychology, one which prescribes a strong causal relation between this dominant physiological feature and language. The restrained account of this line of argument concludes that basic colour categories are universal across distinct languages, determined as they are by the opponent-process. The robust account concludes that there is also an evolutionary ordering to the development of these basic categories, generally as societies develop technologically. Evidence for the robust account incorporates various scenarios regarding physiology and psychology.

I reject this argument on the following grounds. The opponent-process theory is supported by an abundance of recent psychophysiological data about visual perception. But while these data support the opponent-process theory, and specifically the component regarding perception of unique spectral colours, they suggest that this specific perception is only a part of a much more complex system of perception involving not just spectral colour but boundaries between surface colours, movement, illumination, etc. Colour opponency, in conjunction with these other inseparable psychophysiological features, supports the opposite view to the above theory: namely that spectral colour discrimination plays a much smaller rôle in our everyday experiences - those same experiences which are supposed to determine our development of colour categories.

The opponent-process theory in conjunction with other psychophysiological theories cannot provide support for a view of cognition and language based on a simple causal relation between basic physiology and category and language formation. What the current views of psychophysicsology can do is provide explanations of some special cases of visual perception, and particularly, support for a theory about our perception of visual representations. The visual perception of pictures is a special kind of visual experience, one which usually involves attending to a delimited portion of the visual array. Broadly, there are two types of such delimited arrays, those that require the interpretation of a two-dimensional surface as three-dimensional and those that make no such requirement (either by drawing attention only to their two-dimensional quality, as with some abstract paintings, or by existing in three-dimensional space and so not involving a two-dimensional surface, as with dance or sculpture). Following our previous discussion of spectral colours, the
entire visual array is involved in our experience. This holds for arrays containing both delimited types, though to greater and lesser degrees writers on depiction have assumed that in appreciating the psychologically constructed three-dimensional array we ignore or are completely unaware of the entire visual array (for instance, Walton). This is not a mere oversight, for perception of the picture or surface medium as such is essential to the perception of the representation, to the construction of the three-dimensional space, and to the keen interest of our culture in perceptual and psychological immersion in such spaces.

**Colour and cognition**

Before I can discuss picture environments I must construct my argument for the contextual locatedness of perception. I do this by considering the problems that arise when some aspects of current psychophysical theory are applied to an old issue, that of the relation of colour categorization to language. Together these provide the two strands that make up the whole work. One strand involves recent psychophysiological theories about vision, in particular, the perception of colour, and the supposed implications of these theories for debates over cross-linguistic uniformity of perception and categorization. The other strand involves the widely held belief that the perception of two-dimensional representations involves an ability to immerse ourselves in the work without being aware of the work. Though clearly distinct, the arguments used to unravel the supposed implications of the first provide evidence for the unravelling of the second.

The current argument for closely relating the physiology of colour perception to colour terminology has a long history. But in the past quarter century much more has been written on this. Central to this history and to the debate is the 1969 book *Basic Color Terms*, by Brent Berlin and Paul Kay. There they made explicit their argument that, contrary to relativist theses such as that put forward by Sapir and Whorf, colour terms translate too easily between unrelated languages and cultures for the extreme linguistic relativity thesis to be valid. They drew two distinct conclusions: that cross-cultural appellation is consistent, evolutionary, and translatable and that, cross-culturally, humans respond to the visible spectrum in much the same way. Initially, their book was met with mixed reviews (as examples, Conklin and
Hickerson in opposition; Bornstein and Ratliff in favour). Despite an abundance of serious charges, their work has subsequently figured in a number of important philosophical, psychological, and anthropological arguments. However, I argue that their only claim to survive the past two decades of critical scrutiny is that, cross-culturally, humans respond on a basic psychophysiological level to the visible spectrum in much the same way.

In his 1988 book *Color for Philosophers*, C.L. Hardin defends the work of Berlin and Kay by offering what he believes to be independent support that some of their conclusions receive from recent work on and acceptance of the opponent-process theory of colour perception (as proposed by Jameson and Hurvich in the 1950s, after Hering, and developed in the four decades since). However, careful attention must be paid to both the separate claims made by Berlin and Kay, claims that go far beyond perception in a strictly physiological sense, and to the broader claims of recent psychophysiological theories in which the opponent-process theory is situated. Granting the validity of the opponent-process theory suggests that the narrow thesis of Berlin and Kay, about human response to the visible spectrum, may in fact be correct, that the results obtained by the methodology of Berlin and Kay are to be expected. I argue that acceptance of the opponent-process theory does nothing to confirm the broad thesis of translatability presented in *Basic Color Terms*, that colour terms translate easily across cultures. Further, I argue that other aspects of the current psychophysiological theories, of which opponency theory is a part, support an alternative conclusion, that response to the spectrum, to spectral colours, plays a relatively minor role in our perceptual experience of the world, after experience of whole visual arrays, including texture, shape, contrast, relative and absolute illumination and reflectance. Berlin and Kay, and many subsequent writers, have only demonstrated a physiological point about human response to spectral colour, and nothing about linguistic structures built upon such physiology or the centrality of this response.

**Psychophysiology**

A physiological capacity to identify unique hues is of little practical value outside the world of colour chips, in environments where such hues and arrange-
ments seldom, if ever, occur. Colour terminology arises out of usage, in response to colours as they are normally experienced. In the West, there is a long history of interest in colour perception, and colour systems (Munsell chips and C.I.E. charts, colour wheels, solids, and pyramids) abound, and affect our perception, colour lexicon, and responses. Further details of the psychophysiological evidence indicate the complexity involved in experiencing unique hues, and subsequently, it must be emphasized, the rarity of any such natural experience. Moreover, the subtleties of our psychophysiology indicate the importance of shape, texture, and the relation of the components of the visual field in determining colour experience.

An advantage of the opponent-process theory is that it can account for non-aperture colours. If brown is viewed through a black tube, in isolation from any surrounding colours, it appears yellow or orange. Generally, accounts of brown recognize the role of both texture and colour contrast in our perception of this colour. This experience of brown, as necessarily related to its surround, demonstrates that the visual system employs a spatial comparison of the whole field of vision: higher-order cells (distinct from the colour receptors in the eye) receive signals from a variety of cones, such that differentiation involves whole receptive fields. To use a standard case, this is why a white shirt in the shade, particularly when compared with one a few feet away in the sun, looks like a white, and not a grey, shirt: because the other objects surrounding the shaded shirt, themselves in the shade or providing cues that the shirt is in the shade, are considered.

The two chromatic opponent systems (red-green and yellow-blue) do not only involve one particular place in the visual field (specifically, as when looking at colour chips, a small area on the fovea). This was demonstrated by Edwin Land and his associates with the dramatic experiments on colour constancy performed in the 1950s, and by H. Helson and D.B. Judd in the 1930s. The demonstrations in this century were of the long standing view that object colour depends not on absolute illumination, but rather on the amounts of reflected light relative to the other reflected light in the whole visual field. This is aided by the structure of the higher-order cells, called centre-surround cells, because they receive inputs from different cones - for instance, from red sensitive cones in the centre with a surround from green sensitive cones.
The structure of these higher level cells indicates that while we have a proclivity for four unique hues, awareness of those hues depends greatly on the whole of our visual experience, including the predominant colours of our local environment and our attention to and physical separation of particular coloured objects or lights. Further experiments show that borders between colours play an important rôle here, that centre-surround cells are responsive as well to shape. Thus, centre-surround cells do not respond just to colour. Instead, for example, the responses to a white border and the lack of response to diffuse light change indicate that the cell is concerned with shape (Hubel). Separate work done on what are called movement-sensitive cells indicates the important function played by shape and boundary in vision in general. Most cortical cells are designed to respond to movement; we are unable to smoothly scan stationary objects, but rather jump from point to point in a series of saccades or jerks. We tend to scan a stationary object in two ways: by jumping to points of interest and to boundaries of abrupt luminance change.

All of this higher cell activity underscores the interconnectedness of the whole visual array and underlies simple wavelength discriminations. Combinations of colours, reflected from a multitude of surfaces, are integral to colour perception. The context, the environment, in which the observer is situated determines to a large degree the discrimination of colours. Because of the physiology of cones and colour opponency, we do detect unique hues. But such detection is only a part of the higher-order cell activity, activity that is involved with several kinds of detection within the whole visual array. In an environment without colour chips and wheels and self-adjusting monochromators, the observer is unlikely regularly to perceive unique hues, and equally unlikely to develop categories for what is unperceived. The same theory that provides independent support for the Berlin and Kay thesis regarding colour foci also underscores both the infrequency, and relative unimportance, of such experience and the importance of considering the wider context of colour experience (and appellation), of texture and shape and surrounding colours.

Most cortical cells are responsive to movement, presumably for the very pragmatic reason that detecting movement is more important in our lives: prey and predators move. Identifying unique hues, situations involving a high level of brain
grey signals, does not have the same practical application as picking an object out of its surround by means of differentiating texture or shape or subtle colour shifts.

This recent trend to ascribe linguistic category formation to the salience of colour perception, as underscored by work on the opponent-process theory, has relied on the notion that colour vision is uniquely the visual determinant in this dependence of psychology on physiology. Critics of this view have been misguided by also sharing the notion that colour is the single (at least dominant) determinant. This is not the case. If we are to propose a causal link between the physiology of our visual apparatus and subsequent language and psychological features, we must heed the relation between the structure of our colour detection and the detection of movement, form, boundaries, and illumination. Now we are ready to construct a theory which accords the appropriate rôle to colour vision.

Much groundwork has already been done. Extant anthropological and psychological research into colour, language, and social and environmental circumstances can be reinterpreted with success in light of these considerations of the interconnectedness of the psychophysiological features of visual perception. The discrepancies between evidence cited in favour of, and in opposition to, the above theory can be dissolved by reinterpreting this evidence in terms of visual perception rather than colour perception (Heider, Bornstein). So, rather than giving an account of this research as either demonstrating or failing to demonstrate a causal relation between colour perception and higher linguistic and psychological features, I provide a consistent account of this research on colour as a component of visual perception in toto.

**Picture perceptions**

I have indicated that an interest in the physics of optics and the electro-magnetic spectrum has had an effect on our colour vocabulary, and attendant conceptualizations. The observations made in the pursuit of this interest comprise a special, limited domain of visual experiences. Conversely, I argue that a linguistic group living in a forest will have little direct experience of physiologically unique hues. As stated above, the current views of psychophysiology can provide explanations of
special cases of visual perception, such as the implications of our interest in the 
electro-magnetic spectrum. These current views also provide support for my theo-
ry about the perception of visual representations. The way in which this theory 
overcomes some standing problems in turn provides an analogue for the holistic 
approach to visual perception I suggest above. Our culture has a deep and wide-
spread interest in pictures, generally, and a specific interest in picture environments 
that facilitate and encourage perceptual and psychological immersion. To immerse 
ourselves physically is to be physically engaged with, surrounded by, the represen-
tation and representational activity. To immerse ourselves psychologically is to 
imagine that we are so surrounded. As such we have a keen interest in making and 
understanding such pictures.

We cannot make sense of a picture (a representation) if we cannot determine 
that it is a picture, if we are not aware that it is a picture. Looking at a picture, it 
turns out, is not much like looking directly at what was the subject of the picture. 
But it is an experience with which we are familiar, and which we are reasonably 
adept at interpreting (this looks like, represents that). The theory I offer here has to 
do with how we are able to undertake this interpretation. My argument about pic-
tures has its roots in the psychological writings of Ernst Gombrich and the physi-
ological and psychological writings of M.H. Pirenne. Gombrich attempts to answer 
what he calls the riddle of style: artworks look different from culture to culture and 
time to time in part because of the psychology of representation, for the intentions 
of artists and their public change. He notes that “we see a Chinese landscape here 
and a Dutch landscape there, a Greek head and a seventeenth-century portrait....If 
art were only, or mainly, an expression of personal vision, there could be no histo-
ry of art.”[4] Style is ubiquitous, and “we have come to realize more and more...that 
we can never neatly separate what we see from what we know.” [394] Pirenne is 
interested in our ability to compensate for what ought to be the obvious difference 
between a two-dimensional representation and that which it represents. There are, 
then, two aspects to perception of pictorial representations: the experience of the 
situation of perceiving a representation, and the experience of perceiving the repre-
sentation and of what is represented. Though distinct, they are related by the psy-
chophysiology discussed above.
In apparent opposition to this aspect of the work of Gombrich and Pirenne is a widely held and tacit theory of participation in the arts which involves the immersion of the appreciator in the work at the expense of the world around or outside the work. Yet Gombrich himself famously holds this view, as well. Following Kenneth Clark, Gombrich claims that we are unable to observe or attend to both the representation and the means of representing: “you cannot see the one without obliterating the other.” Recently, the philosopher Kendall Walton, in his influential *Mimesis as Make-Believe*, has added his voice to this theory writing that, for instance,

One can ignore the brush strokes enough to lose oneself in the fictional world....Continuous single-minded participation, concentration on the visual surroundings in which one fictionally finds oneself, is easier, for example, for viewers of *Girl Reading Letter by Open Window* by Vermeer, who in the interest of “realism” disguised his own painterly activity and rendered inconspicuous the physical properties of the paint. [277.280]

Although Walton makes more allowance for seeing both, his notion that we ‘ignore the work enough’ still follows the standard theory of a psychological flip-flop between the work itself and the representation. Further, (as I will argue,) Walton assumes that there is immediate representation, free from style, free from the requirements of recognition and interpretation. However, Vermeer cannot, even in the interest of “realism”, disguise his own painterly activity, and if one ignores the brush strokes one cannot interpret the painting.

This tension between style and immediacy is only part of the picture perception problem. Walton and other central writers on aesthetics agree that participation in the world of the art work involves an ability to disregard the art work itself, whether this be visual, literary, musical, etc. Thus, one either attends to (or primarily is conscious of) the work or is immersed within the work. I will argue that this is false. It is only in recognizing that a painted scene is painted that it is convincing at all; it is only by recognizing that tragic events portrayed on stage are fictional that we acquiesce to sit through them. I argue that such tactics only alter that with which we participate and, in fact, may enhance participation. This, I shall argue, is evident in, and supported by, the work of both Gombrich and Pirenne (though argued for by neither).
Two distinct issues are present in the preceding paragraph: participation, which is primarily a psychological feature of our experience, and perception, which is a psychophysiological feature. Clearly, both are often involved in the successful experience of an artwork. Though I will here deal primarily with how the current psychophysiological theories support my claims about the perception of representations, I will inevitably speak of both issues, for "we can never neatly separate what we see from what we know". Though we may try, we seldom perceive only the work itself (the most notable exceptions are the new OMNIMAX three-dimensional film projected on a 180° screen and virtual reality technologies). Higher-order cell activity, processing information about shape, colour, illumination, etc., affects and is essential to our properly interpreting features of our visual array such as linear perspective.

A picture of a girl reading by a window looks little like a girl by a window. It is smaller, two-dimensional, static, often distorted by foreshortening (both within the picture and resulting from our relation to the picture). In fact, as noted above, our physiological apparatus is primarily suited for perceiving and following movement, either relative to us (an animal under locomotion) or between other things (a shadow passing over a plant). This relative inability to perceive uniform surfaces dictates to artists choices of colours and compositions. The success of IMAX and OMNIMAX is the ability to incorporate a broad range of physiological activities and to maximize the similarities between perceiving the filmic representation and a corresponding real scene. This seldom happens with other representations, where there is a difference in our physiological activity of which we must be aware in order to psychologically imagine the one activity like the other. These successes and failures demonstrate the interconnections of psychophysiological features and urge the kind of holistic treatment I have undertaken here.

Perceptual holism

I will argue for a holistic approach to perception. In fact, my thesis has to do with the traditional distinction between analytic and holistic approaches to philosophy and the sciences. Rather than thinking of these as exclusive, I freely draw on both approaches - an approach which I take to be holistic. The nature of my
argument is such that additional premises, additional cases, add support. I consider colour vision, visual perception, and picture environments in as many and varied contexts as space allows. In its most general form, my thesis is this: a substantive, comparative study of the historical record demonstrates the inconsistencies of theoretical assumptions based, primarily, on the analytic approach. To be substantive is to look at actual cases (the historical record) of paintings and electronic representations, of anthropological field work on languages, of historical reconstructions of colour terms in Greece, Rome, and Medieval Europe, of current work on psychophysiology. To be comparative is to consider whether or in what way inconsistencies and puzzles within each domain of inquiry (each historical record) may dissolve or be better explained by comparing them with other domains.

Colour vision is a component of visual perception. Visual perception is a component of perception in general (including hearing, touch, balance). The perception of representations, though primarily visual, is affected by other sensory information. The perceptual activity of any component involves the other senses, and any argument regarding higher cognitive functions must account for the involvement of all perceptual activity. An argument, then, based on atomistic and analytic psychology (that cognition and language are affected by colour perception, without account given to other faculties and other experiences) cannot be universalized beyond the limited domain of its enquiry. The particularities of the context of perception play a great rôle in cognition and language.

In addition to this general thesis there are also several important themes that I will pursue through the work. Whitehead’s fallacy of misplaced concreteness is one, and obviously relates to the general thesis. I will deliberately seek out areas of inquiry pertaining to visual perception that run afoul of this fallacy and attempt to expose and amend theories that incorporate it. Another theme is the rôle and extent of context in matters of visual perception, particularly as this affects perception and language and perception and representations. A third theme concerns the various kinds of awareness that we employ in negotiating our world, kinds that vary from awareness of whole arrays and fields of colours to awareness of surfaces and boundaries, but that all share in being context-dependent. Finally, a fourth theme is the degree and kinds of sensory or perceptual experience that underpin my discus-
sions of experiences that extend from retinal stimulation to aesthetic experiences of immersion.
CHAPTER ONE: COLOUR VISION

The emphasis throughout this whole work will be on the philosophical uses and implications of psychophysiology and neurophysiology, as these underlie the socio-cultural and aesthetic studies of perception. While this has implications for philosophy of mind (reductionism seems an obvious consequence) I will presume no specific theory of mind. This is also not a work about the mechanics of perception. Rather, it is a work that employs our current understanding of those mechanics in an effort to come to terms with the psychological experience of perceiving the world around us. A consequence is that I have much to say about perception. It is my intention to defend a particular theory of perception. As to debates over Gestalt theory and psychophysics, constructed and direct perception, functionalism and neurophysiology, I shall draw freely from all theories as I see profitable; any theory of perception may have value as a partial theory relevant for understanding a complex subject matter. As stated in the Introduction, perception generally cannot be adequately conceptualized by atomistic or narrowly physiological theories. A holistic or contextualized theory of perception better serves and better explains the physiological, psychological, and anthropological evidence.

Having said this, I begin the discussion of colour vision at a neurophysiological level. It seems appropriate to begin with the mechanics of the visual system, since the limits or limitations of the mechanics indicate the limits of our psychological experiences. The mechanics provide constraints. We cannot have experiences beyond the natural limits of our physical nature. We cannot see a field mouse scurrying through thick prairie grass from one hundred yards away because we do not have the resolving power of the eagle. Nor can we see ultraviolet and infrared light. Both of these limits are functions of our physical structure.

In many regards this work may be read as a companion to M.H. Pirenne's excellent Optics, Painting and Photography. Whereas Pirenne begins with an account of the collection of light rays in the eye, I will begin with the neurological (and psychological) response to that light. The history of vision incorporates a long debate over whether visual rays emanate from the eye or whether light enters the eye from
objects.\footnote{Variations of the “extramission” theory were held as recently and by as notable an author as Leonardo, who argued in numerous places both for and against the emission theory:
So long as the air is free from grossness or moisture they [the lines from the eye and the solar and other luminous rays] will preserve their direct course, always carrying the image of the object that intercepts them back to their point of origin. And if this is the eye, the intercepting object will be seen by its colour, as well as by form and size. From the Windsor anatomical drawings, c. 1483-85, quoted in David C. Lindberg, \textit{Theories of Vision from Al-Kh\=endi to Kepler}. See Lindberg for a thorough discussion of the history of this debate.} However, the eventual success of the centripetal theories suggested that the eye is a passive receptor. Pirenne worries that:

the formation of the retinal image by light coming from the outside world is a purely physical process which takes place in the living eye as it does in a dead one, or as in an inanimate object such as the photographic camera.\footnote{Variations of the “extramission” theory were held as recently and by as notable an author as Leonardo, who argued in numerous places both for and against the emission theory:
So long as the air is free from grossness or moisture they [the lines from the eye and the solar and other luminous rays] will preserve their direct course, always carrying the image of the object that intercepts them back to their point of origin. And if this is the eye, the intercepting object will be seen by its colour, as well as by form and size. From the Windsor anatomical drawings, c. 1483-85, quoted in David C. Lindberg, \textit{Theories of Vision from Al-Kh\=endi to Kepler}. See Lindberg for a thorough discussion of the history of this debate.}

As Pirenne notes, this worry is easily set aside. However, the extent to which the visual system is active and interactive is not always acknowledged. For this reason I begin at the neurophysiological level with a review of some simple and well known facts.

\textit{Neurons}

The main components of brains are nerve cells. Nerve cells are also a main component of the visual system. The play of light on the walls of the eye are converted into electro-chemical information, which in turn is processed in the optic nerve and the brain. The human optic nerve is actually a collection of nerve fibres. These nerve fibres transmit information from the
cell body to other cells. A typical nerve cell consists of a nucleus, dendrites, and an axon. Cells have different functions so the activities in the nucleus vary from cell to cell. Those various activities are transmitted and received in the same way among cells. The axon is a single cylindrical nerve fibre that transmits impulses from the cell. Depending on the cell the axon will vary in length from less than a millimetre to about one metre in length. The dendrites are tapered nerve fibres that, along with the cell body, receive information from other cells. Near its terminus, an axon typically branches with each branch coming close to, but not touching, the body and dendrites of other cells. The region of each terminal branch and cell body or dendrite is called a synapse. Information from one cell is transferred across the synapse to the next cell or cells by chemical transmission.

Though all nerve cells have the same component parts and ‘connect’ with each other in the same way, they also differ from each other in two ways. There are different types of cells. In the human brain there could be over one thousand types of cells. Types are distinguished by function and spatial configuration. The most apt analogy is the difference between individual trees and the similarity between all oaks and all poplars. Two cells are of the same type or class if they resemble each other as two poplars resemble each other. Nerve cells with similar or related functions tend to be grouped together into aggregates of cells. The brain contains hundreds of plate and ball shaped aggregations of cells. These aggregates are often connected in series, with signals passing from one cell to the next to the next. The visual pathway is such an aggregate of serial connections.

The retina

The human retina displays the plate pattern often found in the nervous system and brain. This plate has three layers of cells separated by two layers of synapses. The first layer consists of ganglion cells. The second layer contains bipolar cells, horizontal cells, and amacrine cells. The third layer consists of rods and cones, our light receptors. Despite what we would perhaps expect, the structure of the retina is inside-out. Light passes through the first two layers before striking the receptor cells.
The retina is considered part of the brain, maintaining connection with the rest of the brain via the optic nerve, which consists of about 1 million nerve fibres or axons. As each axon is part of a cell located in the first layer of the retina, there are 1 million retinal ganglion cells. As just remarked, the light sensitive receptors are located on the dark side of a dense network of nerves: light in the eye passes through the ganglion, amacrine, bipolar, and horizontal cells before striking the rods and cones.

Each human eye contains nearly 120 million rods and 7 million cones. The rods and cones are not evenly distributed over the retina. Most of the cones are found separate from the rods in a slight depression at the back of the eye near the visual axis. This area is known as the fovea. The rods are very densely distributed over the periphery, that part of the retina not designated as the fovea. It is suggestive to note that approximately 125 million light receptors transmit information to 1 million ganglion cells. Thus, each ganglion cell has a receptive field, gathering information from a number of light receptors. Information flows from receptors to ganglions in two discrete ways. It flows either in a direct path, from receptor to bipolar cell to ganglion cell, or in an indirect path, via the horizontal and amacrine cells to offset ganglion cells.

In the fovea, most receptors (cones) are directly linked to bipolar cells which are directly linked to ganglion cells. This means that individual ganglion fibres in the optic nerve carry information from individual light receptors. The further from the fovea the more receptors share bipolar cells, which share ganglion cells. Beyond twenty degrees into the periphery hundreds of rods will converge on a single bipolar cell. Ganglion cells near the periphery relay information that indicates receptor
activity, but does not indicate which individual receptors have been activated. Any given ganglion cell may receive input from any number of bipolar cells (one, ten, a hundred, a thousand), but always from nearly contiguous cells. Ganglion cells do not receive input from throughout the retina, but only from a local field around each cell. This holds equally for the connections between light receptors and bipolar cells.

1.3 Cell layer connections: the colour receptive cells outnumber the ganglion cells, which receive signals from a multitude of rods and cones via the horizontal cells and bipolar cells.

The eye is not a camera

Working with Tycho Brahe, Kepler was introduced to the problem of radiation through small, finite apertures. Tycho earlier, and Kepler in 1600, observed that the lunar diameter, measured with a camera obscura, was smaller during a solar eclipse. What was the cause of this fluctuation in diameter? Kepler’s solution, discussed in his Ad Vitellionem paralipomena of 1604, drew on the mechanics of a precursor to the camera lucida. To represent rays of light, Kepler stretched taut a thread with one end affixed to a point on the object (a picture of the moon, for instance). Keeping the thread straight and dragging it along the inside circumference of the aperture, he traced circles on the projection surface corresponding to various points on the object. In addition to demonstrating what photographers now call circles of confusion, Kepler convinced himself that the human eye, which also has an aperture greater than a point, must be subject to the same principles as the camera. Given the known anatomy of the eye, Kepler concluded that, as in the camera, the image formed on the retina must be inverted and reversed.

2 A fuller discussion of Kepler’s initial labours to avoid this conclusion, and his subsequent wholehearted acceptance of it, can be found in Lindberg.
I am less concerned here with how rays and patterns of light enter the eye and are focused on the retina, than with how information about that light is transmitted to the brain and so provides the basis for our psychological responses. The oft repeated analogy between the camera and the eye may be appropriate as an account of the manner in which light is focused by a lens into a darkened chamber, but beyond that the analogy is inappropriate and does more damage than good: the eye is like a camera obscura, but not like a camera photographia. To employ the analogy in an accurate and meaningful way we must also consider the manner in which the two 'cameras' record or transmit information and the manner in which they are handled.

Christopher Scheiner marks, in a sense, the beginning of the inappropriate analogy between the eye and the camera. In 1625, Scheiner provided an experimental demonstration of Kepler's theory about the retina, especially that an inverted image is focused on the surface of the retina by the lens of the eye. Scheiner took the eye of a dead ox and cut away the outer coating from the back, leaving a translucent layer. He was then able to view the image projected onto the inside of the retina, in the same way as we see an image projected onto the inside of the ground glass mounted in a view camera. As we see the image in a view camera, Scheiner saw an inverted, reversed image on the translucent retina. This confirmed Kepler's position that light rays entering the eye behave in the same manner as light rays in the camera obscura. At the opening, the lens or pinhole, the rays cross and are focused as a reversed and inverted image on the back of the chamber. The modification to the camera obscura initiated by the pioneers of photography, Nièpce, Daguerre, and Fox Talbot, was to fix (transfix) that image across time and place. In the press of the day Daguerre was described as having "found the way to fix the images which paint themselves within a camera obscura" and Fox Talbot as having "overcome the difficulty of fixing the images of the camera obscura."

3 Pirenne describes a variation of this "experiment in Chapter Six of Optics, Painting and Photography.

4 La Gazette de France (Paris: January 6, 1839) and Fox Talbot, "Some Account of the Art of Photogenic Drawing, or, the Process by Which Natural Objects May Be Made to Delineate Themselves without the Aid of the Artist's Pencil" reprinted in Newhall, Essays and Images, p. 17 and p. 28 respectively.
camera and the eye implies that a stabilized though inverted image is essential to vision.

Prior to the invention of photography there was no reason why the analogy between cameras and the eye should imply that the retinal image was stable and analyzable in the sense that photographs are. Though much has been written about this issue, often as serious debate, with as early a writer as Descartes the deceit in this was exposed:

Now, although this picture, in being so transmitted into our head, always retains some resemblance to the objects from which it proceeds, nevertheless, as I have already shown, we must not hold that it is by means of this resemblance that the picture causes us to perceive the objects, as if there were yet other eyes in our brain with which we could apprehend it; but rather, that it is the movements of which the picture is composed which, acting immediately on our mind inasmuch as it is united to our body, are so established by nature as to make it have such perception...[1637, 101]

Two centuries later, Hermann von Helmholtz writes that “the image we receive by the eye is like a picture, minutely and elaborately finished at the centre, but only roughly sketched in at the borders”[1873, 105] and he notes that because of the rapid scanning motion of the eye “we have practically the same advantage as if we enjoyed an accurate view of the whole field of vision at once.”[106] So, in the matter of photographic cameras he concludes that they

...can never show near and distant objects clearly at once, nor can the eye; but the eye shows them so rapidly one after another that most people, who have not thought how they see, do not know that there is any change at all.[107]

His point is that vision is a matter of interpretation, that there is no stabilized image on the retina projected in a manner approximating the formation of a photograph:

...So far as vision is concerned, I am myself disposed to think that neither the size, form and position of the real retina, nor the distortions of the image projected on it, matter at all, so long as the image is sharply delineated all over...in the natural consciousness of the spectator, the retina has no real existence whatsoever.[1866, 166, 181]

Helmholtz’s reference to scanning hints at how disanalogous the camera is from the eye.
Inbound light traverses the dense network of nerve cells and blood vessels before stimulating the light receptors. Unlike photographic film, these in turn face inward, away from the pupil. But this is not the most significant difference between the eye and the camera. There is no shutter in the eye, there is no decisive moment when a definite pattern of light is recorded by the light receptors. A more apt analogy would be a comparison of the eye to a television “camera”. Unlike still cameras or even motion picture cameras, television cameras have no shutter to block out light between exposures. Instead, a continuous exposure strikes photo-electric cells that convert light signals to electric signals, much as the photopigments in the retina convert light to neural outputs. As with television cameras, there are continually shifting patterns of light on the retina. Indeed, there must be.

There are two ways in which the human eye moves, and so changes what light strikes what part of the retina and light receptors. Movements of the eye are both voluntary and involuntary; voluntary in that we can move the eye around in its socket or move our head around in the world, involuntary in that the eye is constantly moving in a series of microsaccades or minute jerks; this in addition to the rapid scanning we do to investigate our environment. This saccadic movement is essential to seeing. In 1952, a number of researchers independently demonstrated that an image stabilized on the retina fades after about one second so that we no longer see it. Saccadic movement ensures that differing amounts of light continue to strike our light receptors. These receptors, it turns out, quickly desensitize to constant, unvaried light intensity.

The stabilized image that Scheiner saw on the back of the dead eye is not at all what occurs in the active living eye. Though an image can be artificially stabilized on the eye, this is counter to how the eye works and provides information. There is not an image in the eye in a way that would support the oft ridiculed mind’s eye watching a small screen in the head, just as inside the television camera or on the magnetic video tape there is no image. The optic nerve does not send a series of images or tableaus (no matter how quickly replaced) to the brain. So despite the initial appeal, the analogy with optical recording devices fails because they are all designed to replicate the look of the external world, not the ‘look’ of the stimulations of the light receptors.
Receptive fields and microsaccadic movement provide a stunningly different understanding of how the eye works and how the various functionalist tasks cooperate and interact to produce a complex of electrochemical impulses that permit us to successfully negotiate our environment. Along with similar interactive connections at higher levels in the visual system, the connections I have begun to sketch out here have interesting consequences for the issues of visual perception I pursue in later chapters. I will return for a more detailed consideration of these issues in Chapter Six.

**Colour space**

My primary interest in this and the next two chapters is our ability to perceive colour. By Chapter Five it will be clear that I am arguing how careful we need to be if we intend to discuss colour in isolation from other aspects of vision. Part of the care we must take is in agreeing on which of a confusing collection of terms describing colour and light we will use in our discussion. We experience as colour one section of the electromagnetic spectrum. The spectrum comprises a continuous series of waves of energy measured crest to crest in nanometres (billionths of a metre). Waves longer than about 400 nanometres and shorter than about 700 can be experienced as colour. We may think of colour as differing along a horizontal line, with short 400 nm (violet) waves on the left and long 700 nm (red) waves on the right. Reference to the variety of colour sensations can be confusing as differing nomenclature is used by various authors in describing the different characteristics of colour.

These characteristics are conveniently thought of as occupying a three-dimensional colour space. Colour is typically described as having three distinct characteristics: *hue* (blue, violet, red, orange, yellow, etc.); *saturation* (the amount of colour judged against a monochromatic scale of greys); and *brightness* (the amount of black or white in pigments, and the luminance of light). Energy of individual wavelengths is experienced as pure, rich colour; such pure colour is referred to as spectral colour - the colours in a rainbow or obtained by using a prism to split sunlight (or what is called white light) into coloured bands. However, the two ends of the visible spectrum are visually related; violet is an intermediary colour between
red and blue (red and blue combine to make violet). This means we can imagine a
globe with all the hues of the spectrum running around the equator (the horizontal
line bent into a circle). The equatorial axis of the globe is a continuous monochro-
matic gradation from black at the south pole to white at the north. In turn, each
hue may be thought of as being brighter or darker (of more or less luminance, hav-
ing varying amounts of white or black) and as having more or less colour in relation
to its grey content. Fully saturated colours lie on the surface of the globe, less
saturated colours lie within the globe progressively closer to the axis until we per-
ceive them all as monochromatic grey. The brighter the colour the closer it is to
north pole, the darker the closer to the south pole. The brighter or darker a hue, the
less saturated it can be as the surface of the globe curves into the poles. In the
extreme latitudes we experience tinted blacks and whites. Bright red (pink) has less
colour content than crimson.

There are problems with representing perceptual discriminations of colour in
the way we have been describing. Not all colour experiences are represented: iri-
descent colours, for instance. But also, our sensitivity to combinations of hue, sat-
uration, and brightness are not equal throughout the colour space. Numerous dif-
ferent systems have been devised to attempt to account for our experiences, and a
variety of colour nomenclature, differing from hue, saturation, and brightness, have
been employed.

Distinctions also need to be drawn between spectral, aperture, and surface
colours. Spectral colours are those and only those colours produced by splitting
white light. Aperture colours are all the spectral colours plus colours such as brown
and olive green. These additional colours are not present in split white light.
Rather, they require a spatial contrast with other colours. (The term 'aperture' refers
to a technique for producing the sensation: different spectral light is shone
through an aperture in a coloured board so that it is experienced in conjunction with
the colour of the board.) Surface colours, while they may have the same appear-
ance as aperture colours, are the result of the particular reflectance properties of an
object. The iridescent blue of a mallard's neck results from the property of the
feathers, designed to capture air as an insulator. Light reflected off the feathers
appears blue, light transmitted through the feathers appears brown.
Trichromacy and the Young-Helmholtz theory

MEMO: And how do you define color?
SOCRATES: What a shameless fellow you are, Meno. You keep bothering an old man to answer, but refuse to exercise your memory and tell me what was Gorgias' definition of virtue.[Meno 76b]

Socrates avoids directly answering Meno's question; in fact he avoids seriously answering it altogether. The question of the nature of colour has proved not much easier to answer than the question of the nature of virtue. Socrates does give a 'high-sounding answer', which he attributes to Empedocles and which he makes no claim to accept: "Color is an effluence from shapes commensurate with sight and perceptible by it." Socrates's avoidance of the question indicates the difficulty of the topic. And though the parody definition claims little, even so it does miss the point of our current understanding of colour and vision: that the perception of colour is as much a function of our physiology as it is of the tones and reflectance. As David Hubel says:

An object that absorbs some light reaching it and reflects the rest is called a pigment. If some wavelengths in the range of visible light are absorbed more than others, the pigment appears to us to be colored. What color we see, I should quickly add, is not simply a matter of wavelengths; it depends on wavelength content and on the properties of our visual system. It involves both physics and biology.[62]4

Long after Empedocles, Newton discovered that white light (sunlight) split into individual bands of colour using a prism could be recombined into white light. What we perceive as white light is a combination of light of different wavelengths. However, by 1802, it was understood that any number of triplets of widely spaced bands of coloured light could be recombined to form white light; a substantial amount of the component colours of white light could be extracted without altering the sensation of white light. Thomas Young concluded that there must be (at least) three receptors distributed across the retina variously sensitive to three widely

4 Hubel here uses "pigment" quite broadly. Any coloured surface (any surface which reflects less than the totality of incidental light) is a pigment as well as being the plastic of my pen, the cloth of a book cover, etc.

5 In Teevan and Birney, Colour Vision, p. 5.
spaced wavelengths:

Now, as it is almost impossible to conceive each sensitive point of the retina to contain an infinite number of particles, each capable of vibrating in perfect unison with every possible undulation, it becomes necessary to suppose the number limited, for instance, to the principal colours, red, yellow and blue...\(^5\)

He later settled on red, green, and violet. Young was quite right about this structure of the retina, but direct confirmation did not come until 1959 when George Wald and Paul Brown at Harvard and Edward MacNichol and William Marks at Johns Hopkins found three and only three types of cones.

Yet it is misleading to speak of the three cone types as sensitive to three unique primary colours. Each cone type has a sensitivity response to a wide band of wavelengths, with a peak sensitivity at a particular wavelength. These peaks can be identified, and the single, specific wavelength at each peak, while often labelled as a primary colour, does not correspond to what is called a unique hue or colour. Each cone type does respond best to a single wavelength, but the interconnection between the cones, the way they co-operate, is much more subtle.

1.4 Cone sensitivities vary across the visible spectrum with distinct peaks. Combinations of different wavelengths, affecting different cones, result in a multitude of colour experiences. In this regard, it is misleading to refer to the three cone types as red, green, and blue.
Nothing in what Young proposed presumed specific sensitivity to unique wavelengths. Any three narrow bands of light of sufficiently different wavelengths can be mixed to form any other spectral colour.\(^6\) Young's point was that a finite set of cones are responsible for colour sensitivity in normal human eyes and that there must be at least three types of cones. Very young art students are taught that red, yellow, and blue are primary colours, and that various mixtures of two or three will produce all spectral colours plus brown. (And that the three primaries plus black and white will produce all non-metallic or non-iridescent colours.) For instance, yellow and blue paint will result in green paint. This is true, but conventional. Any three sufficiently different pigments could equally do the job.\(^7\)

Both Young and Helmholtz settled on three colours because this was the minimum number of colours necessary to produce all spectral colours plus white. Young's

1.5 Additive and subtractive colour mixing demonstrate two of three colour phenomena (the third is psychophysical mixing) and demonstrate the discrepancy of primary colours that lead to the development of the colour opponent theory.

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6 Spectral colours are those that are contained within sunlight, so those that appear when sunlight is split by a prism. Brown and iridescent colours (gold, silver) are not so produced.

7 Discussions of this sort are always hampered by the difference between mixing coloured lights and mixing pigments. Mixing light is an additive process, mixing three appropriately balanced colour bands produces white light. Mixing pigments is a subtractive process, mixing all three produces black. Helmholtz first explained this difference.
selection of principal colours, the maximal sensitivity of the cones types, was based more on convenience than on evidence. In commenting on Young's selection of fundamental colours, Helmholtz adopts his predecessor's choice, at the same time acknowledging the limited reasons for doing so:

The choice of the three fundamental colours is somewhat arbitrary. Any three colours which can be mixed to get white might be chosen. Young may have been guided by the consideration that the terminal colours of the spectrum seem to have special claims by virtue of their position. If they were not chosen, one of the fundamental colours would have to have a purplish hue, and the curve corresponding to it would have two maxima, one in the red and one in the violet. This would be a more complicated assumption, but not an impossible one.[v. 2, 145]8

The Young-Helmholtz theory has two important features, which typify all subsequent versions of it. First, there are three types of light-sensitive receptors in the retina, which are each sensitive to a broad band of wavelengths, but

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1.6 Young-Helmholtz colour chart, showing the whole spectrum sensitivity of the three cone types.

8 Helmholtz offers some confirmation of the choice of red by a consideration of the responses of colour-blind persons:

this colour that is not visible to the colour-blind person is necessarily one of the fundamental colours; for if there were sensation for all the fundamental colours, no other colour sensation composed simply of these fundamental ones could be lacking.[v. 2, 150]

And given what is known about the combination of triplets and the sensitivity of cones:

If a red not far from the extreme red of the spectrum is really one of the fundamental colours, the two others cannot be very far anyhow from the green and violet as chosen by Young.[v. 2, 151]
which are each most sensitive to a specific narrow band or single wavelength. These peak sensitivities are manifest as an experience of 'pure' (intense, simple) colour and are designated as unique hues or colours. The three cone types in turn get designated by the colour name corresponding to that part of the spectrum in which they peak. Second, our experience of colour, of the visible spectrum, is the result of the varying signal outputs from the three cone types. This process is additive. When the red cones are active and neither the green nor violet are, we experience an intense red. If the red and green cones are active, but not the violet, we experience orange. This additive process is gracefully demonstrated by projecting coloured light onto a screen. Various combinations (additions) of light produce apparently pure colours.

The difference between the primaries of light and those of pigments is explained in terms of this additive theory. In fact, Helmholtz first gave this account. Pigments absorb or subtract from the incident light, reflecting a narrower or several narrower bands of light. A pigment may reflect a monochromatic single or relatively narrow band of light which we experience as a colour (rather than the white, wide band incident light). Or it may reflect several relatively monochromatic bands from different areas of the spectrum. Single dominant wavelengths determine our experience of the pigment (what colour we see it as): so do combinations of dominant wavelengths which excite the colour receptors, as green (500 nm) and red (650 nm) cause a sensation of yellow. Mixing pigments together means subtracting more and more light, until we have a black or a muddy brown.

Coloured filters or gels transmit all light except for the bands necessary to give them their colour; a yellow filter may transmit all light except that around 575 nm or that around both 500 nm and 650 nm. Transmitted light or reflected light of differing colours (wavelengths) stimulate different light receptors. The signals from these different receptors are added together. A screen which discretely reflects a green beam of light and a red beam of light continues to do so even when the beams are adjusted so as to overlap. The sensation we have of yellow is composed of the two sensations we had of green and red. The same receptors are affected but now simultaneously (before we looked first at the green patch and then at the red patch); the effect (the activity of the cones) has been added. Hubel gives a lengthy discus-
sion of the difference between additive and subtractive colour mixing and of Helmholtz's explanation of the phenomenon, only to conclude that

The phenomenon is a physical one; it relates to color vision and biology in about the same way that crossing polaroids and getting black or adding blue litmus to acid and getting red relates to it - in short, not at all. Yet the idea that color mixing is related to color vision still keeps many people confused, and the confusion is due to the notion that red, yellow, and blue are primary colors but that green is not. If any set of colors deserves to be called primary, it is the set of all four - red, blue, yellow, and green.[171]

The opponent: Hering

In T. von Kries' appendix to the 1924 English translation of Helmholtz's *Optics*, he writes that

Even at the present time the theory of HELMHOLTZ is thoroughly justified as to its fundamental conceptions, it is in close agreement with the facts, and as an hypothesis it is qualified to explain a very large mass of actual phenomena.[v. 2, 426]

Ewald Hering was impressed with the small mass of phenomena for which the Young-Helmholtz theory could not account. No amount of adjusting the relative intensities and frequencies of coloured beams of light will result in the experience of brown or olive green. Other mixtures of colour seem unimaginable as well as nondemonstrable: there are no colours that we experience as greenish-red or yellowish-blue.9 So, rather than propose three primaries Hering proposed four. His reason for so doing was based on the phenomenology and psychological effect of colour perception. He somewhat mischievously describes his reasoning thus:

As soon as one admits only three variable properties, for example, red, green, and violet, and attempts to base a nomenclature on these, one is immediately convinced of the uselessness of such a procedure. One is then forced to describe yellow, for instance, as a red green or green red, blue as a violet green or green violet. That this would be quite incomprehensible to the ordi-

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9 Though we can mix yellow and blue pigments to produce green, green itself has a salience which seems independent of any component parts. Certainly, to Hering's point, there is no greenish-red pigment; combinations in the right proportions of green and red or of yellow and blue produce white, a cancellation of hue.
nary person would be disturbing, but of no theoretical consequence. But it would not be immaterial that such a way of assigning names to colors does not at all express in what way and to what extent the colors appear to be interrelated.[47]

This suggested to Hering that there are two independent visual processes handling these four colours and a third handling achromatic signals from the rods.

In the absence of direct physiological evidence, Hering devised a number of simple experiments which demonstrated the opponency of the two chromatic signals. Hering adapted a spectroscope, containing a narrow slit which can be adjusted to emit any monochromatic band of the spectrum (for instance, unique yellow), with a second adjustable slit perpendicular to the first which allows regulation of the amount of light passing through the two slits. A telescope is adjusted onto the slit so that the circular visual field is filled with the monochromatic light emanating from the fixed slit.

If we fixate the center of the illuminated field for a while, say for 20 seconds, and then reduce the intensity of the light more and more by gradually narrowing the slit, as we do so the yellow obviously pales, becoming progressively more whitish and then a hueless white. But this achromatic color lasts for only an instant; then the circular field becomes bluish, and, while the achromatic component of the sensation recedes more and more, the blue becomes better and more clear.[305]

This demonstration of adaption holds equally for a blue light and for red and green.

This relation between the paired colours indicates an antagonistic process rather than an additive one. Hübner, in one of his clear images, says:

We can think of Hering's yellow-blue and red-green processes as separate channels in the nervous system, whose outputs can be represented as two metres, like old-fashioned voltmeters, with the indicator of one metre swinging to the left of zero to register yellow and to the right to register blue and the other metre doing the same for red versus green. The colour of an object can then be described in terms of the two readings.[173]

If the red-green metre is unaffected, rests at zero, and the yellow-blue metre swings to the right we experience blue. If the red-green metre swings to the left (red) and
the yellow-blue swings to the right we experience purple. Herein lies the opponency. Nervous system signals at levels beyond the retina cannot signal both yellow and blue or red and green. Each metre only registers in one direction at a time.

I will leave for Chapter Six discussion of the achromatic processes and the success Hering’s system has in accounting for brown and olive green. An issue I will address is how Hering’s four primary colours can be reconciled with the evidence that we have only three cone types. Not only has empirical research established that we have three and only three cone types, but the work of Leo Hurvich and Dorothea Jameson in the area of psychophysics and Gunnar Svaetichin in electro-physiology has established that Hering was right in postulating three opponent channels. Hurvich and Jameson have championed Hering since the 1950’s, translating his Optics into English and leading the systematization of colour opponency.

As noted, the three cone types each have distinct and characteristic sensitivity curves. The three peak sensitivities correspond to specific wavelengths on the visible spectrum. Traditionally, the cones have had colour names assigned corresponding with the part of the spectrum in which their sensitivity peaks. More accurate, though less mnemonically useful, would be to refer to the three cone types as variously sensitive to long, middle, and short wavelengths and to designate them L, M, and S. With Young and Helmholtz, Hering also recognized three peak sensitivities which he called the three cardinal points of the spectrum (to avoid confusion with his four primary colours); yellow, green, and blue. The three cone types have their peak sensitivities around 430, 530,
and 560 nm, which correspond to monochromatic colours violet, blue-green, and yellow-green. Of greater importance than the individual peak sensitivity of cones is the relation between the sensitivity curves of each type and the opponency of the output signals of those cones. Though Hering could hardly have worked out or anticipated the details of the opponency processes in the absence of direct physiological evidence, he was correct in distinguishing between receptor sensitivity and receptor signal. Colour opponency describes the activity of the receptive fields and higher order cells.

Spectrally unique colours, primary colours, and cardinal points all involve the psychological experience of a hue which is simple, without constituent colours. All oranges seem to have some amount of either red or yellow, all purples have amounts of red and blue. Green does not seem to have amounts of red or yellow, red does not seem to have amounts of yellow and purple or green and blue. When one of the opponent colour systems is unaffected (its metre registers zero, sits idle) and the other system is affected (its metre swings to either side of zero) we experience a unique hue. If the red-green system is unaffected and the yellow-blue registers blue, we experience unique blue. Response curves have minor differences between individuals. However, the important wavelengths - where the curve of one opponent system crosses zero, and so the other system uniquely registers - fall around 480, 500, and 580 nm. (If both colour systems register zero then our experience will be achromatic.) The phenomenally simple colours at these wavelengths are blue, green, and yellow respectively. It is a characteristic of the spectrum that phenomenally unique red does not appear. By adding a small amount of blue light to the spectral light the experience of unique red can be achieved.

Now let us consider what may and may not be concluded from this.
C.L. Hardin has suggested that a lot of fuzzy philosophical thinking regarding colour perception could have been avoided if current physiological theories, in particular the opponent-process theory of colour perception, had been known, accepted, or heeded earlier in this century. In *Color for Philosophers*, Hardin endeavours to make this and several other current theories accessible to philosophers. He includes a chapter on colour language, which he acknowledges is much indebted to the work of anthropologist Brent Berlin and linguist Paul Kay:

That there is a striking correspondence of color categories across a variety of unrelated languages was persuasively argued by Brent Berlin and Paul Kay in their now famous *Basic Color Terms*.\(^1\)

The theses presented in the work of Berlin and Kay take little to state: humans all respond linguistically to a small number of specific wavelengths in the same way, the evolution of basic colour terms follows a uniform pattern, and our terms for these specific wavelengths (major foci) are interchangeable between languages. *Basic Color Terms* has become famous because, in it, Berlin and Kay decisively denounce the claim of Edward Sapir and Benjamin Whorf that languages are semantically non-isomorphic. On the basis of extensive ethnographic comparisons, Berlin and Kay concluded that although different languages encode in their vocabularies different *numbers* of basic color categories, a total universal inventory of exactly eleven basic color categories exists from which the eleven or fewer Basic Color Terms of any given language are always drawn.\(^2\)

Their research indicated to them two distinct dimensions:
1. Of a total ninety-eight languages investigated all demonstrated the same progressive (evolutionary) development of basic colour terms drawn from a finite stock of eleven.
2. Of twenty languages further tested the foci of these terms are closely clustered.\(^2\) Correspondingly, they drew two distinct conclusions:

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1 The intent of clarifying philosophical thought that I attribute here to Hardin is suggested in the introduction to Hardin, 1986, pages xxi-xxii, and more specifically in Hardin, 1984, page 125.
3. Cross-cultural appellation and categorization of colours is consistent, evolutionary, and translatable.
4. Cross-culturally, humans respond to (partition) the visible spectrum in much the same way.

Colour terms in the ninety-eight languages considered are reducible to a universal evolutionary progression of no more than eleven basic terms (some languages exhibit as few as two terms), and the foci of these terms correspond to an inter-language corresponding narrow band of wavelengths.

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2 Berlin and Kay tested twenty language groups for their ability to identify colour foci among an array of Munsell colour chips. Ethnographic field work on an additional seventy-eight language groups was consulted to determine the translatability of the basic lexicon Berlin and Kay decided on.
Reaction

Reaction to the work of Berlin and Kay has been mixed and plentiful. In the years immediately following the publication of *Basic Color Terms* reviews and notices appeared, both favourable and critical. On review it is clear that the overwhelming response was critical; indeed, the basis for the Berlin and Kay theses was quickly refuted. Yet despite numerous detailed and persuasive criticisms (immediately following its publication and continuing to the present), criticisms of the method and of the evidence offered for their theses, their work is still cited as evidence for linguistic universality, anthropological translation, trans-culturally valid standards or conceptions of rationality, and psychological and psychophysiological structures. Two related issues emerge here. For twenty-five years some practitioners in the fields of anthropology, linguistics, and philosophy have assumed that the work on cross-cultural or cross-linguistic colour lexicons done by Berlin and Kay conclusively establishes that colour terminology between language groups is isomorphic. For example, the anthropologist Dan Sperber writes of

the now well-known study of basic colour terms by Berlin and Kay. Colour terms were a favourite case for relativists: the colour continuum was said to be partitioned freely and hence most of the time differently in each language. A more thorough and sophisticated study of the evidence shows, on the contrary, that a universal small stock of basic colour categories underlies superficial difference. In terminology.[161]

More recently, Alisdair MacIntyre has written:

Berlin and Kay have indeed been able to distinguish eight stages in the development of color vocabularies, ranging from languages, such as that of the Dani, with only two terms, to the eleven terms of contemporary everyday American English or the eleven terms of Zuni and the twelve terms of Hungarian and Russian.[15]

Evan Thompson has written, citing in a footnote Berlin and Kay 1969, Kay and McDaniel 1978, and Heider 1972b:

In fact we can be even more precise. It must be remembered that our hue terms are *categorical*: They cover the numerous discriminable colours (specific hue-saturation-lightness values) that belong to a given hue category. (The hue categories have best examples or prototypical members but their boundaries are fuzzy).[326]
The conclusions drawn by Berlin and Kay remain for the large part unsubstantiated and challenged, yet their work continues to be favourably cited. I will say little about why it is so cited, but will offer reasons why it ought not to be. In drawing their conclusions, they suggest the second issue: linguistic relativism theses are not valid for there is at least a minimal bridgehead provided by an isomorphic cross-linguistic colour lexicon.³

Some proponents of the conclusions drawn by Berlin and Kay have argued that the results of this work stand even though the support for these results has been undermined. Problems with the method are averted by appeal to evidence which independently confirms their theses. Hardin enters the debate with such a framework in both philosophy and anthropology laid out. In Color for Philosophers, he claims that,

Since the publication of Basic Color Terms, which has by and large successfully passed the critical scrutiny of linguists and anthropologists, (e.g., Conklin 1973) there have been attempts, notably by Marc Bornstein (1973) and Floyd Ratliff (1976), to produce more comprehensive psychophysiological explanations of the Berlin-Kay data.[156]

Conklin rejects the work of Berlin and Kay and neither Ratliff nor Bornstein defend the work. Given the controversial history of this work, Hardin ought to have provided more convincing evidence of the value of citing and relying on it.

As with so many references to the Berlin and Kay work, Bornstein and Ratliff do not respond to the extant criticisms; they in turn simply cite Basic Color Terms in support of their own work. Although he is a careful writer and only suggests pos-

³ It is important to note that rationality or objectivism and relativism are frequently characterised in extreme terms. While the consequence of giving up belief in objective standards does entail relativism, it does not entail extreme, anarchistic relativism. Berlin and Kay defend linguistic standards against extreme relativism. Yet more broadly, arguing against specific claims for “bridgeheads” does not necessitate arguing for extreme relativism. There are many innocuous forms of relativism: recognition that a society can benefit from the diversity of its citizens’ heritage (multiculturalism) acknowledges and validates different, culturally relative (that is, context specific) approaches to agriculture, medicine, art, as well as epistemologies, cosmologies, metaphysics, etc. The alternative to ‘objectivism’ is a wide array of ‘relativisms’. See for discussion “Notes on Relativism” in Feyerabend, 1987.
sible explanations for the conclusions drawn by Berlin and Kay. Ratliff begins: “Berlin and Kay found that certain basic color categories serve as the perceptual focal points for Basic Color Terms in all languages.”[311] and concludes:

The apparent universality of the Berlin-Kay color terms and apparent partial order in their temporal appearance strongly suggest that there may be some psychophysiological predispositions which determine, to some extent, the nature and evolution of the basic color vocabulary of any language.[328]

As indicated by his concluding remarks, Ratliff, assuming the conclusions of Berlin and Kay, attempts to explain these assumed phenomena by recourse to psychophysiology:

the view of the psychophysiological bases of universal color terms I have presented here (essentially Hering’s hundred-year-old ideas brought up to date) is that the perception of a single basic set of specific and distinct colors is common to all races of man; it is inherent in genetically determined structures and processes of the visual mechanism.[328]

Bornstein attempts to account for one aspect of the findings of Berlin and Kay, that many languages indicate diminished differentiation of the colour spectrum in the region of 475 to 520 nm (blue and green). He claims that “with increased proximity of societies to the equator, color names applied to short wavelengths (green and blue) become more frequently identified with one another”[257] because human sensitivity to the blue-green region of the spectrum diminishes due to protective intraocular pigments resulting from the change in sunlight. Ratliff rejects Bornstein’s thesis:

The difficulty with such an interpretation is that these differences in density of intraocular pigments are very small - perhaps little or no greater than that caused by the gradual yellowing of the lens of the eye between the ages of six and sixty. Therefore, effects on relative sensitivity to the blue end of the spectrum are also likely to be quite small, and effects on hue discrimination slight.[322]

Neither Ratliff nor Bornstein defend the Berlin and Kay theses against the extant charges, particularly the methodological ones. Both assume that the work was properly conducted and so has, with acceptable probability, confirmed their own theses.

The Berlin and Kay theses have remarkable staying power. Hardin’s book adds renewed credibility to their theses. Nonetheless, I believe it can clearly be shown that the psychophysiological theories which Hardin musters, and which I have
introduced in Chapter One and will return to in Chapter Six, do not confirm the larger thesis of Berlin and Kay that colour language provides at least a minimal bridgehead for cross-cultural translation. The criticisms initially directed against the Berlin and Kay thesis stand. Let us first review the importance of the Berlin and Kay work.

**Arbitrary or isomorphic**

*Basic Color Terms* marks a turning point in the approach linguists and anthropologists took to the study of languages. Prior to its publication, particularly in the fifties, ethnographic work was much guided by the cultural relativism of Franz Boas and his followers, and the subsequent cognitive relativism of Sapir and Whorf. In this regard, concerned primarily with linguistics and colour perception, the work of Berlin and Kay as much as anything has put the relativists on the defensive; since 1969 the burden of proof has lain with the relativists, a burden they did not carry in the decades immediately prior to this. Most everyone engaged in these debates, it sometimes seems, has had to say something about the work of Berlin and Kay.

What is most striking is the way this disagreement has been cast: as between extreme relativists on the one hand, making wild and clearly unsustainable claims, and on the other, the followers of the empirically evident evolutionary and universalistic claims of Berlin and Kay. A primary source for this casting is the historical discussion within Berlin and Kay's book. There they seem to argue that two assumptions about human (physiological and cognitive) response to the visible spectrum have been readily made and accepted prior to the close of the sixties. First, it was assumed (or assumed proved) that the divisions of the spectrum into discrete colours was wholly arbitrary. The anthropologist Verne Ray, in 1952, claimed that “There is no such thing as a ‘natural’ division of the spectrum. Each culture has taken the spectral continuum and has divided it into units on a quite arbitrary basis.”[258] In 1955, the linguist H.A. Gleason wrote that

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4 For instance, in his recent, brief review of Hardin's book, James A. McGilvray says the opponent-process theory “is supported by neurophysiological data; by psychophysical color discriminations in all the circumstances in which color discrimination is a factor...; and even by linguistic facts, such as Berlin and Kay’s color-name clustering data.” [329]
It is largely fortuitous that the spectrum came to be so divided, that the specific words were attached to the colors so distinguished. These irrational facts, with many others like them, constitute the English language. Each language is a similarly arbitrary system.[6]

In 1959, Eugene Nida, then considered one of the leading authorities on translation, wrote that "The segmentation of experience by speech is essentially arbitrary. The different sets of words for color in various languages are perhaps the best ready evidence for such essential arbitrariness."[13] And in 1968, R.N. Krauss wrote that "Our partitioning of the spectrum consists of the arbitrary imposition of a category system upon a continuous physical domain."[268]

The second assumption, while presented in *Basic Color Terms*, is less evident there, but is nonetheless made by other Berlin and Kay proponents in conjunction with discussions of their work. It was assumed (or assumed proved) that members of a society are presented with a complete and stable language which, in this case, determines the partitioning of the spectrum, as arbitrary as that may initially be. Rush Rhees, in 1954, claims that

I cannot learn the colour unless I can see it; but I cannot learn it without language either. I know it because I know the language....I can remember the sensation I had, just as I can remember the color I saw. I feel the same sensation, and this is the same color. But identity - the sameness - comes from the language.[81]

And Krauss concludes:

Here we have a clear case of speakers of different languages slicing up the perceptual world differently. And, of course, it is also the case that the kinds of slices one makes are related to the names for the slices available in his language.[269]

Not to do too great an injustice to these authors (for the term 'arbitrary' is ill-defined), it seems clear that the division of the visible spectrum is not, strictly speaking, arbitrary. Ray is quite right in saying that there is no natural division of the spectrum. But the further claim, made by all these writers, that each culture arbitrarily imposes linguistic categories on the spectrum cannot be correct, if "arbitrary" means capricious. Berlin and Kay, and their followers, have argued that not only is the division of the spectrum and the naming of the constituent parts not arbi-
trary, but it is isomorphic between languages: so (leaving aside for the moment the reasons offered why this is so) all people divide up the continuum in the same places. According to Berlin and Kay the basic colour terms designate the major divisions of the spectrum, and all languages conform to these divisions, though some languages (at a lower "evolutionary" stage) may have as few as two terms.

The cultural relativists, if arguing for this extreme position of arbitrariness, clearly must be wrong. But it is clear from comments within the discussions of arbitrariness that anthropologists and linguists do not mean caprice. They really only deny the isomorphism defended by the advocates of universality: our colour categories have something to do both with our psychophysiology (which is common to all cultures and languages) and with the purpose for which and the context (environment) in which we use such discriminations. Of this latter point, the relativists argue that purposes and contexts differ between language groups and cultures. There may then be similarities in languages as there may be similarities in purposes and contexts. And against the second assumption introduced above (that language is complete and stable), languages change and evolve just as purposes and contexts change.

Berlin and Kay, in arguing that the relativists are wrong, insist that there is an isomorphic relationship between languages regarding the division of the spectrum, and only speculate about what may be the reasons for this isomorphism. Subsequent writers, notable among them Ratliff and Hardin, offer substantive reasons for this presumed isomorphism, namely the division of the spectrum captured by languages, rather than being arbitrary (capricious), is the result wholly of our psychophysiology, of a particular aspect of our psychophysiology: colour opponency. As we all share the same psychophysiological features, our experience of the spectrum and our subsequent nomenclature is by and large the same. For the sake of brevity I will refer to Berlin and Kay and those authors who generally support their universalist theses against relativist or cultural theses as the new universalists.⁵

In point of fact, the authors cited by Berlin and Kay do provide fuller explanations of 'arbitrariness' than offered by Berlin and Kay and their proponents.
Gleason, for instance, also writes:

It is easy for an American to conclude that the English division into six major colors is superior to the two major divisions of Bassa. For some purposes it probably is. But for others it may present real difficulties. Botanists have discovered that it does not allow sufficient generalization for discussion of flower colors. Yellows, oranges, and many reds are found to constitute one series. Blues, purples, and purplish reds constitute another. These two exhibit fundamental differences that must be treated as basic to any botanical description. In order to state the facts succinctly it has been necessary to coin two new and more general color terms, *xanthic* and *cyanic*, for these two groups. A Bassa-speaking botanist would be under no such necessity. He would find *ziza* and *hul* quite adequate for the purpose, since they happen to divide the spectrum in approximately the way necessary for this purpose.[5]

This last phrase, that the two Bassa colour terms ‘happen to divide’ the spectrum goes to the heart of the confusion. Most Bassa are “botanists” of some sort and the importance in their lives for making the appropriate plant discriminations is encoded in their language. That Gleason first points out the importance of these colour divisions and then claims they are arbitrary suggests that ‘arbitrary’ here means *not biologically determined*, but freely chosen (even while this choice is made in accordance with practicality). More charitably, then, the debate is about the importance of physiology for colour perception; whether colour terminology is the sole result of physiological features (and so universal) or whether *in addition* to physiology, social and linguistic factors play a rôle. The debate, then, should not be whether our divisions of the visible spectrum and our corresponding appellations are ‘arbitrary’ or are isomorphic. The debate should be over how important the rôle of physiology, especially the opponent-process, is to colour perception and language. In what follows I do not offer a cultural or social account of why it is reasonable to expect different cultures to partition the spectrum in different ways. (I leave this for Chapters Four and Five.) What I offer instead is a fuller consideration of physiological fea-

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5 By using this term I do not mean to suggest that there is any uniform, let alone organized, group with members who put forward in various arenas the new universalist platform. This is a stylistic device to quickly refer to Berlin and Kay and any authors who may, at one time or another, defend their theses. Authors may come and go as they choose, and may challenge my so labelling them. Nothing hinges on whether or not anyone wants to be a member of the new universalists. What is important is that since 1969 many researchers in many disciplines have defended a universalist position, though even the definition or focus of the universal theories has changed.
tures, beyond those usually rallied in support of the universalistic arguments, features that undercut that argument.

Two tactics

In the introduction to their book, Berlin and Kay make explicit their conclusion that

a total universal inventory of exactly eleven basic color categories exists from which the eleven or fewer basic terms of any given language are always drawn....If a language encodes fewer than eleven basic color categories, then there are strict limitations on which categories it may encode.[2]

To reiterate: of ninety-eight languages investigated all demonstrated the same progressive development of basic colour terms, and of twenty languages further tested the foci of these terms are closely clustered, from which Berlin and Kay conclude: cross-cultural appellation is consistent, and evolutionary, and all humans respond to (partition) the visible spectrum in the same way (response is universal).

It is important to note that the claim about universality of foci selection is based on the empirical examination of only twenty languages. The extrapolation from the twenty to the additional seventy-eight languages, only holds for lexicon: there is no evidence regarding the location of foci for the larger group. Also, the claim about a basic and evolutionary language stock is based on the quality of the interpretation of extant ethnographic and linguistic work which was surveyed by Berlin and Kay.

Criticism of the Berlin and Kay theses takes two forms. First, it is possible to critique the work on the basis of the method employed by Berlin and Kay; which calls into question the possibility of concluding that they have proven anything at all, much less the cross-cultural and trans-evolutionary generalized conclusions they draw. Much has been written about the methodological failings of their work; detailed and extensive criticisms began to appear immediately, as early as 1971, in the first round of reviews of their work.6 Second, it is possible to critique on empirical rather than methodological grounds the conclusions they draw from their
research (regardless of any failings in the research itself). There is counter-evidence undermining their conclusions, demonstrating that there are other theories which better account for their findings. This second approach has enjoyed less popularity than the first. In parallel fashion, defenses of the Berlin and Kay theses have focused either on providing supportive research which avoids the methodological shortcomings of the original work or on justifying (demonstrating the adequacy of) the original work.

The point of discussing this debate here is to demonstrate a particular methodological error which is pervasive in the social sciences, psychology, and studies of perception. Phenomena can be isolated and studied, with interesting results, but what is then studied is isolated phenomena. The two critiques distinguished above are most effective in conjunction. To this end I will briefly outline some of the extant methodological critiques.

**Boundaries, categories, and foci**

The extensions or boundaries of colour terms are quite a separate matter from foci. As Berlin and Kay note, "In marked contrast to the foci, category boundaries proved to be so unreliable, even for an individual informant, that they have been accorded a relatively minor place in the analysis."[13] Hardin, in turn, argues that boundaries are not "fixed rigidly" and "although biology and culture both have a part in the establishment of these boundaries, context and purpose play the leading role".

6 In the criticisms that follow I present only a sketch of the objections raised against the method of Berlin and Kay. For more detailed accounts of the problems present in Basic Color Terms the reader is directed to articles which take these up more fully. Progressing from the earliest critiques of Basic Color Terms several are particularly commendable: Hickerson, 1971; Conklin, 1973; Sahlins, 1976; Ratner, 1989.

7 Kay and McDaniel [1978] argue that this problematic aspect of boundaries can be reined in by analyzing the original 1969 data in terms of fuzzy set theory. Inclusion in a set or category is not categorical - standard set theory says an element either is or is not a member of a given set, while fuzzy set theory allows degrees of membership. Kay and McDaniel suggest as examples the denotation of congressman for the former and gourmet for the latter. They see correspondence between fuzzy category inclusions and the opponent response sensitivity (visually displayed against wavelength): the greater an individual curve varies from zero the greater degree of inclusion a corresponding colour chip receives.
2.2 A representation of the Munsell colour chart.

roles."[171] The presumption is that all humans with normal vision see light between about 400 and 700 nm as colour, and that we equally see surface and aperture colours. The array of Munsell chips used by Berlin and Kay presents some problems in eliciting responses for all colour terms, but we can employ it here for illustrative purposes. If not a complete mapping of our colour experiences, these 330 colour chips are at least a large enough portion to demonstrate how categories map.

There are two possible ways this space can be divided into categories. It is possible that every chip falls within one category or another, when all the basic colour terms are mapped there are no unaccounted for chips. In this case the colour term categories are contiguous. It is also possible that not all chips are captured by one or another of the colour categories of a given language. In this case the colour term categories are not contiguous. There is little evidence of this second possibility. Heider reports that the Dani had several colour terms in addition to mili and mola, but that there "was no indication of a term for the 'green' area of the spectrum, nor did the denotation of jualegen [blue] extend into the green area."[1972a, 451-456]

However, the Dani are able to refer to the green area of the spectrum as mili.

It could be the case that all languages have eleven basic colour terms (categories) that have contiguous boundaries (as with English). This is of course not the case; the colour space is divided differently between language groups. Many languages have fewer terms or terms that incorporate different components of the visual world (as Dani incorporates brightness and hue, and many languages have terms
for variegated surfaces). Such languages must have either unnamed chips (parts of the spectrum) or categories with greater extension than those categories of languages with more terms. Berlin and Kay postulate languages with as few as two terms, all with contiguous boundaries. Consider Heider's discussion of the Dani colour terms *mili* and *mola*. Whether or not Dani have an abundance of other colour terms, these two terms divide the colour space in a way quite different from any terms in English.

When we look at the array of Munsell chips we are quite certain about the best exemplars (the foci) of each colour category. We are much less certain about the crossover between categories, about where the boundaries lie. Indeed, the boundaries may vary greatly from observer to observer and, for the same observer, between contexts. Should a term that maps all the orange, yellow, green, and blue chips be translated as equivalent to English yellow or green? Clearly not. Boundaries are much less certain than foci and are not an indicator of foci of the category. Paul Kay has subsequently authored and co-authored papers which employ two strategies to address these issues. First, with McDaniel he has introduced fuzzy set theory as a way of making explicit the uncertainty we experience at the boundaries of colour categories and of placing greater importance on foci for determining each category. Second, he has shifted the discussion from foci to the neurologically determined crossover points between unique hues. This neurology will be discussed in the next chapter. As employed by Kay and McDaniel it is essen-

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8 However, their interpretation of the ethnographic record is suspicious for all nine of the languages they identify. Four are related New Guinea Dani from research that predates Heider's criticism that ethnographers have generally failed to identify all the terms, five are suspicious simplifications of more robust vocabularies reported.

9 We may group a boundary yellow-green with yellow and call it yellow, or with green and call it green.
tially a vehicle for arguing for the rigidity of foci and boundaries: "the locations of the basic category foci and their absolute boundaries are universal."[624]

The first strategy allows Kay and McDaniel to account for our varying feelings of certainty when determining the membership of any chip on the colour array. At the foci we are certain and a chip has full membership (for example, 'is yellow'); at the boundary we are less certain and a chip has partial membership ('sort of is yellow'):

Each category is thus distinguished by the set of color percepts which are assigned some positive degree of membership in it. The general structure of these categories, as shown in their pattern of membership assignments, is such that, as one moves through the perceptual color space from the focus of a category toward its boundaries, there is a continuous and gradual decline from unity to zero in the membership values of successive color percepts.[624]

Foci and the determination of neurologically unique hues, then, are the important determinants for colour categories. This is an easy task for those fluent in English.\(^\text{10}\) The burden for demonstrating their theory lies with the determination of foci, with their sub-group of twenty languages. Berlin and Kay claim to have sufficiently demonstrated this, but, as we shall see in the next section, there are serious questions surrounding the method used with the sub-group. Without identifying the foci of each colour term it is impossible to determine how that term relates, for instance, to English. We cannot determine whether it is equivalent to any English term let alone to what term. This is a major failure on the part of the new universalists: adequate and extensive testing of foci has not been carried out for other languages since 1969.

Further, the ability to pinpoint unique hues is quite separate from the use we make of such terms when referring to colours between those unique wavelengths. This indeterminacy sets colour terms apart from other names we employ. Berlin and Kay get into trouble when they assume that meaningful and practical translation is

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\(^{10}\) This is in part because English provides the base line for the Berlin and Kay theory, rather than, for instance, Russian or Hungarian, and in part because of cultural familiarity with such practices.
2.4 The devolution of evolutionary basic colour terms.

captured by identification of foci. The boundary terminology, determined by context and purpose rather than by physiology, carries the real work load in colour language.

**Methodological difficulties**

I will consider five central criticisms regarding the claims made by Berlin and
Kay and of the method employed to establish their claims. The first two of these concern their sample size and representativeness, the second two their definition of the basic colour lexicon, and the fifth their claims about translatability.

1. Sample size

Berlin and Kay do not systematically identify the numbers of informants for each of the twenty language samples they tested. In passing, they do mention that they had only a single informant for each of Cantonese, Korean, and Japanese; that is, fifteen per cent of the samples tested consisted of one informant. This percentage may in fact be greater: “Often we had access to only one informant for a language.”[7] And they indicate that the largest sample, of Tzeltal Indians, had forty informants. It may be argued in defense of these sample sizes that the cultural pervasiveness of colour terminology is such that variation between individuals within a culture may be expected to be minimal. In fact, Berlin and Kay do a cursory test of the Tzeltal for such variance, and conclude that it is greater between language groups.11 However, such a defense assumes that informants operate in cultural isolation, free from acculturation, specifically of foreign colour terms.

2. Sample representativeness

Much is missing in the account given by Berlin and Kay of the work on which they base their theses. It is suggestive that in the years since the publication of Basic

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11 Nothing much hangs on this demonstration as ten speakers of Tzeltal were compared against one speaker for each of three other languages, and the inter-language difference was only marginally less than the inter-informant difference. Berlin and Kay note that among the Tzeltal there is a greater variance of foci determination than between groups. The existence of colour systems such as the Munsell chips suggests the same: that the extension of colour terms is not uniform.

12 Indeed, the recently published soft cover edition of Basic Color Terms is an identical reprint, complete with all the typographical, mechanical, and research errors of the original. The only alterations are a two page preface and an incomplete bibliography of writings on the matter since its publication. In a sense Berlin and Kay are right when they state that “the volume of research that has taken place in the area of basic color terms in the past two decades has rendered it unfeasible for us to revise the original text for this printing.”[1991, v] Once they begin to correct the mechanical and factual errors in the work there is no end to it. Ultimately the whole work must go, including especially their interpretation of the extant ethnographic literature and the conclusions they draw throughout the work.
Color Terms this account has not been filled in.\textsuperscript{12} The Tzeltal were the only informants tested in their native locale. All informants of the other nineteen language samples lived in the San Francisco Bay Area. All informants were native speakers of the language for which they were tested, but were bilingual. No other information is given regarding them. We do not know how many informants they tested (in total and for each language sample), how long they had been living in the United States, how much they had assimilated of new forms of conceptualizing, how much of their native tongue they retained or regularly used, whether or not they still thought in their native language. The possibility and extent of acculturation could not be determined in any case from the minimal sample sizes employed by Berlin and Kay. Questions about representativeness, therefore, cannot be discounted. Other questions regarding the representativeness of the two sample groups (the twenty tested by Berlin and Kay, and the encompassing ninety-eight including seventy-eight drawn from ethnographic literature) may be raised.

In her 1971 book review, Nancy Hickerson raises this and other methodological objections. Of particular interest is her analysis of their stratified sampling, of the disparity between the sub-group of twenty and the whole group of ninety-eight. She argues that even if the sub-group of twenty “were optimally selected by such criteria as geographical distribution, diversity of language families, or known variety of structural types” this would not be adequate support for the universal claims made by Berlin and Kay, given that “there are an estimated 3000 languages spoken at the present time.”\textsuperscript{260} The sub-group is poorly selected on these three criteria and so is not representative of the target population (all languages). Further, the total group of ninety-eight languages exhibits a different bias from the sub-group; it represents different geographical distribution, diversity of family languages, and structural types.\textsuperscript{13} This makes it impossible to extrapolate from the sub-group to the world population concerning colour foci and impossible to extrapolate from the total group regarding lexicon and categories, given that the sub-group which is intended to provide a base line for translation is not properly representative.\textsuperscript{14}

\textsuperscript{13} She notes that neither sample is well chosen on the basis of geography or language family classification. There are 38 African, 23 Australian and Oceanic, 17 American Indian, 13 Asiatic and 7 European.
3. Aperture colours
The most problematic aspect of their determination of a basic lexicon is their assumption that colour terminology must fundamentally refer to aperture colours, and not to surface colours (that is, colours which cannot exist except in relation to surface texture; just as the blue of the blue jay is a product of the texture or structure of the feathers). This assumption, in turn, is built into their account of colour lexicons and thus determines the subsequent reduction to 'basic' terms. Colour terms that refer to pure spectrum colours are considered by Berlin and Kay as basic, all terms that refer to colours in any other context are counted as secondary, derivative and combinatorial. The simplest linguistic lexicons reflect fewer fundamental discriminations between perceived colours, so that initially the world is only characterized by brightness and darkness. The most sophisticated and terminologically rich dis-

14 In a remarkable display of prescience of the way the debate has continued for twenty-five years the International Journal of American Linguistics published Hickerson's review with another by Newcomer and Faris. While Hickerson gives a thorough and decisive criticism of the Berlin and Kay research, Newcomer and Faris give a round endorsement of the book while indicating concerns over method. Basic Color Terms should have died a quick and quiet death after Hickerson's detailed critique; her criticisms still stand and have yet to be directly addressed. Newcomer and Faris claim of the semantic universals and evolutionary ordering theses that either of these findings would be startling, but attending both in a single small book is truly amazing, and immediately raises questions. In this review we will discuss what it is that they have done and will raise some basic and, we feel, important questions about the theory and methods adopted by the authors.[270]

They continue that there are issues of “potential bias”[272], that there are "many errors of fact in the book, disturbing since the work is in essence merely an arrangement of facts”[272], and that "Berlin and Kay claim to have disproved the hypothesis of linguistic relativity, but in point of logic, they have not.”[272]. Despite these worries they describe the book as “ostensibly significant and important”[270], argue that "challenging the facts is likely to leave the overall study largely intact”[273], and throughout accept the research as given. The acceptance by Newcomer and Faris of the research claims of Berlin and Kay, despite the recognition of serious methodological errors, typifies the debate.

15 There are no blue birds on this planet. The blue that we perceive the blue jay to be is the result of reflected light, not of pigment. A feather, lit from the front so that the light is reflected off and to our eye, looks blue as the result of the structure of the feather. It is designed to trap air or water as insulation. Light reflecting off the feather is broken up as it is in the atmosphere. The same feather, lit from behind so that the light passes through it to our eye, will appear brown. The pigment in the feather is a broken hue and not the pure blue we think.
criminations are reducible to the eleven basic terms, upon eliminating combinations and mutations of these terms, and any colour term which is also the name of an object (salmon, peach, aqua) or a recent loan from another language. This presupposes a criterion for determining which colour terms will count as basic, according to which individual responses will be discounted as basic. Given this reduction Berlin and Kay report that

In addition to the fact that the stages of complexity of color vocabulary have a temporal ordering, there appears to be a positive correlation between general cultural complexity (and/or level of technological development) and complexity of color vocabulary.[16]

In point of fact, both this determination of 'basic' colours and the implementation of the criteria for identifying 'basic' terms or linguistic correlates are arbitrary. In general, European languages reflect a historic interest in colour perception. We consider hues produced by a prism 'pure' colours, the spectral quality freed from substantial context. We treat colours so produced as fundamental, as prior or superior to colours experienced by reflected light. The terminology used to designate these hues is likewise designated by Berlin and Kay as fundamental. However, other colour terms, which designate surface colours, are not considered reducible to or extensions of terms designating spectral hues.[17] To treat terms thus and sharply distinguish them from borrowed terms runs counter to some standing notions of the role of metaphor in language enrichment.[18] It seems just as reasonable to suggest that what are taken as basic colour terms, with the possible exception of black and white, and perhaps red, all emerged through metaphoric (or other)

16 Societies have been arranged according to the reducibility of their basic terms and it is assumed that linguistic developments arise, evidenced by the production of new basic terms, as the society develops. In Chapter Three, I give a fuller consideration of ethnocentrism and imperialism, suggested here by the choice by Berlin and Kay of English as the base or norm against which the development of other languages is judged. It is interesting to note that of the ten stage VII languages 'completely developed' (with eleven basic terms) seven are European or colonial European, West Asian, or Middle Eastern. No European languages appear with fewer than eleven terms.

17 Berlin and Kay offer eight criteria for determining basic terms; in fact, elimination rules. These criteria are ranked in two ordered sets of four. If, after an application of the first set the status of any term remains doubtful, the second set of criteria is to be applied. That in each set there is a criterion for eliminating terms associated with objects suggests the importance given by them to spectral hues.
extension from the name of a thing or group of things. There are serious methodological problems with the rest of the Berlin and Kay work, so conclusions cannot be drawn from their work. Given their criteria for determining basic terms, all they could have shown is that many other languages do not have terms which are reducible to English or European colour terminology, that there is not a set of universal colour terms. I will return to this point at the end of the next section.

4. Reduction criteria

In addition, if consistently applied, the criteria established by Berlin and Kay for determining basic terms would discount several of the terms they identify as fundamental. This, in turn, calls into question their notion that increases in the complexity of the basic lexicon (that is, in the ability to discriminate between colours, and use such discriminations) follows upon the progressive increase in the complexity of a society, as viewed from a Western European stance. For example, we might be quite willing to accept their rejection of the term ‘aqua’ from our basic set. However, my Oxford English Dictionary suggests that I should also reject ‘orange’ and ‘purple’, two of the eleven identified basic colour terms. By their criteria orange is a borrowed term, from Arabic or Persian. And in the more lush climate from which these languages arose, it is conceivable that the term originally had a specific application, to a fruit. On either count, in keeping with their basic-secondary distinction, orange should be rejected as a basic term. Purple comes from the Latin name of a mollusc, the purpure purpuram, which yields a ‘purple’ dye. Also, the etymol-

18 I am thinking here of dead metaphors. Consider this example from Davidson: Once upon a time, I suppose, rivers and bottles did not, as they do now, literally have mouths. Thinking of present usage, it doesn’t matter whether we take the word “mouth” to be ambiguous because it applies to entrances to rivers and openings of bottles as well as to animal apertures, or we think there is a single wide field of application that embraces both. What does matter is that when “mouth” applied only metaphorically to bottles, the application made the hearer notice a likeness between animal and bottle openings.[35] Many colour terms suggest similar histories of internal borrowing.

19 By West I mean that culture (the cultures of Europeans, their descendants and colonies) of which Berlin, Kay, Hardin, Munsell, Young, Helmholtz, Jameson, Hurvich and myself are members; in addition, all those who’s primary understanding of colour results directly or indirectly from exposure to the work of those specifically listed.

20 See the fuller discussion of purple and dyes in Chapter Five.
ogy of green suggests a link via the Germanic ‘gronjaz’ to ‘grow’ and that of yellow suggests a link via the Indo-European ‘ghelwo’ to ‘gold’. That these terms entered our vocabulary long ago and gained broad extension does not weaken the point that under the criteria Berlin and Kay have identified, they ought to be discounted along with aqua.

If such a reduction is carried through, English should be considered more ‘primitive’ than many of what Berlin and Kay class as ‘primitive’ languages. It may be appropriate, in consistently applying their criteria, to reclassify English as a Berlin and Kay stage VI or V language with as few as seven basic terms. Such arbitrary application of the criteria is not exclusive to English. For example, the Bahasa Indonesian terms ‘oranje’ [orange] and ‘tjoklat’ [brown] are allowed; and Russian and Hungarian, both of which exhibit twelve term basic vocabularies, are treated as exhibiting eleven term vocabularies. 21 Many foreign loans, not counting as basic in their native language, will satisfy three of the four primary criteria. Consider the addition of ‘chocolate’ to a language which previously did not distinguish brown. The term is monolexemic, its signification is not included in any other colour term, and its application is not restricted to a limited class. Of the primary criteria, then, the determining characteristic is psychological salience. Unless salience can be determined, all borrowed terms must be held in doubt (and a secondary criterion for elimination is ‘recent foreign loan words’). Berlin and Kay do not address the issue of determining such salience. Instead, seemingly arbitrary decisions of inclusion and exclusion are made. While I have identified a substantial number of problematic terms, they claim “there is no counter-example to the finding of universality of the eleven color category foci, and there are just six serious candidates for counter-examples to the evolutionary ordering...”[45] none of which are the cases I cite.

21 The two distinct Russian terms for blue, indicating dark and light blue, suggest a twelve term basic vocabulary. It is indicated that the term for light blue may be a legitimate recent addition, yet it is treated as a secondary term rather than as an evolutionary development, a further discrimination of the spectrum. Hungarian has two basic terms for red. By contrast, Berlin and Kay, without presenting reasons, treat the two basic terms for red as red1 and red2, thus fitting Hungarian to their schema of eleven basic colour terms. Consider also: Arabic, lailki [purple]; Bulgarian, kafjavo or kafyavo [brown], oranz [orange], rozovo [pink], moravo [purple]; Mexican Spanish, café [brown]; Tagalog, liila [purple], rosas [pink]; etc.
5. Translation
The strength of their thesis regarding translation is based on the extrapolation of the results of standardized testing to additional ethnographic reports. The wavelength specific foci identified in the twenty tested groups is imputed to another seventy-eight. This is based on their belief that the extension of foreign colour terms, at least for these considered languages, is similar to that of English terms, that is, on a claim about the intertranslatability of colour terms: "color words translate too easily among various pairs of unrelated languages for the extreme linguistic relativity thesis to be valid." Berlin and Kay indicate a difference between the extension of common English terms and their basic terms by printing their eleven basic term translations in upper case. Though these eleven basic colour terms printed in upper case look familiar, they are not equivalent to the lower case common English terms. The terms gathered by ethnographers for the additional seventy-eight languages are provided by the individual ethnographers with common English glosses (in lower case).

Given that Berlin and Kay have no evidence indicating where the foci lie for colour terms in the additional seventy-eight languages and that there is counter-evidence within their sub-group for a belief that foci are centrally located within extension, the overlap between colour terms across language must be in terms of gross extension. A term for red in a three term language must be located in the same region of the spectrum as English red, or the sum of all such terms in all languages must map roughly onto one another - this area to be designated RED. Now consider the Procrustean translation which Berlin and Kay documented.22

What is at issue in an adequate translation is the extension of terms, and the translation of that extension. The fewer the basic colour terms in a language, the greater the extension of those terms and the more difficult the fit to English or any other language in translation. To translate the terms of a two term language as BLACK and WHITE should not presuppose that their extension is the same as for English 'black' and 'white'. This is more obviously the case for a single term with extension from, for instance, dark red through orange and yellow to green and blue-green. Without the presence of informants who can point to the best foci on a

22 Hickerson describes the translation in this manner. [268]
colour map, how are we to determine an English equivalent gloss? Should we gloss this space as yellow (the middle term), or as orange (the middle space), or as red (the more ‘evolutionary’ basic term)? Do any of these glosses not do damage to the notion of isomorphism and transitivity?

In the absence of any established standards for determining the accuracy of the glosses either by the ethnographers or by Berlin and Kay, the task Berlin and Kay took up was that of providing a translation of those glosses into their eleven basic terms. Yet they fail to treat this basic lexicon as fundamentally different from common English colour terms. A broad spectrum of colour glosses are assimilated to terms with narrower or different extension. To achieve this, Berlin and Kay strain the fit of ethnographic glosses to their eleven basic terms. This is their Procrustean feat.

For example, Berlin and Kay collapse the distinction between white and black and brightness and darkness. Yet the equivalence here is dubious. Often the terms so glossed are determined by illumination and reflectance. Well lit, shiny black objects can look lighter in colour than dimly lit, absorbent white objects, but are not necessarily to be identified, on this basis, with ‘white’ objects. Ethnographers working with two and three basic term languages use terms such as dark, dark shades, dark green, dark blue, dark colours, dull, bright, light, light shades, light blue, illuminated, all light colours, green, yellow; Berlin and Kay translate these glosses as BLACK and WHITE.[46-62] What is suggested by the terminology of the ethnographers is not a distinction according to hue, but rather of relative brightness.

The basic term RED covers the glosses reddish, gold-like, maize colour, pink, orange, brown, purple, maroon, and yellow. GREEN covers light brown, orange, blue-green, and all yellows and greens.[53-70] Frequently, ethnographers report that a single term in a language extends equally over blue and green. In all such cases Berlin and Kay translate the glosses as GREEN. Berlin and Kay subsequently adopted GREY to cover such cases. In one case Keith Basso, reporting on Western Apache, indicates that the term glossed as GREEN covers the color of turquoise, which can range from light sky blue to rich ‘Kelly’ green; the color of all grasses...the color of all bush and tree leaves; the color
of the eyes of an Appaloosa horse (perhaps the lightest blue there is); the color of an under-water algae...which is perhaps the darkest green.[Berlin and Kay, 43]

The Berlin and Kay basic terms, designated by upper case, are not equivalent to the common English lower case terms, though they treat them as equivalent. Nor are they equivalent to any other single language. Tailored to embrace all ninety-eight languages, the Berlin and Kay basic colour terms are ultimately equivalent to no language. Moreover, there is considerable ambiguity and overlap between the constructed terms of this language; the English term 'green' may designate, liberally, a range from 560 nm to 485 nm, whereas the Apache term duklz may designate a range from 560 nm to 450 nm. Both are translated as equivalent to GREEN.
CHAPTER THREE: COLOUR AND PHYSIOLOGY

As I suggested in the last chapter, there are two distinct although related claims made by Berlin and Kay on the basis of their glossed sample of colour terms. They claim to have observed certain phenomena of relation and ordering, and make only tentative explanatory suggestions as to the causes which may underlie those phenomena. All the extant charges concerning method stand. Yet the theory has always had supporters. For instance, in 1978, Ralph Bolton had the confidence to write:

It would appear, then, that the available evidence to date permits certain conclusions. First, it is clear that most color lexicons do fit into one of the seven types described by Berlin and Kay originally; even fewer exceptions remain when a proposed revised set of types is employed (Berlin and Berlin 1975; Dougherty 1974; Kay 1975). Second, these seven types can be arranged into an evolutionary sequence of stages that correlates with societal complexity. Third, color lexicons expand by adding new Basic Color Terms in the order predicted by the evolutionary hypothesis. And fourth, the learning of color terms by individuals follows essentially the same sequence as the evolutionary one.[288]

Arguments that Berlin and Kay have correctly described this phenomenon of colour language and categorization tend to appeal to subsequent research, and so avoid questions of how they came to make their claims. At issue, then, are the two questions of description and explanation, each based on two distinct bodies of evidence. Regarding description, the first body of evidence (the ninety-eight compared languages in Basic Color Terms) led to a series of descriptions by Berlin and Kay (their theses, discussed in the last chapter, and partially reiterated by Bolton). The second body of evidence (a sub-set of other ethnographic work on colour languages) has led others to conclude that the Berlin and Kay description is confirmed and remains applicable. This avoids questions surrounding their own evidence by making appeal only to their description. Regarding explanation, the first body of evidence (the ninety-eight languages) led to very tentative suggestions by Berlin and Kay comparing cultural and biological development of sound and colour. The sec-

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1 This at the same time that Kay and McDaniel (1978) were recasting the original theory in terms of fuzzy set theory, in an attempt to deal with what they recognized as serious difficulties with the fit of the theory to the original and subsequent research.
ond body of evidence (work in psychophysiology and neurophysiology) has led others to conclude that the Berlin and Kay description can be explained and so confirmed. My contention is that the methodological problems, especially with the determination of basicness, are so severe that Berlin and Kay, by so extensively distorting the phenomena, have failed in providing even a description. Subsequent ethnographic work which adopts the criteria set out by Berlin and Kay equally fails. This leaves the issue of explanation. Is it possible that despite their worst efforts their broader theses can be confirmed by recourse to physiological factors?

There is an argument among the descriptive claims made by Berlin and Kay:
1. They interpreted the ethnographic record (the seventy-eight languages studied) as conforming to the staged or evolutionary development of eleven basic terms.
2. They observed members of twenty language groups pointing to clusters of colour chips among a test field.
3. They concluded from their observation that colour term foci are universal.
4. They concluded from their interpretation and their observation, conjointly, that colour terms are universal across languages.
5. They concluded, further, that colour terms are translatable between languages (and that in general languages are translatable).

Following the lead of others, I have demonstrated in the last chapter how the first premise fails on the basis of the strain of fit between the ethnographic record and the eleven colour term glosses. It fails because Berlin and Kay fail properly to interpret the record. It also fails because the selection of basic colour terms incorporates an aperture colour bias, which I will discuss below. This means that Berlin and Kay are not testing all possible colour terms and so cannot draw universal conclusions. Confirmation of the third claim is suggested by the opponent-process theory, however this move fails to provide sufficient grounds for the fourth claim. Questions surrounding the sub-group of twenty make it impossible to extrapolate universal generalizations. I discuss both issues in this chapter. I will show that the opponent-process theory does not confirm either the universality of terms thesis or the universality of foci thesis. (Though this latter may be confirmed by the opponent-process theory it cannot be on the basis of the Berlin and Kay work.) This means that the fourth claim is left unsupported and so also fails, as does the fifth
claim for the same reason. I will conclude this chapter with discussion of these last two claims, though the fifth is really not a concern of the present work.

Hardin's basis for crediting Berlin and Kay with establishing universality of foci and categories is not their own research and findings, but independent support he believes that their conclusions receive from recent work on and acceptance of the opponent-process theory of colour perception. While the opponent-process theory does have its critics, and there is disagreement about its finer points, it has widespread acceptance. Hardin himself is clearly among its supporters.

**Receptor–neural linkages**

To refute the argument from colour opponency we need to know more about this theory of colour vision. The linkages between light receptors and neural signals are critical to establishing unique hues. These linkages also demonstrate why this argument fails. The opponent-process theory postulates a differentiating light receptor system. Though the three types of cones are misleadingly thought of as responding roughly to blue, green, and red, they are variously sensitive to great portions of the visible spectrum each with peak sensitivities to either short, middle, or long wave radiation. In turn, the signals produced by these three types of receptors are more properly designated by S, M, and L, or by the peak wavelength sensitivity of each. As noted, the Young–Helmholtz theory does seem to be an accurate

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2 Hardin is by no means the first to attempt this redemption. Paul Kay and Chad McDaniel made such an attempt in their 1978 paper, and though he is critical of the Berlin and Kay theses, Marshall Sahlins also gives an account of the relation of colour opponency to term foci. It is notable that Hardin's bibliography makes scant reference to the voluminous literature on Basic Color Terms, and no reference to any of the subsequent works by Berlin, Kay or their collaborators.

3 Though in my representation of Berlin and Kay's argument the evolutionary development thesis is a premise unsupported by the foci thesis, some commentators have suggested that the opponent-process theory confirms the foci thesis and the evolutionary development thesis [Bornstein 1973, Ratliff 1976, Kay and McDaniel 1978, Hardin 1988]. This confuses the foci sub-group of twenty with the total group of ninety-eight. Berlin and Kay only tested foci with the sub-group, and there has been little additional testing in the years since. There just is inadequate evidence for extrapolation to all languages.
description of activities at the receptor level. This theory suggested that the outputs from each type of cone were combined, their products accounting for various colour discriminations. The opponent-process theory attempts to account for residual difficulties with the additive theory. Both Helmholtz and Hering were correct in their differing descriptions of the mechanics of colour vision. Their two positions can be reconciled, and not just because they similarly propose tripartite colour systems. The differences between these systems involve different levels of colour vision. It is important to consider in what way the current research has reconciled three cone types with four primary or unique colours. There is increasing evidence that with higher level, or post-receptoral, cells of the visual system, differentiation (rather than mixture) of the neural output of various cones determines our colour response.

Both Young and Helmholtz assumed there were three and only three cone types because of indirect evidence to this effect, for instance, the necessity and sufficiency of three differing wavelengths in producing all the spectral colours. Only since the 1960s, with the aid of microspectrodensitometry, has there been the beginning of accumulated direct evidence that supports this assumption. A very narrow beam of light is directed at individual receptors removed from the eye. The four types of receptors (rods and cones) function by absorbing light quanta in distinctive and different amounts, with characteristic peak wavelengths. As with paint pigments they do this by means of photopigments. The absorption spectrum of the receptor is determined by varying the wavelength output of the beam through the entire visible spectrum. This directly determines response curves like the indirectly determined curves used by Young and Helmholtz. Not surprisingly there are minor but distinct
differences between individual sets of human eyes. There are also only three characteristic curves. The three types of cones, differentiated by the three differing absorption responses of their photopigments, are labelled $\alpha$, $\beta$, and $\gamma$ carry subscripts that indicate the statistically mean wavelengths at which absorption is maximal. The evidence here underscores the problem with the use of colour, rather than wavelength, nomenclature for photopigment sensitivity of cones. The subscripts correspond with the alternative labelling introduced above: $L =$ long wave, $M =$ middle wave, and $S =$ short wave.\(^4\)

Opponent theories postulate interactions between the four receptors, prior to what would count as colour coding. Spectral distributions the paired chromatic responses can be derived by effectively cancelling the sensation of one half of a pair with an appropriate amount of the other half. In 1957, Hurvich and Jameson described the procedure in this way:

\begin{itemize}
  \item In brief, a wave length is first selected that evokes, say, a blue hue response.
  \item The observer then views, in turn, a series of spectral wave lengths that appear yellowish in hue (yellow-greens, yellow, yellow-reds). To each of these yellow stimuli just enough of the previously selected blue stimulus is
\end{itemize}

\(^4\) In this section I will follow, in part, the symbolism employed by Hurvich and Jameson of $\alpha$, $\beta$, and $\gamma$. Because the discussion does not only concern peak absorptions, and as I emphasize throughout that receptors respond to broad bands of light, I will ultimately adopt the less cumbersome $S$, $M$, and $L$. 
then added exactly to cancel the yellow hue without introducing any blueness. The observer simply reports when the test field appears neither yellow nor blue. Knowing the energies of the series of spectral yellow stimuli, and having determined experimentally the energy of the blue stimulus of fixed wave length that is required for the hue cancellation in each case, we can now plot the distribution of the relative magnitudes of yellow hue response evoked by the various test wave lengths. [122]

This is plotted with the achromatic responses (associated with the distribution of brightness over the spectrum) and arranged for comparison with the three absorption curves. This comparison effectively demonstrates the linkages between the receptors at the neural level and prior to colour coding. (This is not a demonstration of the mixing of colours or colour sensations, but of electrochemical responses affecting the three paired colour-response systems).

Following Hurvich, we can now calculate for any combination of wavelengths the responses of each of the receptors and determine what the combined signal will be. For any specific wavelength we can calculate the response value (colour sensation) given that we know the absorbances of the three cones. The formula, where the first of the binary colour terms is a positive algebraic total, is:

\[
\begin{align*}
\text{yellow/blue} &= [\beta_{530} + \gamma_{560}] - \alpha_{450} \\
\text{red/green} &= [\alpha_{450} + \gamma_{560}] - \beta_{530} \\
\text{white/(black)} &= [\alpha_{450} + \beta_{530} + \gamma_{560}]^5
\end{align*}
\]

The absorption of light quanta by each of the three photopigments can activate three kinds of neural responses: \(\alpha_{450}\) activates blue, red, and white; \(\beta_{530}\) activates yellow, green, and white; \(\gamma_{560}\) activates yellow, red, and white.
The formula is derived by working back and forth between sensitivity and absorption. For the observer plotted, at 430 nm the absorption of $\alpha$ is 100, of $\beta$ is 30, and of $\gamma$ is 25. The yellow/blue output is $(30 + 25) - 100 = -45$ or blue for the opponent response sensitivity and the red/green output is $100 + 25 - 30 = 95$ or red for the opponent response sensitivity. The sum of the three values is positive so the response is white. This sum is always positive, since we are dealing with light; the important variable is how great is the sum. Given the individual sensitivities (and allowing for the arbitrary adjustment of the absorptions) the observer will experience a reddish-blue with a slight white component. At 540 nm the observer will experience a green with a significant yellow content, and at 660 nm red. At this level of neural output it first begins to make sense to use colour terminology.

Among proponents of the opponent-process theory there are variations according to detail; Hardin provides the following schema of opponent systems (after R.W.G. Hunt):

$$(L + M) \text{ is the achromatic signal.}$$
$$(L + M) > 0 \text{ codes whiteness;}$$
$$(L + M) < 0 \text{ codes blackness;}$$
$$(L + M) = 0 \text{ codes for "brain gray", as do all '0' values.}$$

$$(L - M) \text{ is the red-green signal.}$$
$$(L - M) > 0 \text{ codes redness;}$$
$$(L - M) < 0 \text{ codes greenness.}$$

$$(L + M) - S \text{ is the yellow-blue signal.}$$
$$(L + M) - S > 0 \text{ codes yellowness;}$$
$$(L + M) - S < 0 \text{ codes blueness.}$$

The important and essential feature of all theories of opponent systems is that when one system is equivalent to zero, and registers neutral, the other system will register a unique hue. So when the difference between the long and medium wave equal zero, and the sum of them less the short wave radiation is less than zero, we see a blue without any other

5 'White' as used here refers to the white light of the sun (which is not really white, but light devoid of hue). This is really a brightness response, indicated by the parenthetical 'black'. Casual observation of a spectrum will demonstrate that the midsection (yellow) is brighter than the extremes (blue, red). Typically such spectral yellow is also less saturated than spectral blue or red (saturation just is a function of the white content).
colour: unique blue.

The argument for colour language is that the physiological evidence of unique hues corresponds with the colour categorization (foci and language) described by Berlin and Kay: colour opponency provides the physiological explanation for their observations. Before addressing that claim, it is clear that under proper conditions, usually in comparative tasks, we are able to identify our own unique hues. The argument I am setting up is that unique hues are a special case, that additional physiological evidence of visual perception makes this point even more obvious, and that this further weakens claims that physiology supports the Berlin and Kay theses. I begin next to consider additional physiology.

Unique hues

The graph plotting opponent response sensitivity against wavelength is an arithmetic transposition of a logarithmic representation of cone responses. The technique for plotting cone response involves an observer viewing narrow spectral bands in a dual arrangement of monochromators. A monochromator is a device that splits a beam of white light into spectral bands; an observer, looking through a short focus telescope, may adjust the device so that a varied amount (energy) of any narrow band is presented. The assumption in this experiment is that there are two opponent systems of four colours. The aim is to cancel one colour with its opponent colour. The observer begins by subjectively selecting a pure or unique hue, for instance, a blue at 475 nm without any red or green present. By means of a second monochromator and a beam splitter (a transparent mirror mounted at 45° to the first beam) a series of narrow band wavelengths (moving in 10 nm increments from 510 through 700 nm) are observed, to which the original blue is ‘added’. For each wavelength the observer adjusts a light absorbing wedge that varies the energy of the original wavelength until each test hue is cancelled. Again, this is subjective; too much or too little of the 475 nm stimulus and the observer will experience blue with some mixture of colour. With the right amount the test field will appear neither blue nor yellow.

The logarithmic representations of the four opponent colours are converted
into an arithmetic representation and plotted with positive and negative values. The assignment of positive and negative values is arbitrary; the aim is to visually represent the opponent nature of the systems, just as Hubel described this in terms of voltmeters. There are two features of particular interest to our discussion. First is the subjective nature of the determination of unique hues. The responses plotted logarithmically represent the amount of each subjectively selected unique hue required to balance equally bright narrow bands of light (colour). Determination of unique hues is done visually rather than photo-chemically. Any set of four wavelengths could be chosen as the cancellation hues for this experiment. It is well known that unique red is not a spectral colour, so the experiment as described by Hurvich requires the observer choosing a psychologically complex colour rather than unique red.

On these two points Hurvich notes:

There is a small amount of yellow in the 700-nm stimulus, but this does not affect the cancellation procedure. The observer's task is to produce a field that looks neither red nor green. The yellow associated with the 700-nm stimulus is simply part of the "remainder" perceived when red and green are balanced. It is, in fact, not necessary to use unique stimuli to obtain any of the chromatic response function. [1981, 59]

There is, in fact, nothing critical about the use of perceptually unique equilibration stimuli. Their use is favored only because it simplifies analysis. [1955, 549]
For each balanced state the resultant colour is not a uniform grey across the spectrum, there are remainder hues that tinge the grey. For the original experiments done in 1954, Jameson and Hurvich describe three significant features of these remainder hues. (1) In all cases the remainder, if coloured, is one of the two colours of the non-tested opponent channel. (2) This colour varies across the spectrum; for any part of the spectrum the remainder corresponds to the colour we normally associate with that band. When cancelling yellow with blue, from approximately 700-580 nm the remainder is a whitish red, from 580-500 the remainder is a green; when cancelling red with green, from approximately 700-580 the remainder is yellow and from 465-400 the remainder is blue. (3) At the interchanges between these remainder hues, at the subjective loci of unique hues, the observer experiences a neutral colourless sensation.

A second feature of interest are the points at which the response functions cross the zero, the points at which one or the other of the opponent systems is in equilibrium, at which the remainder is zero. It is at these points that we experience unique hues. And it is the experience of these hues that underpins the argument that the opponent-process theory provides independent confirmation of the Berlin and Kay theses. Unlike the peak sensitivities of the three cone types, which do not correspond to our experience of primary colours, the unique hues subjectively determined by Hurvich and Jameson do. Yet questions remain about the relation between these unique hues and the several theses put forward by Berlin and Kay.

**An entanglement of tasks**

The work on the opponent-process theory and the receptor-neural linkages demonstrates that under test conditions we do experience four unique hues. This work also puts the experience of these hues into a broader context. Various visual mechanisms function together to accomplish a variety of tasks. The isolation of unique hues is not one of these tasks. As the voltmeter analogy demonstrates, as the

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6 The implication is that the response curves are characteristic of individuals regardless of which two spectral bands are compared.
needle changes its right-left orientation it must cross the zero; the physiological arrangement responsible for unique hues is a function of the mechanics of the system. Of significance is the degree and duration that the needle registers right or left.  

Locating unique hues in the spectrum may not be a significant component of our visual system. But there are important components that function in conjunction with colour vision. Consider the following example offered by Hubel: The screen of a black-and-white television set when turned off is greyish white. When turned on, various amounts of light are fired at the back of the screen, causing phosphors briefly to glow, making the screen variously brighter but never darker: “no part of it will ever send less light when it is turned on.” But, as Hubel says,

We nevertheless know very well that it is capable of giving us nice rich blacks. The blackest part of a television picture is sending to our eyes at least the same amount of light as it sends when the set is turned off. The conclusion from all this is that “black” and “white” are more than physical concepts; they are biological terms, the result of a computation done by our retina and brain on the visual scene.[57]

What underlies this is a spatial variable involving a comparison early in the visual pathway of what are called centre-surround fields. This is important in the case of colour perception as well:

We get brown only when a yellow or orange spot of light is surrounded by light that on the average is brighter....We can regard brown as a mixture of black - which is obtained only by spatial contrasts - and orange or yellow.[173-174]

The importance of this spatial characteristic is also evident in experiments with stabilized colour borders: stabilizing the border between, for instance, a blue figure and red ground causes the blue patch to disappear.

These three examples are all the result of the spatial interconnectedness of the cells in the retina. Recall that a multitude of rods and cones may send signals to one

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7 Kay and McDaniel’s fuzzy set theory lays greater emphasis on the height and shape of the sensitivity curves rather than on the zero crossings. These crossings are of course significant since they demarcate the curves.
ganglion cell via the horizontal and amacrine cells. Each ganglion cell has a receptive field composed of a centre and a doughnut shaped surround; it receives output signals from an area of rods and cones, and differentiates between the receptors at the centre and those surrounding. In their resting state ganglion cells emit a steady irregular firing of impulses. A narrow beam of light directed at the centre of the field will cause the cell to either increase or decrease this random, base firing. This depends on the type of cell; for instance, on-centre, off-surround and off-centre, on-surround. If the centre increases its firing, is an on-centre cell, the surround will be an off-

3.5 Centre-surround cell structure.
Stimuli recordings: the top line records low random firing of cells at rest (no light stimulus); the second line shows a stimulus affecting only the centre, which increases firing on the left (on-centre) and decreases it on the right (off-centre); the third line shows that a stimulus affecting both centre and surround equally results in a cancellation of response; the bottom line shows a stimulus affecting only the surround, which decreases firing on the left (off-surround) and increases it on the right (on-surround).

round. Then a ring of light covering the surround only will cause the cell to stop its normal slow, random firing. A wider beam of light covering both centre and surround will severely decrease the centre stimulated firing, sometimes completely.

One striking upshot of this is that colour perception is signalled at the borders of objects or fields. Cells receiving signals from the middle of a colour field, equally affecting centre and surround, will not fire, will not relay information on colour stimulus. Elimination of the border between the red and the blue stimuli eliminates the sensation of colour.8 If the boundary of the blue figure is eliminated we see only the red ground. If the boundary of the red ground is also eliminated we

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8 Adaptation plays a rôle here; a change in light patterns (shape of beam or stabilization of image) will not produce an immediate cessation of firings.
experience no sensation of colour. This demonstrates the relationship between colour detection and form. There is also a relationship with movement (and though I will not discuss it here, stereopsis). There are three ways by which this loss of colour stimuli can be prevented — actually variations on the same mechanics — all related to moving the boundary relative to the cell, or the eye: the object, and so the boundary, can move or be moved; the eye can be rotated in its socket; or we can move our head. All of these mechanisms are quite basic. When an object moves it attracts our attention. We learn something about our environment: an object (lunch?) enters the peripheral field and is detected moving against a static ground. We direct our foveal field toward the object, fixing it in our field, and proceed to track it. While we do this we may also be studying the object, determining what is on the menu (visually matching it with an inventory of past experiences). A variation of eye rotation is the constant and automatic microsaccadic jerking of the eye.

A physiological capacity to identify unique hues is of little practical value outside the world of Munsell chips where such hues and arrangements seldom, if ever, occur. As Berlin and Kay acknowledge, colour terminology arises out of usage, in response to colours as they are experienced. However, in the West, where an interest in colour perception and experience has a long history, colour systems such as the Munsell chips and C.I. E. charts, colour wheels, solids, and pyramids abound, and affect our perception, colour lexicon, and responses. Missing from the Berlin and Kay tests is a consideration of surface colour, and of the complexities of usage of colour terms in other, less limited contexts. Further details of the psychophysical evidence indicate the complexities involved in experiencing unique hues, and subsequently, it must be emphasized, the rarity of any such natural experience. Moreover, the subtleties of our psychophysiology indicate the importance of shape, texture, and
the relation of the components of the visual field in determining colour experience.

Brown is a related or surface colour and not an aperture colour; it is not produced by splitting white light with a prism. Incident light waves (light emanating directly from a source such as the sun, a light bulb, or flame) cannot be brown; this colour can only be produced by reflection, in conjunction with colour contrast, so is inseparable from the surface from which it is reflected and the environment in which it is found. An advantage of the opponent-process theory is that it can account for non-aperture colours. If brown is viewed through a black tube, in isolation from any surrounding colours, it appears yellow or orange. Generally, accounts of brown recognize the role of both texture and colour contrast in our perception of this colour.

This integrates the third or the opponent systems, that of the achromatic signal. But more, it demonstrates that all three systems employ a spatial comparison of the whole field of vision; again, higher order cells receive signals from a variety of rods and cones, such that differentiation involves whole receptive fields. Without the tube, when looking at the dark yellow, higher order cells compare and differentiate the outputs from both those receptors signalling ‘dark’ and ‘yellow’ and others that are not; that is, outputs from receptors directed at the dark yellow and receptors receiving input from what surrounds it. Hering, in anticipating the consequence of the later discovery that higher order cells receive information from a variety of receptors.
realized that black and gray are not produced simply by absence of light coming from an object or surface but arise when and only when the light from the object is less than the average of the light coming from the surrounding regions. [Hubel, 173]

The limits of physiology

If the opponent-process theory is correct we could expect to be able to identify four unique colours (wavelengths) on the continuum of the visible electromagnetic spectrum; colours that our physiological apparatus is capable of recognizing as unique. We would therefore expect, under the appropriate conditions, to be able to discriminate (as fundamental hues) a unique blue, yellow, red, and green. Additionally, we could expect the determination of achromatic neutrals to be as fundamental. Should the foci purportedly identified by Berlin and Kay and designated by the category names RED, YELLOW, GREEN, and BLUE correspond with those foci of unique hue identified by separate psychophysiological studies?

This is certainly the position taken by Kay and McDaniel in 1978. Their interpretation of fuzzy set membership demonstrates diminishing participation in semantic sets corresponding with the location of physiological unique hues. Maximal participation in a set corresponds with a unique hue and minimal participation corresponds, in either direction, with the adjacent unique hue. Of course, all that Kay and McDaniel really demonstrate is the unsurprising fact that English basic colour terms correspond with physiological unique hues; they do not test this correspondence for other languages. Further, as noted, in the selection of a basic lexicon an overdetermining ethnocentrism effectively ensures the stability of the categories they select. This stability is ensured by the implicit presuppositions that pervade their methodology. In the last section of this chapter I will explore more fully the consequences of this ethnocentrism.

9 This is not very surprising as Hurvich and Jameson demonstrated this in the early fifties and Hering anticipated it at the turn of the century. For their purposes, what needs to be demonstrated is that this is a universal correspondence between language and physiology and that, for English, this is a function of physiology rather than a development of sociology (a long standing interest in spectral colour).
Hardin also argues that psychophysiology demonstrates the basicness of linguistic categories. By using standard conversions into dominant wavelengths for the Munsell chips used by Berlin and Kay we find that:

the foci for YELLOW range from 586 nm to 572 nm, with most of the foci on the 580 nm chip. Unique yellow is at about 580 nm for most observers. Excluding the two data points we have mentioned before, which represent terms that extend across both GREEN and BLUE, we see that BLUE foci are on chips extending from 481 nm to 474 nm. Unique blue is around 475 nm for most observers. The spread of foci for GREEN is considerably larger: chips from 557 nm to 494 nm were picked out by respondents. The average for unique green is about 503 nm.[160-161]

Corresponding results are obtained by Hurvich and Jameson with their experiments involving monochromators.10 The selection of unique hues varies from observer to observer, but clusters around 575 nm for yellow, 475 nm for blue, and 500 nm for green.11 Hardin argues (or rather, takes as having been argued) that the agreement between foci and unique hue is seen as corroborating both the opponent-process theory and the Berlin and Kay thesis.12 It seems, though only seems, that despite the methodological flaws of the work done by Berlin and Kay, they may have generated results which are independently corroborated.

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10 This is a variation of the procedure described above. The device can select and combine (and adjust the energy of) any two narrow spectral bands. By self-adjusting the wavelengths, the observer can scan the spectrum in search of psychologically (psychophysically) unique colours (without any other colour cast or component).

11 Unique red is not a spectral colour but must be obtained by adding a small amount of short wavelength, blue light to a spectral red. Though not a unique red, 650 nm can be treated as such. Hardin is careful to stress the variance and subjectivity of these unique hue locations. What is relevant is not that there is absolute agreement, but relative agreement.

12 Without direct mention, Ratner, in arguing against the conclusions of Berlin and Kay, argues against the opponent-process theory: the evidence to date is best explained by positing theories of social experience and learning. He finds it 'illogical' to maintain that colour boundaries are culturally determined and colour foci are governed by natural, universal mechanisms. I think that the opponent-process can allow for these "two disjointed, incompatible processes" [362] because the determination of colour foci is a special case rarely encountered in daily life where the extension of colour terms is determined. This is why I maintain that if humans do indeed pick out close clusters of foci, this is largely irrelevant to the possibility of universal consensus of colour terms.
A number of authors have developed the initial explanatory suggestion by Berlin and Kay regarding the total eleven basic terms. Account has been given of the secondary colours, orange and purple (and grey), as a balance between two identified unique hues (or achromatic neural codes). Brown and pink have also been explained, less convincingly, in terms of achromatic coding. Because unique yellow is quite bright, there is a large unspecified area (on colour charts or solids) below it. Hence brown is located as dark yellow. The converse holds for red and pink.

In contrast, Marshall Sahlins [1976] gives an account of why those actually tested by Berlin and Kay chose category foci. Berlin and Kay selected the maximum chroma for each Munsell chip included in their array. However, the Munsell system is constructed such that the maximum chromas range from a value of 2 to 16. Sahlins correctly concludes that “it cannot be said that saturation was thereby held constant, since these chroma maxima vary in absolute level according to hue and value.”[13] In fact, mapping the chroma values onto the Berlin and Kay foci charts shows that respondents chose the maximum chroma chips for yellow, orange, and red, and that with brown, blue, green, and pink the responses taper off from chips of maximum chroma. Nonetheless, there is substantial evidence that semantic categories correspond with psychophysiological unique hues.

Why would this independent corroboration not count as a confirmation of the Berlin and Kay theses about universality? If we grant the opponent-process theory, we should not find it surprising that the Berlin and Kay respondents identified close clusters of colour foci; although, given the methodology, we might find it surprising that Berlin and Kay should have elicited these correct results. (Sahlins gives a good account of how they may have stumbled onto correct results.) These foci are psychophysologically determined. However, in their initial work Berlin and Kay only tested 20 language groups. Since 1969 very little subsequent work on foci has been carried out; clearly not enough from which to draw general, let alone universal, conclusions. Even if the correspondence in foci between speakers of different languages suggests a corresponding consensus in language, it does not establish the two theses based on descriptive claims about language use (that there is a universal basic lexicon and that this lexicon is evolutionary).[13] It fails to do so as these claims are extrapolated from an undersized and non-representative sample of 20
languages. In a curious recent paper, Kay, Berlin, and Merrifield claim to have improved on the sample:

Preliminary analysis of color naming data from 111 languages in the World Color Survey confirms the main lines of the original Berlin and Kay hypothesis regarding the existence of semantic universals in basic color lexicons. [abstract, 12]

The World Color Survey is composed of Kay, Berlin, and Merrifield, yet in their report there is no mention of what languages were tested, no mention of what vocabularies were elicited, and no mention of sample size and representation or any methods used; in short, there is no evidence with which to confirm or evaluate the claims made. 14

Work in psychology such as the 1987 paper of Boynton and Olson on locating basic colors does not aid in establishing universality of foci or translation. Boynton and Olson are clear that their work is not cross-cultural, but is restricted to English speakers. However, they do make the sweeping claim that “our research confirms that the link between basic color sensations and their names is congenital and psychologically based.” [104]

Could extrapolation from a proper sample establish the Berlin and Kay theses?

With the Boynton and Olson work at least five of their total sample of seven

13 This is even less true of the further (and much more ambitious) argument that this is an example of the bridgehead necessary to and presupposed by anti-relativist arguments.

14 The purpose for publishing their report seems to be concern over a ‘newly discovered’ and ‘previously unencountered’ yellow-green category: “Categories including yellow and green did not show up in the original Berlin and Kay data report of 1969.” [18] This concern quickly dissolves on examination of Basic Color Terms where Berlin and Kay present five languages that, though not made explicit, include categories that extend over yellow and green: Queensland, Shona, Hanunóo, Arunta, “Fitzroy River” group. Also Homeric Greek is presented with a category extending over green and yellow tints, and Ibo and Urhobo as having categories over yellow and green-yellow.
were psychological researchers with knowledge of the aim of the experiments. This seems a critical flaw in their research, but not because of the inadequate size of the sample. The central concern with this sample has to do with the cultural activity of the subjects, as Gleason and the Beagleholes (cited below) indicate. A group of colour photographers with darkroom experience would, with ease and consistency, subdivide the blue-green region of the colour space with a category cyan, much as the term 'cadmium red light' evokes an uniform mental image among painters (this colour is not among those arrayed on the Munsell chart). The cultural activity of informants will affect their knowledge and usage of colour terms and categories. When Kay, Berlin, and Merrifield claim that language groups demonstrate transition from one stage to the next, they may only, or as likely, be recording the complex technical and pragmatic usage of colour terms within a 'non-evolving' language. The distribution of different tasks throughout a society will result in different skills manifested in different informants.

A basic colour is not an aperture colour

The evidence of physiologically determined unique hues as indicated by the opponent-process theory suggests confirmation of the Berlin and Kay identification of category and foci. Yet, other aspects of the visual system suggest this identification is not confirmed. Higher cell activity underscores the interconnectedness of the whole visual array, and underlies simple wavelength discriminations. Combinations of colours, reflected from a multitude of surfaces, are integral to colour perception. As I will argue, the context, the environment, in which the observer is situated determines in large part the discrimination of colours. This criticism rests with interpretation of the psychophysiology. Another criticism rests with interpretation of the Berlin and Kay work.

As noted in the last chapter, to draw a distinction between basic colour terms and secondary colour terms, in the way that Berlin and Kay have done, is to specifically focus attention on, and grant preeminent importance to, terms that can be attributed to isolated spectral or aperture colours, discounting other discriminations of colour and discounting the spatial aspect of the opponent-process system. Before testing their respondents, at the stage of determining a basic colour vocabulary,
Berlin and Kay excluded the possibility that the respondents could choose other than their physiologically determined foci (unique hues) by imposing these criteria for inclusion. The aperture bias employed by Berlin and Kay in determining basic colour terms ensures that those terms mapped will conform to spectral and aperture colours, to those experimentally isolatable colours our physiology is best able to discriminate. Because of the physiology of receptors and colour opponency we do detect unique hues. But such detection is only a part of the higher order cell activity, activity that is involved with several kinds of detection within the whole visual array. It is possible to never notice that we detect or to never experience such hues.

The opponent-process theory leaves untouched questions concerning the validity of the Berlin and Kay thesis that there is a small universal stock of basic color categories in language; even if, physiologically, we can all distinguish the same range of spectral colours, it does not follow that colour terminology maps onto these colours. In an environment without colour chips and wheels and self-adjusting monochromators the observer is unlikely to regularly perceive unique hues, and equally unlikely to develop categories for what is unperceived. The same theory that provides independent support for the Berlin and Kay thesis regarding colour foci also underscores both the infrequency, and relative unimportance, of such experience and the importance of considering the wider context of colour experience (and appellation), of texture and shape and surrounding colours. Most cortical cells are responsive to movement for the very pragmatic reason that detecting movement is more important in our lives: prey and predators move. Identifying unique hues, situations involving a high level of neutral neural signals, does not have the same practical application as picking an object out of its surround by means of differentiating texture or shape or subtle colour shifts.

For speakers of English, and of European languages in general, the cultural fascination and preoccupation with spectral and aperture colours may affect the location of our semantic foci. Different environments produce different semantic categories; a need to describe, and familiarity with, spectral and aperture colours is analogous to a need and familiarity with plants and animals. Again, the location of foci, rather than the brute number of aperture terms, is an all but unconsidered area of ethnographic research.15 Since the new universalists conclude that colour terms
and colour term foci are universal, the failure to account for all possible and meaningful basic terms is serious. This failure also poses serious problems for their claim that languages develop in an evolutionary pattern - from making two discriminations through six to eleven. We have already considered the difficulty of extrapolating universal generalizations from their sample of twenty based on its size and representativeness. Now we can see that the task performed, the questions asked, and the elimination of data may have as equally profound an outcome.

The context of culture

Hardin draws a parallel between an early neo-Aristotelian treatise on geometrical gunnery and a fictitious account of colour. Though the text of the treatise describes the trajectory of a cannonball as a straight motion followed by a circular motion and then a straight drop, the frontispiece shows a parabolic trajectory. Hardin’s fictitious colour text, which he sets circa 1950,

assures us that the spectrum is the very paradigm of continuity and its division the product of cultural accident embedded in language. The frontispiece is a pleasing photograph of a rainbow, whose most prominent feature is that it consists of a small set of clearly differentiated colored regions.

The perceptual salience of certain spectral hues suggest the existence of a natural, biologically induced set of hue categories which may in turn leave its traces in a variety of natural languages.[156]

Hardin, of course, advocates the basic discrimination of four unique hues which are determined by biology rather than cultural accident. Yet, as with the book on gunnery, Hardin’s frontispiece exposes the discontinuity between the thesis and the experience. The frontispiece of Color for Philosophers shows in shades of grey a beam of light fanned out. As with the photograph of a rainbow, the repre-


sentation makes clear that we do not accidentally or arbitrarily divide a continuum into constituent parts. It shows distinct bands of grey (colour), but not four, clustered around our salient unique hues. It represents five distinct hues. Culture plays the significant rôle in how we interpret our experiences, experiences that are limited by our physiology.

The spatial aspect of the higher cell activity and the interconnectedness of both the visual field and colour sensitive and non-colour sensitive (for example, movement-sensitive) cells gives surprising new currency to descriptions such as that of the visual field of the Pukapuka described by Ernest and Pearl Beaglehole:

The Pukapukan has little need to distinguish fine degrees of color gradation. The environment is monotonous in color scheme: white coral sand, dull green coconut and other tropical trees, blue sky and sea. Tropical reef fish are of course a riot of bright, variegated coloring, but they are easily distinguished in terms of shape, number of fins, and so forth. In general, therefore, the Pukapukan is content to distinguish one or two colors....because color terms can be duplicated and combined with other terms to give an approximation to a desired degree of saturation.[356]

The Beagleholes stress the qualities of the visual field and the purposes or desires of the Pukapuka. This relative unimportance of wavelength discrimination may account for frequent ethnographic reports about disagreement and indifference over colour appellation, particularly over culturally and pragmatically unimportant spectral and aperture colours.

This exclusion by Berlin and Kay of non-aperture features extends to their evaluation of ethnographic data. They cite H.A. Gleason as the material source for Shona, one of their seventy-eight investigated languages. Gleason compares the Shona language with that of English and Bassa. Berlin and Kay do not include Bassa in their ethnographic data, and do not mention Gleason’s discussion of it. But what he says is pertinent. Though there are terms for specific colours, Bassa has only two major colour categories, and he cautions against thinking the greater number of divisions (basic colour terms) in English ‘superior’. To reiterate:

For some purposes it probably is. But for others it may present real difficulties...In order to state the facts succinctly (in English) it has been necessary to coin two new and more general color terms, xanthic and cyanic, for
these two groups. A Bassa-speaking botanist would be under no such necessity. He would find ziza and hui quite adequate for the purpose, since they happen to divide the spectrum in approximately the way necessary for this purpose.[5]

Do the lower stage languages described by Berlin and Kay (those exhibiting only two, three, or four basic colour terms) have other basic terms which are rejected because of (valuable) associations, for instance, with flowers? More generally, are there terms which are rejected or unidentified because they fail to apply (and be applied) to aperture colours or Munsell chips, or because they cut across English categories of both colours and objects?

The majority of our colour experiences are of complex arrays of colours, seen in proximity to one another and interacting, and in broken form (of admixed wavelengths). The standard colour wheel is inadequate as a descriptive framework of our experiences (although it must be noted that frequently this is not the intention of colour schemata). In an effort to produce a simple and reproducible account of colour, the role of texture has been ignored. Granting the importance of texture and object recognition, it may be of greater practical value for some groups of people to distinguish between objects in terms of texture rather than aperture colour. The 'colours' they identify will be much influenced by discriminations of these other dimensions; and texture, or for example, shape or means of locomotion, nonetheless may count as colour criteria.

W.H.R. Rivers, cited extensively by Berlin and Kay, compiled colour vocabularies for several tribes in the Torres Straits region of the Philippines. For the Murray Island language group he identifies eight 'chief' colour names, making this a stage VII language; although it is missing a term for brown and the only term for blue is

17 A.H. Munsell developed his system of colour chips as an aid in mixing and distributing paints and pigments. With the system in place people could communicate their colour choices by corresponding codes without the need for mailing or carrying around colour samples; but more, they could view the colour under the specific lighting conditions of their home or office. The chips standardized variables such as texture to minimize their effect on the overall appearance. Texture, and its subsequent effect on the appearance of a paint, is added later when the paint is applied to a surface.
borrowed from the English. Berlin and Kay reject all but two of these terms on the grounds that they are reduplicative of names of objects and descriptive. (They accept the term for white because Rivers fails to determine its derivation, and for black-blue because they are ‘suspicious’ of the derivation Rivers offers.) Interestingly, Gleason, in the work cited above, provides an account of the legitimate role of reduplication in language construction: in some languages (not English) this is a ubiquitous structural feature. This construction of colour terms from objects which are experienced and important to the Murray Island residents ought to be expected given the higher-order cell activity described by current psychophysiology, and specifically the opponent-process, theories. In answer to my first question above: Berlin and Kay reject these terms because of (seemingly valuable) associations with familiar objects. Many lower stage languages are more robust than Berlin and Kay allow. Moreover, given the glosses and derivation provided by Rivers, these terms are not all equivalent to unique hue foci: *bambam* firstly associated with turmeric, *siusiu* with ochre, *soskepusoskep* with bile, *golegole* with the ink of cuttlefish and glossed as black and blue.

In answer to my second question above, Eleanor (Rosch) Heider, in doing work with the Dani of New Guinea, notes two important discrepancies from the Berlin and Kay categorization of Dani as a stage I (two term) language group. First, “in addition to the basic terms *mili* and *mola*, about half the informants used colour names with some consistency which were roughly equivalent to the English terms ‘red,’ ‘yellow,’ and ‘blue.’”[451] As is the case with Murray Island, this language is more robust than Berlin and Kay allow. More striking though, is Heider’s discovery that the two colour terms *mili* and *mola*

were not based purely on brightness.... *mili* included both dark and ‘cold’ colours; *mola* light and ‘warm’ colours. The form on the division into *mili* and *mola* was identical for the saturated and unsaturated arrays. There is no equivalent English categorisation of the spectrum, where ‘dark’ and ‘light’ are purely brightness-based. Not only did use of the terms vary with hue as well as brightness, but the focal points (best examples) of *mili* and *mola* were not ‘black’ and ‘white’:[451]

Dani is robust in a way not isomorphically equivalent to English. Though Heider has often been cited as supporting the original Berlin and Kay work, she has raised serious criticisms. The main criticisms are that the extension of terms in Dani is dif-
ferent from the English glosses and the foci of terms is different from the proposed evolutionary ordering. Not only are \textit{mili} and \textit{mola} different from black and white on the basis of the warm-cold separation, but also on the basis of foci; Heider states that the terms were multi-focused, variable across informants (67\% of her informants located the foci of \textit{mola} in red).

Kay and McDaniel attempt to address these criticisms in their 1978 paper. Though first asserting that "the locations of the basic category foci and their absolute boundaries are universally fixed in the color space"[624] (meaning the location of spectral unique hues) they recast the evolution of terms "not as the successive encoding of foci, but as the successive differentiation of previously existing basic color categories."[640] This misses the point of Heider's and the present criticism: the basic colour terms that are recast are aperture colour terms. This process tests whether any subject language has developed terms that name or seem to name aperture colours.\textsuperscript{18}

Carl Ratner and Jennifer McCarthy are two of the few researchers addressing the problem of using aperture colours rather than contextual colours. Historically, one of the main techniques for testing the location of foci has been to test various colour stimuli for psychological salience, particularly as this is manifest in memory (Heider did much of the early work on this). In their 1990 paper, Ratner and McCarthy argue that

The cultural dimensions and the importance of focality for color memory cannot be explored by Munsell color chips because they are bits of color removed from any social psychological context and deprived of social psychological significance....The limitations of Munsell color chips make them not only unsuitable for investigating social dimensions of color memory but also inappropriate for investigating the importance of focality under normal recall conditions pregnant with social psychological significance.[371]

They replaced Munsell chips with shapes cut out of Munsell paper (tree, bird, jack-

\textsuperscript{18} J. Bousfield in "The World Seen as a Colour Chart" criticizes the continual absorption of misfit (counter-example) languages by proponents of the theory on much the same grounds.
o-lantern, sailboat) in appropriate and inappropriate colours. These were mounted on a neutral ground. They concluded that

The use of ecologically relevant stimuli in our experiment has enabled us to demonstrate the importance of a cultural variable on color memory, and it has illuminated the lack of importance of locality for normal color memory. The cultural variable - typicality, or appropriateness, of a color for a scene (object) - was found to have a significant effect. The combination of these results demonstrates the predominance of cultural factors over locality on normal color memory.[374-75]

These conclusions are compatible with the claim that different contexts will produce differently appropriate colour-object combinations.

The main thrust of Heider's paper is to demonstrate how unlikely it is that such non-equivalence with English categorization will turn up:

Only combinations of stimuli named in a fashion unlikely under the 'brightness hypothesis' could lead the ethnographer to suspect that these terms were not entirely brightness- (or entirely hue) -based. In fact, there is only one kind of combination that would lead to a suspicion of the real form of *mili* and *mola*. The ethnographer must see simultaneously that a very dark 'warm' and a fairly light 'cold' colour are both called *mola*.[461-462]

This distinction is based on the combined characteristics of the specific visual field, sensitivity to reflected wavelength, texture, and context (surround). Such a culturally basic colour distinction would not show up in the descriptive schema of Berlin and Kay. Many more of what Berlin and Kay call 'lower stage ethnic groups' may in fact make many such distinctions, recognizing and using as many 'colours' as English speakers.

**Ethnocentrism**

Ethnocentrism is an easy charge to lay. Like poisoning the well, it is more difficult to justify making the charge. In point of fact, since the debate between Peter Winch and Alisdair Macintyre over standards of rationality, the term has taken on a more robust meaning. Initially, it meant to judge what is foreign to us by our own standards, as if those standards were inherently superior. The subsequent
extension is to interpret empirical evidence by our own standards, by our own theoretical assumptions, such that we fail to be aware of foreign standards and theories. In this regard, our standards become not only superior but universal. It is in this latter sense in particular that the new universalists fail, and for which a case for ethnocentrism can be maintained.

Ethnocentrism plays an important rôle in much of the collection and interpretation of colour categories and language, specifically, in the identification of 'basic' and common colour terms. What is 'basic' about the colour terms that Berlin and Kay elicit is that they can be applied to an array of Munsell chips, they are all aperture colours. The things in the world referred to by such terms are spectral arrays of colour. In fact, the criteria employed for determining 'basic' are designed to elicit just such a list: colour terms which do not apply to things, which can be abstracted from any context of application or experience. This, in turn, may be expected to systematically misrepresent the colour distinctions encoded in the language of use. Here lies the crux of the charge: the new universalists fail to attribute the appropriate importance to colour terms which do not readily appear isomorphic to our own spectral designators.

The new universalists presume that the basic colour lexicon is typical of all users of each given language and, on this basis, is psychophysically determined, and therefore is general to all languages and cultures. As I will show in the next two chapters, a variety of cultural, aesthetic, and pragmatic considerations provide evidence that language and culture can and do overstep the psychophysical factors. The formation of basic categories cannot be attributed to a single underlying factor. Further, there is evidence of ample instability within our own cultural

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19 The debate begins following the publication of Winch's *The Idea of a Social Science and its Relation to Philosophy*. The exchange is reprinted in Wilson's *Rationality: Macintyre's "Is Understanding Religion Compatible with Believing?"* pp. 62-77, then Winch's "Understanding a Primitive Society" pp. 78-111, both originally published in 1964, and it ends with Macintyre's 1967 article, "The Idea of a Social Science."
heritage, specifically the aesthetic, technological, cosmological, and mythical interests in constructing categories that effectively overdetermine the emergence of colour terms that stabilize around spectral colours.

The colour categories that Berlin and Kay treat as universal are ethnocentric in two ways. The next two chapters demonstrate how these categories only appear to be universal, by ignoring the complexity of factors actually shaping colour identification in a host of contexts not considered by Berlin and Kay. Relevant counter-evidential contexts arise between different cultures and within our own. The nature of the evidence I bring forth in the next two chapters goes some way towards answering my earlier query regarding the longevity of the Berlin and Kay theses. Notably, this evidence goes to the heart of the apparent empirical success and theoretical corroboration of their theses from the opponent-process theory. It also underscores how Berlin and Kay went wrong, how their own conceptualizing about colour suppressed the ethnocentric and interest-specific nature of the concept of ‘basic’.

As will become clearer in the following chapters, the new universalists make the mistake of assuming that our cultural interest in colour is a universalistic interest (or a potential universalistic interest in cultures demonstrating fewer than eleven basic colour terms - cultures at a lower ‘evolutionary’ stage of development). Our society, and Western-European-Mediterranean culture, has been driven in large part by a desire to predict and control the natural world. Our preoccupation with investigating the natural world has had strong pragmatic consequences. There is no denying that we have a practical use for dividing the spectrum as we do. But as useful as our scientific efforts have been, this is still a cultural artifice. This artifice has led us to carefully observe the spectrum as such, to consider light itself as phenomenon. Other cultures consider more brute or intricately contextualized phenomena as sufficient a preoccupation. In the next two chapters I consider how cultural preoccupations undercut physiological constraints, first in the case of sound perception and then in colour perception.
CHAPTER FOUR: SOUND AND CULTURE

In the last chapter I introduced two bodies of evidence raised by Berlin and Kay, the first based on their ethnographic survey, the second on developments in the opponent-process theory. I also discussed this second issue. I want to give credence to the claim I made in the previous chapter that languages for encoding colour space have a much to do with social or cultural context as with basic physiology or natural categories, that is, to flesh-out what counts as context. I will consider two sorts of examples of how physiological limits manifest themselves in cultural contexts. In this chapter I begin with a discussion of the cultural and biological similarities and differences of sound and colour. Two tactics have been employed by Berlin and Kay and some of their proponents to argue that the physiological basis of colour categorization has an analogy in the physiological basis of our experience of sound in general and of musical pitch specifically. The second example, developed in the next chapter, is an (historical) anthropological study of the relation between the availability of pigments and categorization, and more generally the relation between cultural purposes and beliefs and categorization.

The analogy from sound: phonology

The effort to equate, in various manners, our experiences of colour and of sound, especially musical sound, has a long history. There is also an equally long debate over the fruitfulness of such endeavours. Plato's friend Archytas is generally credited with having developed the chromatic scale, and of the three scales available to the Greek musician and listener the chromatic scale is seen both as the most emotionally expressive and, as its name indicates, as sharing certain qualities with colour. This chromatic scale was regarded as simply 'colouring' its two neighbouring scales, the diatonic (divided into full tones) and the enharmonic (divided into quarter tones). Some Greek theorists considered 'colour' (chrōia) to be a quality of sound itself, together with pitch and duration; it may have been thought akin to what we now describe as timbre. [Gage, 227]¹

¹ Unless otherwise noted references in this chapter are to Gage, 1993.
Plato himself railed against the association of colour and sound:

Though there are figures and tunes in music, as its subject matter is rhythm and melody, and we may accordingly speak of a tune or a posture as rhythmical or melodious, we cannot properly use the metaphorical expression of the choir trainers, 'brilliantly colored,' of either. [Laws II, 655a]

Aside from the particular psychological responses attributed by the Greeks to the diatonic, enharmonic, and chromatic scales, the question arises as to why different cultures choose different scales and consistently employ their choices. Is there an analogous physiological basis to our response to pitch as to colour and does this determine, for instance, our partitioning of the tonal spectrum? My answer to this question is that there is a physiological basis to our response and that we can choose or condition ourselves to ignore it.

From the outset of the current debate on colour, a line of speculation has
explored the possible lessons for colour experience to be taken from our experience of sound. In 1969, Berlin and Kay wrote of this connection:

The early stages of development of color lexicon show a haunting parallel with the early Jakobson-Halle (1956) theory of phonological development -haunting because although the strength of the analogy is unquestionable, the reason such an analogy should exist at all is far from clear.[104-5]

In a more recent, brief note Marc Bornstein draws attention to parallels between categorizations in vision and hearing for a number of functions (identification, discrimination, reaction time, adaptation) as well as for ontogeny of categorization processes in humans.² First I will sketch out how this analogy is supposed to work, but then I will argue why it is in fact very questionable.

The connection, as Berlin and Kay state it, stems from the fact that both colour and sound travel as waves and can be “described in terms of (i) total energy or amplitude; (ii) frequency, or inversely, wavelength; (iii) purity of wavelength, and so on.”[105] Following Jakobson and Halle, they try to draw a parallel between the ontogenetic phonological development in children and a phylogenetic (cultural) colour categorization. Plotting energy (loudness and brightness) against frequency (pitch and hue), they conclude that the development of basic phonetic utterances corresponds with the development of colour categories: /p/ and /a/ with black and white as expressing only energy, /p/ and /a/ and /t/ with black and white and red as expressing energy and frequency, etc.³ They conclude that

the same sequences hold in phonological development phylogenetically and in the development of color categorization ontogenetically. With respect to phonology, Jakobson and Halle appear to have in mind a developmental pattern with languages based on the same kind of distributional evidence across languages we find in color nomenclature.[108]

The connection that Berlin and Kay attempt to establish is very superficial. Again

² These parallels are presented as a chart in “Perceptual categories in vision and audition”.

³ This is a standard notation employed by linguists to note basic utterances of phonetic sounds.
there is a strain of fit, now between the colour and phonological categories. First, with
the introduction of green and yellow, red changes energy (brightness). With a three
colour categorization Berlin and Kay are forced to make black and red indistinguish-
able in brightness. Second, as Berlin and Kay describe it, red emerges out of black (at
an earlier stage of development black is a more encompassing category), yet for
Jakobson and Halle /t/ does not emerge out of /p/ but is quite distinct from it.

More seriously, there is no reason to suppose that the sound space is parti-
tioned at all like the colour space, that the phonetic utterances form a finite set
which are comparable to basic colour terms. That sound and light both travel in
waves makes them no more similar to each other than to water which also travels
in waves.4 This is Plato's criticism in Protagoras [331de]: superficial similarities (in
this case the characteristics of waves) do not make literally true metaphors.

There is a further contradiction in the employment of this analogy. While
Berlin and Kay claim it provides some kind of support for their evolutionary devel-
opment thesis, there is evidence that to whatever degree this analogy is established
it contradicts and weakens the universality thesis. Since different languages use dif-
f erent and non-isomorphic phonemes, by analogy we could expect colour cate-
gories to be non-isomorphic. Gleason provides a good example in this regard.
While in English we would agree that key, ski, and caw all share the phoneme /k/,
Arabic and Hindi speakers would not. A speaker of Arabic may object to the in-
clusion of key and caw in the same /k/ classification, and a speaker of Hindi may object
to the inclusion of key and ski:

Arabic has numerous minimal pairs [for example, hill and till] contrasting in
two varieties of [k]-like sounds. These may be written /k/ and /q/. /k/ is
rather far front: /q/ much farther back....Though narrower in their variation
than English /k/, both these are, like all phonemes, classes of sounds....The
speaker of Hindi will be unlikely to hear any difference between the conso-
nants of key and caw....There is, however, a contrast between aspirated stops
such as /kh/ and unaspirated stops such as /k/.[260]

While for English no distinction is made between the /k/ of key, ski, and caw, Arabic

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4 It is also worth noting that sound is the medium in which it travels, while light is
self-generating; there is no phonological equivalent to photons.
differentiates between the /k/ of key and the /q/ of caw and Hindi differentiates between the /k/ of ski and the /kh/ of key. And as Gleason points out, these phonemes in Arabic and Hindi are by no means identical with the phonemes of English.

Gleason suggests that an important aspect of learning a second language involves, among other things, learning to make distinctions, both in hearing and speaking, that are phonemic in the new language, and learning to overlook those distinctions which are not significant, even though they may be phonemic in the mother tongue.[260]

Anthropologists bear this out, especially those doing field work with people who employ substantially different phonemic systems. Not all phonemic differences are as subtle as with the Arabic and Hindi examples. Marjorie Shostak describes three differences that had to be overcome in learning to communicate in the language of the !Kung: different phonemes (in this case glottal and fricative sounds), specific intonation, and the cultural context.

There were four different click sounds and two throat sounds, all fairly easy to master with practice. But many words that sounded the same to our Western ears were actually distinguished by the use of four or more different tones - a dimension of speech that was difficult to hear, let alone master....By the time three months had passed, the !Kung sounds had become a little less strange, the clicks, glottal stops, and fricatives a little more manageable, and I could finally hear the tones....But more was required than finding the !Kung equivalents for English words; it was, of course, necessary to say them correctly, at the appropriate times, and in the culturally accepted manner. My first attempts were awkward and embarrassing.[17–18]

The implication of this second difference is that phonemes do not associate with a fixed pitch as is suggested by Berlin and Kay after Jakobson and Halle. The third difference has implications, beyond the issue of non-isomorphic phonemes, for (though not a premise of) the central theme of this chapter: culture easily and frequently oversteps physiology.

A more compelling analogy between sound and colour is developed by Floyd Ratliff. In his 1976 paper “On the Psychophysiological Bases of Universal Color Terms” he concludes his discussion with a consideration of other linguistic mani-
festations of physiology. Pitch (frequency) is described as high or low, when in fact

A low-pitched sound can originate from a high-elevation source - e.g. a fog horn on a high bluff, and a high-pitched sound can originate from a low-elevation source - e.g. a cricket chirping on the ground.[326]

He concludes that this may be the result of how sounds are formulated in our vocal cords and head cavities: "the ultimate pitch and timbre of a sound depends so much on how we shape the air passages through which the sound is carried that it appears to originate in those cavities."[326] 'Higher' sounds tend to be produced in our nasal cavities, 'lower' sounds in our throats. Universal terms, Ratliff concludes, develop because of universal experiences (the sun, moon, stars, water, fire), because of universal characteristics of our bodies (right, left, up, down, ten fingers and ten toes), and because of universal characteristics of our nervous system (pain, taste).

This is akin to the line of argument presented by Bornstein in his 1987 paper. He sets up his discussion as a demonstration of the universalist rather than relativist account of colour categorization. He identifies four separate lines of evidence: cross-cultural, infant, animal, and physiological. As he states that the "most comprehensive cross-cultural investigation has been conducted by Berlin and Kay" we may be suspicious that he offers little cross-cultural evidence for universal categorization. The remaining three lines of evidence demonstrate a tendency among pre-language infants and non-language animals for uniform categorization that conforms with the physiological evidence. Yet none of this evidence addresses the issues of language or culture affecting conceptualization. It is perfectly compatible to say that we have basic physiological constraints that manifest themselves under particular test conditions at specific stages of development and that cultural factors overstep these constraints by producing more useful categories. Nor is it a defense of universalism to say that we have physiological constraints and that these constraints manifest themselves in determinate ways at an essentially precultural stage. This is what Bornstein does say:

If color categories are functional at or near birth, if they have an identifiable neurological substrate, and if this is "hard wired," then human infants will be expected to partition the spectrum in uniform ways before they have experience with language or with culture, as indeed seems to occur. Afterward, development may follow different courses...However, in societies where color-naming systems differ from the basic fourfold categorization, special
linguistic or cultural experience may have influenced the structure of naming, or even of category perception, in particular ways during development. As a consequence, the "universal" categories of infancy may be differentiated or lost, or new categories may be induced.[292]

Bornstein gives up too much here. What is universal about a "category" that does not affect language and is demonstrable, indeed, usable, only under laboratory conditions?

As to the supposed parallels between colour vision and phonology, Bornstein follows the four lines of evidence for the universality of colour categorization: adults, preverbal infants, and infrahuman species tend to partition the VOT (voice-onset time) and the wavelength continuums categorically, and these categorizations reflect underlying neurological substrates. As the evidence for adult colour categorization is woefully inadequate, Bornstein cannot draw a parallel for linguistic and culturally situated humans. But as Gleason suggests the remaining similarities are superficial and gross. Indeed, in the same volume as Bornstein's paper appears, Randy L. Diehl and Keith R. Kluender, and Robert E. Remez, criticize the strategy proposed by, among others, Jakobson and Halle. Diehl and Kluender defend a more culturally rich account of speech categorization, one that squares with Shostak's practical experience:

1. Within certain time and frequency limits, there is almost no significant aspect of the acoustic structure of speech signals that is irrelevant to phonetic categorization.
2. Experienced listeners make use of all potentially relevant cues for phonetic categories, provided these cues are detectable.
3. It is generally not the case that relatively localized (e.g., syllable-sized) portions of the acoustic signal contain sufficient information to specify phonetic categories unambiguously.[226-27]

Ratliff's is a more modest account than that of Berlin and Kay, but both accounts overstate the case. The claim is that because there are physiological features and limits to our experience of sound then physiology, rather than culture, is the determinant in categorizing pitch (a spatial 'metaphor' for Ratliff, a scaled division for Berlin and Kay). I do not dispute either Ratliff's claim that pitch is designated by elevation across cultures or that this is physiologically determined. My criticism is with the broader argument about culture and physiology, more obvious-
ly typified by the Berlin and Kay usage of pitch. As Ratliff identifies three possible causes of universal terms, the issues are first which terms are universals and then from which causes do these universal terms arise. In both cases, not all possible universal terms arise.

The analogy from sound: musical intonation

A further example about pitch will indicate how easily culture can overstep physiology. The octave and the perfect fifth appear in almost all known musical systems. These are quickly recognized (and preferred) by young children with little musical acquaintance. All relations of pitch are expressible in terms of mathematical relations of wavelength frequency or, as Pythagoras knew, in relations of lengths of vibrating strings. A string divided in half sounds an octave higher. The frequency of wave of the higher note is twice that of the lower, the length of the wave is half. Pythagoras is noted for having drawn attention to the mathematical relation between the length of a vibrating string and the attending pitch. Some ratios produce easily identifiable intervals and pleasing chords, others do not. The more consonant intervals are produced by the simpler ratios: 2:1 (octave), 3:2 (fifth), 4:3 (fourth). The larger the numbers in the ratios the greater the dissonance: 6:5 (minor third), 9:8 (major second), 16:9 (minor seventh), 16:15 (minor second). The mathematical elegance of the relation of consonance to simple ratios suggested to many, for centuries after Pythagoras, that humans directly perceive the numerical ratios and prefer the simplest ratios.

There are several explanations of the acoustic properties of complex (simultaneous) tones. As Carol Krumhansl explains:

With increased knowledge of acoustics, and an understanding of the relationship between the length of a vibrating string, its frequency of vibration, and the dependency of perceived pitch on frequency, came a variety of other explanations. These theories assumed that consonance of intervals with simple frequency ratios contained vibration patterns with a common periodicity, producing corresponding neural-firing patterns with a common periodicity.[52]

5 There is evidence of the former designation in Aristotle’s Topics.
Single vibrating strings (and virtually all musical instruments) produce several tones. We identify the note with the fundamental (lowest) frequency but it is accompanied by higher harmonics or overtones, which are multiples of and consonant with the fundamental frequency. An emphasis on the periodicity of neural-firing gave way to a greater emphasis on the complex interference patterns of fundamental and harmonic frequencies:

Because of the pattern of harmonics, when two complex tones are sounded, their component frequencies will coincide to the extent that their fundamental frequencies are related by simple integer ratios. For example, if two tones, one an octave higher than the other, are sounded simultaneously, all the harmonics of the higher tone will be present as harmonics of the lower tone. As the integers needed to express the ratios of the frequencies increase, the number of mismatches between the harmonics of the two will also increase.[52]

It is still the case, however, that there is a physiological basis to consonance. Complex vibration patterns produce complex (or differently complex) neural-firing patterns in the inner ear. Our ability to identify with greater ease and less training octaves and fifths over minor sevenths and major seconds reflects the limits of our physiological acuity.

The Pythagorean scale is based on the consecutive arrangement of natural fifths. The result of successively shortening a vibrating string by one-third (3:2) is a series of natural or perfect fifths. Through transposition by octaves these notes can be compressed within one octave. The ancient Chinese, long before Pythagoras, used such a scale. They used bamboo tubes of lengths based on the 3:2 ratio to produce a series of twelve natural fifths. By transposition they produced three octave scales of twelve tones each. A full chromatic scale can be formed by transposition of twelve successive fifths.

The problem with the Pythagorean and Chinese systems, as with any system based on mathematical ratios, is that from any given note successively series of fifths and octaves never return to a unison, the culmination of a transposed scale is not the octave above the keynote. This difference, called a Pythagorean comma, compounds with each additional octave. The difference between twelve natural fifths and seven octaves is 12 centitones.6 This is only problematic if the musician desires
a wide pitch range or if the full chromatic scale is to be used. If music is composed in one key using the naturally derived pitches and played on instruments constructed so to sound only those notes, then there is no problem. This is noticeable in Baroque music with its heavy reliance on the natural third, fifth, and octave. However, as musical composition in Europe became more complex and varied, a corresponding desire for instruments capable of performing the works arose. As the musical historian Alex Harmann writes:

Voices and stringed instruments are capable of flexible intonation, but keyboard instruments are not, and up to c. 1500 organs and harpsichords must either have sounded vilely out of tune sometimes, or else some of the notes must have been slightly and inoffensively mistuned.[v. 2, 11]

Even within the Chinese three octave system some audible dissonance is heard. This is a product of compromise and invention: compromise in wanting one instrument to play in many keys and invention in wanting to use rich and dense notation.

In keeping with the principles elucidated by Pythagoras, both the European and the Chinese systems were based on natural fifths, on the mathematical ratio of frequency. Adjustments (temperings) were made to this natural scale to compensate for non-unison multiple voicings. But not until 1482 with Bartolomé Ramís de Pareja and the publication of his Musica practica did a successful technique of temperament develop. In the early part of the sixteenth century the equal tempered system was

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6 A centitone is one six-hundredth of an octave (or one one-hundredth of an equally tempered tone).
<table>
<thead>
<tr>
<th>Interval</th>
<th>Pythagorean tuning</th>
<th>Ramis’ just intonation</th>
<th>Aron's meantone temperament</th>
<th>Equal temperament</th>
</tr>
</thead>
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<tr>
<td>unison</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>minor 2nd</td>
<td>114</td>
<td>92</td>
<td>76</td>
<td>100</td>
</tr>
<tr>
<td>major 2nd</td>
<td>204</td>
<td>182</td>
<td>193</td>
<td>200</td>
</tr>
<tr>
<td>minor 3rd</td>
<td>294</td>
<td>294</td>
<td>310</td>
<td>300</td>
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<tr>
<td>major 3rd</td>
<td>408</td>
<td>386</td>
<td>386</td>
<td>400</td>
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<tr>
<td>fourth</td>
<td>498</td>
<td>498</td>
<td>503</td>
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<td>590</td>
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<td>5th</td>
<td>702</td>
<td>702</td>
<td>697</td>
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<tr>
<td>minor 6th</td>
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<td>800</td>
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<tr>
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<td>1083</td>
<td>1100</td>
</tr>
<tr>
<td>octave</td>
<td>1200</td>
<td>1200</td>
<td>1200</td>
<td>1200</td>
</tr>
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</table>

4.3 Comparison of tempering systems
The movement away from perfect consonance: any number of extant systems of adjustment and temperament could be used as transitional steps. Note that the Pythagorean tuning does not strictly follow the perfect tuning of fifths for this would end at the octave. Part of the scale is tuned by fourths down from the octave (equivalent to fifths tuned up). An ascending tuning, such as used by the Chinese, would be: 0, 114, 204, 318, 400, 522, 612, 702, 816, 906, 1020, 1100, 1224.

This system ignores the mathematical ratio of notes and divides the octave into twelve equally spaced semitones. The piano keyboard spans seven octaves and twelve fifths, yet a series of octaves and a series of fifths built on the bottom A are in unison at the top A on the keyboard. Each fifth of the piano has been flattened by one twelfth of the interval separating the twelfth fifth from the seventh octave.

This is the system championed in 1722 by J.S. Bach with his series of compositions comprising *The Well-Tempered Clavier*.  

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7 The system introduced by Ramis is a cross between Pythagorean tuning and just intonation, a system of temperament that maintains the perfect fifth and perfect major third. It was not the successful temperament, it is not the system used now. Pietro Aron is credited with introducing, in his 1523 *Toscanello In musica*, a system of tuning that flattened the pure fifth. Known as meantone temperament this marks the next stage in the progression from pure fifths to equal temperament.
selling this system of tuning to the public, and with great success. The preludes and fugues demonstrate that any keyboard can play multivoice compositions in any of the twelve keys, and, as numbered, they progress from C major through all the semitones to B minor. Bach was adamant that each key evoked a unique emotional response in the listener. The consequence of well tempering was the great flourishing of composition in the late Baroque and Romantic eras, resulting from and utilizing the new found advantages of modulation and transposition. While there is no denying the beauty of Bach's preludes and fugues, there is also no denying that to Bach's audience they would have sounded unusual, just as the quarter tones of Indian music initially sound unusual to Bach's successors: the basis of the system is to 'mistune' most of the notes on the piano. As recently as 1879, William Pole wrote in *The Philosophy of Music*:

The modern practise of tuning all organs to equal temperament has been a fearful detriment to their quality of tone. Under the old tuning an organ made harmonious and attractive music, which it was a pleasure to listen to....Now, the harsh thirds, applied to the whole instrument indiscriminately, give it a cacophonous and repulsive effect.[in Lloyd and Boyle, 66]

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8 That Bach titled his work *Das wohltemperierte Clavier* rather than the available *die gleichschwebende temperatur* has raised the question among some theorists as to whether Bach was using equal temperament. If he was using an irregular form of cyclic temperament, then he still marks an important stage in the retuning of scales to facilitate the ease of composition and playing, rather than the consonance of musical vibrations. That *The Well-Tempered Clavier* is now played and recorded in equal temperament successfully, with pleasing results, supports my argument that follows.

9 In the same year Rameau published his *Traité de l'harmonie* in which he argued that music depends on 'reason, nature, and geometry' and was a 'physico-mathematical science' expressible in ratios and logarithms.

10 As Lloyd and Boyle suggest (quoting Philip Spitta), there was no necessity for Bach in equal temperament:

"...he carried out his method [of tuning] with such rapidity and certainty that it never took him more than a quarter of an hour to tune a harpsichord or clavichord." Thus it would appear that Bach knew exactly what kind of temperament was best suited to his music, and also how to tune it to his satisfaction with speed and efficiency.[169]

Any tuning that deviates significantly or at all from pure ratios deviates from the psychophysiologically determined concordance.
Concurrent with Bach, Georg Andreas Sorge wrote of the instrument maker Silbermann, who advocated meantone temperament:

In a word - Silbermann's way of tempering cannot exist with modern practice. I call upon all impartial and experienced musicians - especially the world famous Herr Bach of Leipzig - to witness that this is all the absolute truth. It is to be desired, therefore, that the excellent man [Silbermann]...should alter his opinion regarding temperament.[In Barbour, 196]

Given the mistuning of temperament, we are now quite comfortable listening to notes which do not have the purity of natural tuning, which present to our ear more complex harmonic mismatches.

Despite the physiological bias toward mathematically related notes and chords that minimize wave interference Western culture deliberately opted for a more complex and arbitrary system of pitches. The trade off was between consonant, pure, and simple music and more dissonant, dense, and complex music. The trade off was made and was ultimately successful, because of a change in the cultural demands placed on music. Playing within two or three octaves of a Pythagorean scale will not produce significant dissonance. As Barbour explains, for composers like Bull and Pachelbel and Scarlatti "who effected enharmonic modulations and used double sharps...equal temperament was needed."[195] This trade off is greater still:

The pedals of the harp are constructed to produce the semitones of equal temperament; therefore, once the harp is put in tune with itself, it, and it alone of all the instruments, will be in equal temperament. The violins show a tendency toward the Pythagorean tuning, both because of the way they are strung and because of the players' tendency to play sharps higher than enharmonic flats. Furthermore, in a high register both the violins and the flutes are likely to play somewhat sharp for the sake of brilliance...[and] the brass instruments...have a natural inclination toward just intonation...Of course the ears of the audience, trained for years to endure such cacophony, actually are pleased by what seems to be a good performance.[200]

Playing within the limitations of the Pythagorean scale produces extremely pleasing results and was still championed in the early sixteenth century. The two restrictions of the Pythagorean scale, and on meantone temperament and just intonation, are on a dense and extended range of harmonics and on playing in different
key signatures. Equal temperament addresses the limitations of dissonance in the Pythagorean scale, but the solution is to mistune all notes. Society adopted one method of tuning over another, giving up by so doing discernable tonal simplicity for the greater emotional expressiveness the Greeks had recognized in chromatic scales and that was now available in all keys.
CHAPTER FIVE: COLOUR AND CULTURE

Our second anthropological study is of historical European and Mediterranean cultures, the historical roots of English. We are interested in the colour experiences of people in different cultural contexts. How were colours used? Is there evidence that cultural aims overstepped the psychophysiology of colour perception? What was the status of basic colour categories and primary colours? What were the foci and extension of their colour categories? For some time there has been consensus that there are three colour systems, that of light (the additive system), that of pigment (the subtractive system), and that of vision (the psychophysiological system). There is less consideration of how these three systems relate and affect one another - the general assumption is that each system can and need only be treated in isolation. Following Berlin and Kay the standard practice has been to first ensure colour vision normalcy, the perceptual awareness of the whole visible spectrum (the psychophysiological system); then to test experience and categorization of light (the additive system), without any separate consideration of pigments (even though the tests usually involve the informants looking at pigments) or intermodal activity between the experiences of the two objective systems. On the evidence it turns out that a less complete understanding (categorization and compartmentalization) of these systems removes a psychological impediment, allowing for freer interaction in the treatment of colour experiences. This in turn introduces a pragmatic, cultural component into our colour categorization: categorization by aperture colour is inseparable from other categorization tasks.

Cultural determinants

The work initiated by Berlin and Kay concerns spectral colour and our perception and categorization of it. As I and others have argued, there are sharp distinctions to be drawn between spectral and aperture colours and colours as we experience and use them in our daily lives. Ecological colours include those colours that humans both create and manipulate, and they have social and psychological

1 See Davies, Corbett, et al (1991) and Davies, MacDermid, et al (1992) which use colour squares on a computer screen (light fired at the eye from a cathode ray) and varnished colour chips mounted on wood.
significance. In painting, weaving, and decorating we deliberately alter and introduce colour with dyes and pigments. In describing subtractive mixtures of pigments in Chapter One I said that red, yellow, and blue were the conventional primary colours. While conventional, these (with black and white) have been, historically, a dominant choice as primaries or as hierarchically important. But they have not been the exclusive choice as primaries or basic colours. Nor have their optical counterparts enjoyed exclusivity. Until quite recently painters were taught to have two sets of primaries on their palettes. Known as split primaries, the reason behind this advice is that pigments are as they come - minerals, salts, extracts and chemicals do not neatly occupy simple and psychophysically unique wavelengths. Artists were advised to have on their palettes, for example, in addition to red and yellow, red-orange and yellow-orange for mixing to create orange. With black and white, six rather than three basic pigments would enable the artist to mix a fuller palette (though even this will not allow the artist to produce all the colours of nature). 2

If Berlin and Kay were correct (and there were an underlying, universal psychophysiological basis to our categorization of colour), then we ought to detect an overriding prevalence in our own past of four chromatic and two achromatic categories, and following Kay and McDaniel we should expect to find evidence of the constriction of these categories by the rise of the secondary terms purple, pink, orange, and grey. If, on the other hand, we find substantial social variance, then my claim that the opponent-process theory subsists but does not significantly determine cultural categorization is warranted. There are two components to this argument. First, there is evidence of the instability of hue categorization. This manifests itself in two ways: terms referred to both hue and non-hue features simultaneously or successively and terms referred to different parts of the spectrum or colour space at different times. Second, there is varying identification of the loca-

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2 Cézanne, commenting on Émile Bernard’s limited palette, exclaimed: “You paint with just these? Where is your Naples yellow? Where is your peach-black, where is your sienna earth, your cobalt blue, your burnt lake?...It is impossible to paint without these colours.”[In Gage, 224] Faber Birren, in the 1987 edition of his Principles of Color, advised that to achieve true brilliance of color the artist’s palette should contain “in addition to primary red, yellow, blue - such other vivid pigments as vermillion, cadmium orange, lemon yellow, ultramarine blue, cobalt violet - plus the new phthalocyanine blues and greens and the new monastral reds.”
tion of foci applied to spectral light. This is notable when viewed against the strong physiological justification of the Berlin and Kay theses. The first component goes against both the evolutionary and the universal theses, the second against the universal thesis. In the case of painting, when terms have been stable (as hue terms), categorization follows the availability of pigments and the extant cultural cosmology, mythology and mercantilism as much as psychophysiological salience. In the case of rainbows, identification of foci (bands) follows physics and mythology. I first take up the case of terminology, then pigments, then spectral colour and rainbows.

The evidence that I rally in this chapter should not be taken as supporting or compatible with the Berlin and Kay thesis of evolutionary development. For instance, I present evidence that the ancient Greeks demonstrate stronger discriminatory powers for brightness than for hue and a subsequent development of hue discrimination. However, there is no evidence that this is physiologically rather than culturally based, and there is evidence that the categories used by the ancients are not equivalent (even roughly) with those set out by Berlin and Kay. That some of this evidence can be interpreted as supporting the evolutionary thesis is due in part to the claims made by Berlin and Kay. To merely state that a black-white discrimination is the most primitive and universal colour categorization says nothing about why this may be the case. Even the strong physiological argument says nothing about why cultures should not have categories which exhibit fully six categories and intermediaries. What I offer is an explanation of the rich historical record of these differences, both between and within cultures. Such an investigation of the cultural factors provides a better explanation of the evidence than does the Berlin and Kay theory.

**Semantic shifts**

The historical record suggests two intriguing and interrelated features of the use of colour terms. First, there is evidence that from the Greeks and Romans through to the Renaissance colour terms were used primarily in association with specific things or classes of things, and secondarily and infrequently with abstract spectral and aperture phenomena. A 'colour' term is more apt to designate materials and processes, non-colour categories and concepts, and families of related
hues (by no means equivalent to our categorizations) than colours as we identify them. Consequently, from the present perspective, colour terms have seemed at various historical times unstable hue designators. Second, over time terms have shifted in meaning, sometimes coming to be stabilized around specific hues when before they were used primarily as non-hue designators. Generally, but not exclusively, the move has been toward stabilization around hue rather than to stabilization around non-hue; that is, on average, the number of specific colour terms has increased rather than decreased. For instance, terms that at one time referred exclusively to material substance came to be associated with specific abstract or spectral hues. However, such terms have only come to be stabilized (localized around spectral hues) with changing social desires and practices.

The real sea change came with the observation of dispersion of refracted light and the interest this subsequently generated in the early seventeenth century in spectral colours. Prior to the detailed and oft repeated experiments with prisms performed throughout the seventeenth century, experience of spectral colours (notably in rainbows) seems not to have generated stable categories for perceived bands of colour. It was not until there were technological developments for controlling and measuring these colours that a keen interest arose in fixing the categories. Widespread interest in fixing spectral colour categories emerged only with the technological capability to do so. It was not until accurate and repeatable measurements were possible that spectral categories became a useful rule of comparison and classification. In one sense the move is not from concrete occurrences to abstract, but rather from concrete to concrete as the understanding of spectral light and colour changed. Colour itself was now something (conceptually) tangible; it could be manipulated, observed, and isolated all under strict conditions with repeatable and recordable results. The following examples demonstrate that colour concepts were unstable and how and why some came to be stabilized.

in her book *Colour Terms in Greek Poetry* (a title which does not do justice to

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3 See for an example of this latter John Gage's discussion of 'red' in Latin and Greek circa 200 AD. The Latin *rufus* "comprehended many colours, from purple to gold, where Greek had four terms - *xanthos, eruthros, purros, and kirros* - to cover the same area as rufus."[80]
the breadth of discussion of colour terms and categorization). Eleanor Irwin describes in detail the shift in extension and reference of terms in early Greek from 900 BC to 600-500 BC. She underscores how assumptions about terms that came to refer to specific hues create confusion in reading older texts where those terms do not refer to spectral or abstract colour terms:

The Homeric Greeks had not yet learned to think in abstract terms. "What is colour?" is a question they would never have formulated, let alone been able to answer. This condition accounts for the much-lamented vagueness of Homer's use of "colour" terms, in particular his habit of not restricting a term to colour, but using it for other effects.[22]

Two words that she devotes considerable discussion to are kyanos and chloros. Though these are usually treated as blue and green respectively, of the former, she notes that

if we translate it as "blue" in early poetry, we produce effects which are hard to imagine: blue clouds (ll. 13.563), hair (ll. 22.401-403), earth (Od. 12.243); a blue bull (h. Herm. 194), a blue-winged grasshopper (Hes. Sc. 393), blue men from Ethiopia (Hes. W.D. 527).[28]

Of the latter term, she says that "It is fixed by the theorists as "green", but it describes in poetry many objects which we would not call green: honey (ll. 11.631), a nightingale (Od. 19.518), dew (Pind. Nem. 8.40), tears (Eur. Med. 906), and blood (Eur. Hec. 127)."[29]

Irwin gives detailed evidence of the shift in meaning and extension of both terms. It has been suggested elsewhere that kyanos was synonymous with black, that its subsequent separation from black is evidence of the evolutionary progress claimed by Berlin and Kay. An important aspect of Irwin's study is the demonstration that terms could refer to non-chromatic phenomena at the same time as referring to chroma. Kyanos meant both dark or black (and so was sometimes used synonymously with melos and shimmering or glittering.4 In its earliest occurrences kyanos meant dark, dark-gleaming, or iridescent and was increasingly associated with

4 In this regard Irwin cites J. Lindsay. The Clashing Rocks: A Study of Early Greek Religion and Culture and the Origins of Drama who says "kyanos-dark is not a dead black. It glitters and shimmers like snake scales and the many-hued rainbow set against storm-clouds: it involves a movement of lustres on a dark surface."[In Irwin, 109]
the colour of the sea, to which it was often applied because of the glitter and iridescence of surf and wake.

Homer used *chloros* primarily to mean fear and pale. He occasionally, and those after him increasingly, used it to mean *moist* and *young* and *fresh*, and finally green (first used in a chromatic sense by Xenophanes). The solution to these and many other mysteries of archaic colour terms is to recognize that the meaning or extension of terms changes over time, for a variety of reasons. *Kyanos* and *chloros* did not metaphorically refer to sheen and fear or fresh, but came by common agreement to have the more limited meaning specific to hue. Such shift in meaning seems to have been common. For various historical reasons terms came to have their meaning localized around specific hues.

In an appendix to her work Irwin discusses cross-category terms used by the ancient Greeks. terms that refer to both brightness and movement. She notes that such terms have been problematic for translators who tend to translate them into one or another category. She suggests it would be more fruitful to endeavour to understand why the Greeks employed such a category, “to try to understand the unity they saw between brightness and movement.”

One of the keys to the meaning of these words is the effect of changing light or the play of light on a polished surface. This shimmer, sheen, gloss, or gleam seemed to the Greeks to be like the blurring of animals’ feet in swift flight, the flash of lightning, the gnashing tusks of wild animals or the vibrations of an insect’s wings.[213]

Her argument is that brightness and movement were conceived by the Greeks as a unity in two ways, either as the movement of spectral highlights on a shiny surface, such as glossy fur or feathers, or as quickly moving objects. Of the former, the appearance of movement of spectral highlights on the glossy feathers of a goose or coat of an ox is captured by a word that means both bright and moving. *Halos* is “gleaming” whether that gleam is caused by a bright surface reflecting light (like armour) or a swiftly moving object”, and captures both glossy and the sudden flash of movement as when the tail feathers of an eagle “flash out brightly and suddenly when it rises in flight.” *Argos* also refers to the flash of lightning and the teeth of a wild boar. Of the latter, it refers to the swift movement of the legs of a running dog or horse.
Similar cross-category features are documented in modern languages. Many languages have been reported with terms that describe and differentiate the colour and pattern of coats of cattle. This is notable among African languages, which are frequently classified low on the Berlin and Kay evolutionary staging. These languages typically exhibit few spectral terms and many surface and cross-category terms. This is particularly evident among groups of people for whom cattle are of primary importance in the terms for differentiating cattle. Somewhat atypical is Setswana, reported in Davies, MacDermid, et al:

The diminutive suffix -ana is used with color terms to signify female sex when denoting animals, particularly domestic animals. Thus botcifha (with the appropriate prefix) would be used of male animals and botshana of female animals. This is an unusual and interesting feature of Setswana, but one which is shared with other members of the Sotho (or Sotho-Tswana) group. [...] This intersection of sex and color in Setswana is interesting in a language that, as is normal in Bantu languages, has a well-developed gender/noun-class system but in which sex is not a defining characteristic.[1071]

Pigment and purpose

In Chapter Two I gave a cursory etymology for the English colour term purple. John Gage gives a more substantive account of purple in his Color and Culture, describing the cult status of the colour during Roman times and providing a more general history of the meaning of the term. His discussion of purple is part of a general argument that ‘colour’ terms have shifted meaning over time and at frequent times have been non-hue designators - all for cultural reasons. Of the cult status, Pliny wrote that purple

is the badge of noble youth; it distinguishes the senator from the knight; it is called in to appease the gods. It brightens [illuminat] every garment, and shares with gold the glory of the triumph. For these reasons we must pardon the mad desire for purple, but why the high prices for the conchylian colour, a dye with an offensive smell and a hue which is dull and greenish, like an angry sea?[In Gage, 25]

Why should there be such an interest in purple? Purple is a secondary colour and a term which, by Berlin and Kay’s criteria, is a late addition. However, what is commonly translated from the ancients as ‘purple’ initially referred to the source of the dye and the technique of using it, not to the colour. The importance attributed to ‘purple’ results from the scarcity of the source and the quality this
invests in garments: Pliny prefers the sheen the process imparts to the cloth, but any fabric dyed in this way is valued for the addition of the expensive pigment. This distinction was not worthy of special note by Pliny as (what we now consider colour) terms were variously attributed status according to the value (scarcity) of things, to precious pigments and to precious materials, such as furs or metals. By 'purple' Pliny means those things visibly dyed in a specific manner. In this case, colour is not the distinguishing characteristic.

As noted in Chapter Two, the word is derived from the source of a dye. The dye comes from two types of conch, the buccinum (purpura haemastroma) and the purpura (murex brandaris). Pliny describes the process of extraction and dyeing:

The buccine dye is considered unsuitable for use by itself, for it does not give a fast colour, but it is perfectly fixed by the pelagian [purpura], and it lends to the black hue of the latter that severity [austeritatem] and crimson-like sheen which is in fashion [intoremque qui quaeritur coeci]. The Tyrian colour is obtained by first steeping the wool in a raw and unheated vat of pelagian extract and then transferring it to one of buccine. It is most appreciat'd when it is the colour of clotted blood, dark by reflected and brilliant by transmitted light [colore sanguinis concreti, nigricans adspectu, Idemique suspectu refulgens].[In Gage, 25].

Gage suggests that part of the attraction of purple seems to have been the lustre it imparts to cloth, "it may well have been that...it was the miracle of purple to incorporate within itself darkness and light and hence the whole world of colour" especially as the dyeing process produced other colours (yellow, blue, red, at blue-green) as intermediate stages.[25]

Purple was not merely a preference among royalty and nobility as Pliny suggested, but came to be their exclusive possession by force of law:

Cicero and other first-century writers had spoken of 'royal purple' and by the

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5 Meyer Reinhold cites Nepos as reporting that “in his youth at Rome an inexpensive quality of violet purple was in vogue, selling at 100 denarii the pound; not much later red Tarentine purple came into fashion, and soon after dibapha Tyrian purple, the most expensive quality, the asking price for which was 1000 denarii the pound, if available.”[44]
time of Diocletian (early fourth century AD) it had come to be associated exclusively with the emperor. For anyone else to wear purple was tantamount to their plotting against the state. The ownership of any purple-dyed cloak or any cloth dyed with the finest purple or even an imitation of it incurred severe penalties...[25]

The emphasis in the various edicts is on the material production of the dye, not on the colour produced. At the time, the term ‘purple’, used generally of the colour, was also used exclusively of the dye extracted from the mollusc from which the word originally derives. The inclusion of the colour in the extension of the term was a later derivation. Purple only came to refer to a specific colour as a result of social demands.

This is not an isolated phenomenon:

...in the case of purple late-antique lawyers sought to stabilize the concept by referring not to a chromatic term but to a method of manufacture: medieval users of colour attempted to do the same with their textiles by isolating not the hue but the quality of cloth that the most precious dyestuff were used to colour....In Spain purpura was, as early as the tenth century, the name of a silk fabric, not a colour. It continued to be so in Europe at large until the Renaissance, so that we find many ‘purples’, from white and yellow to blue and black, as well as red and green.[80]

The implication in Gage’s argument is that lawyers and society at large opted for a definition based on material substance (whether a process of manufacture or a substrate) because of the unimportance granted to spectral and aperture colours. Authors such as Pliny do indicate hue preferences, such as the most appreciated hue of clotted blood. Nonetheless, the term ‘purple’ refers to the dye source and method of production; it is fortuitous when the resulting colour is most popular but garments with any of the resulting colours are ‘purple’. There is evidence that colour terms were abstract properties but such abstraction is not prior to material substance (even secondary qualities exist only in relation to substance).

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6 Boethius wrote that “‘black’ was used to describe rational man, irrational crow and inanimate ebony, and ‘white’ equally to refer to swans and marble, men and horses, stars and lightning”. [Gage, 79]
Gage describes similar histories for other ‘colours’:

The history of the much more recent colour-term ‘scarlet’ suggests a similar progression from material to abstraction...the term...appeared in the German-speaking world in the eleventh century to signify a fine shorn woollen cloth of great value. ‘Scarlets’ of many colours from black and blue to white (undyed) and green are documented in the early literature but since the complement to the most valuable woollen textile of the period was, understandably, the most valuable dye (which in the Middle Ages was the bright red kermes or coccus), it seems that by the thirteenth century the most usual ‘scarlet’ was that dyed with this colour.[80]

The examples of purple and scarlet trace the stabilization around specific wavelengths for two colours.7 With the rise of aniline dyes and pigments in the nineteenth century much was written about the instability of the pigments derived from natural sources. This instability along with the various results of individual dyeing processes and of pigment preparation may additionally account for the disregard for hue terms and the attention to process and materials. In the case of purple importance lay with the value of the dyeing substance, which was obtained with great effort, not the final hue, which was at best variable, at worst uncontrollable. The example of perse is of a term that fell out of use before or without being stabilized. Historians have puzzled over the word, as it seems to have been used to refer to colours as disperse as purplish-blue, blue, bluish-pink, peach, and rust. Gage’s account explains these references as well as references to fabric:

Perhaps, like ‘purple’ and ‘scarlet’, perse was a term primarily used of cloth...which was usually dark but could be supplied in a range of hues. If so, it was another example of the way in which medieval users of colour were able to stabilize their fluid perceptions of hue by focusing on the material substance.[80]

We find then that when colour terms do have fixed meanings this is not nec-

7 In 1978 Gage wrote that Pandius, which occurs in the early technical literature of colour-making, has been found, by experiment, to include hues as various as fiery red, ice-blue and a sandy yellow with an olive cast. One treatise alone, the eighth- or ninth-century Compositiones Lucenses, lists recipes for green and purple pandius, as well as one for pandia omnia...although some of the colours produced by recipes for pandius are decidedly dull, it is perhaps premature to dismiss an interpretation which may well have pointed to some other quality (e.g. lustrousness) than hue.[105-6]
essarily as indicators of spectral colour or colour abstracted from material substance. Quite the opposite. The rise of heraldry is a cultural change that had demonstrable effects on the unstable colour categories of medieval Europe and produced specific groups of basic terms. With the increased prevalence of heraldry for identification in battle and of kinship came a new demand for the stabilization of colour terms. Colour was central to heraldry and early in its history catalogues appeared which attempted to standardize the blazonry. In the mid-thirteenth century armorial rolls appeared which greatly standardized the selection of possible colours as well as the colours of existing heraldry. The selection of appropriate or allowable heraldic colours was based on the scarcity and value of the materials, 'colour' terms referred to materials rather than spectral properties. Consider the eight terms of heraldry, as identified in the French Bigot Roll and the English Glover's Roll: or, argent, azur, gules, vert, and sable, and the furs ermine and vair (squirrel). Or and argent were the most precious metals, azur (ultramarine blue) the most precious pigment, gules, sable, ermine, and vair the most precious furs. Sable, unlike the two actual furs, draws its name from the habit of dyeing black the fur of the animal (and was known as black-gold), and gules derives "from the Latin gula (throat) and used of the fox-fur collars, including the head with its open mouth, that were fashionable in the twelfth century."[Gage 82]

Of the colour terms of heraldry Gage writes that

the requirements of that highly artificial vocabulary were abstraction, in that it should be removed from everyday language, and at the same time the concreteness of association with objects of great material worth. Even the four furs were included because of their monetary value not because the animals from which they came (the fox, the sable, the ermine and the squirrel) had any special place in the medieval bestiary, which fulfilled an essentially moral function.[82]

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8 Through a mistranslation from the French to the English, Cinderella's valuable fur shoes became the certainly uncomfortable and probably unwearable glass (verre) slippers.

9 Vert is a common term for green but because of its similarity to vair was replaced by sinople, a term which "was generally used to denote red but which had, paradoxically, come to stand for green by the early thirteenth century. (Sinople, however, continued to mean red in poetic usage for another two centuries.)"[82] That a term for red could come to refer to green (and to both) further suggests the instability of colour terms in this time.
A further complication in the categorization of colour results from this association of colour value with material value. Had other precious pigments been available other colours could have dominated heraldry. In painting and weaving, the same valuation is evident and colours in general are ranked and re-ranked according to the current value of the material sources. In painting, more often than not the clothing of the Virgin is depicted with the (currently) most precious pigments or exhibiting the colours of the (currently) most precious dyes.\footnote{See Gage, page 122.}

These Greek and Latin examples should not be taken as confirmation of the claim about evolutionary staging made by Berlin and Kay.\footnote{It is worth noting that in 1858 William Gladstone first made his claim that the colour sense of ancient Greeks was inferior to that of Europeans (including Greeks) in his own time. This is a culture for which we have longitudinal evidence of the possible evolution of the colour sense. Many authors have subsequently pointed out that the rate of evolution necessary to have occurred in the intervening years is completely inconsistent with all other like evolutionary changes. Grant Allen in his 1879 \textit{The Colour-Sense} is probably the first to point this out. See Hickerson 1983 for a fuller account of the various interpretations given to Gladstone over the years. Berlin and Kay generally argue for cultural or developmental evolution, as when they state that “the sequence of elaboration of color lexicon is an evolutionary one accompanying, and perhaps a reflex of, increasing technological and cultural advancement.”[16] They also seem to leave open the possibility of physical Darwinian evolution in their discussion of earlier research which includes the work of Gladstone.} Within cultures demonstrating significant historical and cultural continuity terms come to refer to specific hues (focal, basic, and neither), fall out of use altogether, and shift in reference away from hues. The Greeks, Romans and Medieval had, at times, terms for abstract colours. Yet each successive culture did no more than casually adopt the terms and categories for spectral hues used by its predecessors. The eleven basic colour terms identified by Berlin and Kay comprise a group of terms that apply to spectral light or light in abstraction from surface. Other groups of colour terms exist in our own and other cultures. The presence of any particular group indicates the interests of that culture. Consider the exclamation of Cézanne. Three of the five colours he finds essential to painting are clearly not related to focal hues. It is really only in introductory discussions of colour theory that basic primaries arise. In turn, spectral terms arise only with the advent of serious and sustained discussion of spectral light...
which first warranted a distinct vocabulary and ultimately co-opted the extension of
colour terms, so that 'colour' means in our culture 'spectral colours'. Painters may
think in terms of Berlin and Kay's basic terms (as do we all in Newton's successor
culture), but they speak and work with a completely distinct group of terms. Cultures
produce groups of basic terms and categories as the need and the occasion arises.

Aristotle's rainbow

Although a thousand different colours gleam,
Their mere transition escapes the watching eye,
So alike are adjacent colours.
Yet far-parted colours are distinct.[Ovid, Metamorphoses] 12

Pigments and dyes do make up much of our, and our ancestors', colour expe-
rience, particularly of our exceptional colour experience, experience of bright hues
and combinations of hues, in context independent situations. But our ancestors did
not only experience a world of colour available from extant colouring agents. The
most notable natural phenomenon shared by all our ancestors is the rainbow. This
is especially important for, if anything, it is to the colours of the rainbow that Berlin
and Kay's basic colour terms refer. On their account an accurate description of the
rainbow must surely elicit these terms. As Hardin suggests in Color for Philosophers,
in thinking of the "stereotypical representation of the rainbow as consisting of col-
ored bands....we recognize it as a stylization, we do not see it as a serious distor-
tion of the truth."[204 n. 22]

Ovid and Virgil had both described the rainbow as composed of a thousand
colours indistinguishable from each adjacent colour. 13 Seneca followed them in this


13 As when the rainbow, opposite the sun
A thousand intermingled colors throws.

With saffron wings then dewy Iris flies
Through heav'n's expanse, thousand varied dyes
Extracting from the sun, opposed in place.

[Aeneid V 88 and IV 700, trans. in Boyer]
But seven, five, four, three, and two colour rainbows were also championed. Aristophanes identified purple, green, and yellow in the rainbow; Empedocles identified four colours associating them with his four elements: white/fire, black/water, red/air, and yellow-green/earth. Democritus, Plato, Isidore of Seville, the Brethren of Purity, Theodoric, and J.C. Scaliger all described four colour bows. Metrodorus of Chios and Posidonius described two colour bows. Aristotle, Theophrastus (or whoever is the author of De Coloribus), Olympiodorus, Albertus Magnus, Pierre d'Ailly, Piccolomini, and Descartes described three colour bows. Bacon, Jerome Cardan, and Kepler had five colour bows. Ptolemy, Franciscus Maurolycus, and Newton had seven colour bows.

This already suggests a problem for the Berlin and Kay thesis and the claim that opponent processes manifest themselves as four colour categories surrounding four distinct wavelength foci. As we now know, the rainbow is the spectrum refracted in individual droplets of water. While the size of droplets will affect which parts of the spectrum are visible, so that not all colours are visible at all times, those parts that are visible will be visually grouped into bands of dominant colours just as the full spectrum produced by a prism. Long observation of various rainbows will reveal the continuity obscured in the individual occurrences of bows. With time the experience more closely approaches that of a full spectrum of light dispersed by a prism. As with all spectra, the rainbow presents an array of continuous wavelengths; the appearance of bands is physiological and psychological. Why then has the history of observation of the rainbow not elicited only four (or eight) bands? Further, why has there not been agreement about the colours (foci) of the bands? Why does the disagreement not follow the proposed evolutionary development suggested by Berlin and Kay?

While interest in and careful observation of the rainbow dates in Europe and the Mediterranean at least to Anaximenes, the evidence suggests that there was far

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14 Using pigments, such a rainbow must be represented using a finite number of rows of mosaic tiles or the blending of a finite number of pigments. See Boyer and Cromble for good histories of colour categorization of rainbows.

15 See Boyer. Chapter XI, especially page 315.
from universal agreement on how to describe the colours that it comprises. The number of distinct bands varies from observer to observer from two to over a thousand. Even the order of the colours across the bow seems to have caused problems for some observers, though I am prepared to attribute this to casual and non-rigorous observation, and so not a central concern here. My argument is that the historical record demonstrates that individuals in different cultural milieus perceived and described the rainbow in different ways, ways that were commensurate with their cultural expectations and with the tools of investigation, of science, and of logic that were available to them. That we are completely wrong in believing $x$ does not mean that we cannot hold (even hold deeply) beliefs that are entailed by $x$. From Aristotle to Newton there are observable differences in the terms used to describe the colours of the rainbow. The modification and replacement of several deeply rooted cultural beliefs underlie these differences. One is the gradual stabilization of colour terms and another is the replacement of the metaphysical and mythological hierarchical ordering of colour, both discussed in the previous two sections; another is the replacement of the Aristotelian belief in the physical production of colours by admixtures of black and white with the theory of refraction (and dispersion). At times the differences are obscured by translators who are less concerned with colour terms per se than we are here. We must differentiate between how philosophers of the natural sciences at various times in history have described the colours of the rainbow and how translators and commentators have glossed those descriptions.

Though his theory of the production of colour has been dismissed as wrong for the past 350 years, Aristotle's account of the formation of the rainbow has enjoyed the longest success of any theory. His accounts of the production of colour and of the colours of the rainbow differ substantially from those given since Newton. In the Meteorologica, he maintains that "the rainbow must be three-coloured and its only colours must be these three": red, green, and purple.[375a5] He gives several arguments in support of this claim. One is that:

These colours are almost the only ones that painters cannot manufacture; for they produce some colours by a mixture of others, but red, green and blue

16 Irwin translates Aristotle's Greek in De Sensu as crimson, green, and purple. H.D.P. Lee translates these as red, green, and blue in the Loeb edition of the Meteorologica.
Aristotle is wrong about the production of green (and purple?) by painters. This may be an indication that Aristotle is not using these terms in their modern sense. But more importantly, this demonstrates a general confusion between additive and subtractive processes that plagued all accounts of rainbow or spectral colours until the sixteenth and seventeenth centuries. Aristotle was not immune to the urge to find regularity in the world, and another argument that he offers for the number of colour bands in the rainbow is that most things have three aspects or components. The passage above concludes that “between the red and green band there often appears a yellow one.” So Aristotle identifies four phenomenal bands in the rainbow with three objective bands, and rejects the objectivity of the fourth as a case of contrast between the red and green. the green making the red look lighter, hence yellow.

This squares with his account of the formation of colours in general. Colours were formed by the mixing of white and black light (light and dark). As white is darkened by black we get a variety of mixed colours and three unmixed secondaries - first red (closest to white), then green (intermediate between black and white), then purple (closest to black). In all, Aristotle lists eight colours - white, yellow, red, violet, green, blue, grey, and black - but claims there are only seven (he is undecid-

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17 It is significant to note that today painters have no trouble mixing green if they so desire. Part of my argument is that the physical and perceptual colours available to us shape our understanding of the nature of colour in the abstract. Prior to the work of Newton the colour available for manipulation to the Greeks was that of pigments. A limited ‘palette’ limits the material available for experimental purposes. Karl Schofield writes that the “brilliant colouring of Cretan art...was derived from but few basic colours.”[5] Much has been written on the Greek predilection, prior to Aristotle’s time, for restricting the palette to four colours. Pliny lists these as white, yellow, red, and black, or more specifically as “ex albis Melino, e silacis Attico, ex rubris Sinopide Pontica, ex nigris atramento”.[Natural History XXXV, 50] With the notable absence of blue, green would be impossible to produce. Interpreting purple as the third primary, if blue were unavailable then both green and purple would be impossible to produce by mixture. However, I have no evidence to support such a reconstruction of Aristotle’s meaning.

18 See Irwin, Chapters Four and Five.
ed about the inclusion of yellow or grey). Aristotle was not the first to propose an admixture theory of colour with black and white as the only pure or primary hues and all other colours as mixed or secondary hues. Though with characteristic care he worked out a theory of how the various mixtures produce the secondaries and by contrast the tertiaries, the theory dates to Anaxagoras and Empedocles (and there is evidence that Homer and other ancient poets employed this distinction, though it is likely it was not strictly a hue distinction).

This theory of admixture, developed by Aristotle, had champions as recently as the mid to late seventeenth century. The rival theory, the dispersion of light by refraction, was probably first demonstrated by Mersenne in 1634. In the 1660s, prior to reporting to the Royal Society his views on dispersion and colour, Newton first disproved to himself the older, accepted theory. The prima facie phenomenal evidence for the admixture theory failed to withstand the closer scrutiny of the new scientific method. Yet this seemingly modest distinction between admixture and dispersion has a profound effect on the conceptualizing of colour entailed by each of the theories. One immediate consequence of admixture is that it eliminates value or brightness as a distinct dimension of colour space. In fact the admixture theory does not propose a colour space but rather a colour continuum much like the spectrum produced by a prism: colour changes along the length but not along the height. Each colour is strictly associated with a particular brightness between black and white. Red is by nature light. This makes it unlikely that pink would be distinguished as a distinct category, it being close to a true red in the admixture colour space. Blood red, in turn, is apt to be associated with purple or black or, as pigment, as a mixture of two distinct pigments, red and black, and not as a distinct or pure colour, but as an analyzable compound. Is this a significant difference? Is Aristotle's account anomalous? Is there any way to plausibly reconstruct Aristotle's colour space?

As just noted, Aristotle's theory had currency even in the seventeenth century. For two thousand years this was the predominant theory of colour and light in Europe, the Middle East, and North Africa. Aristotle's account, then, is neither

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19 M. Mersenne. Questions Théologiques, physiques, morales et mathématiques.
anomalous nor insignificant. As to a reconstruction of Aristotle’s colour space, it is impossible to determine the location of category foci, but it is possible to determine that they are not equivalent with those of modern English. Aristotle’s hue names

\[
\text{A.: white, yellow, red, violet, green, blue, grey, black}
\]

\[
\text{B&K: white, yellow, green-blue-grey, red, purple, black}
\]

5.1 Comparison of colour space: Aristotle vs. Berlin and Kay

designated fixed brightness between black and white (light and dark). This certainly means that category boundaries differ and, more significantly, that foci differ from modern English, contrary to those determined by Berlin and Kay. In terms of brightness, the twenty language groups tested by Berlin and Kay identify foci of colours in this order: white, yellow, pink, orange, grey, green, blue, red, brown, purple, black (the foci for grey, green, and blue are all about equal brightness). Even omitting those colours not included in Aristotle’s scheme, the foci between the two accounts necessarily differ (and Aristotle thought that yellow may be a species of white and grey a species of black).

\textbf{From admixture to dispersion}

The history of colour theory from Aristotle to Newton is one of gradual change, and certainly involves the gradual shift of category foci, so that Newton’s seven colours are probably, for the most part, equivalent to modern English terms.\(^\text{20}\) It was not until 1230-35 that the admixture theory was significantly changed. That was when Robert Grosseteste wrote his \textit{De Colore} in which he relied on Aristotle’s theory of admixture, but with the significant modification of separating brightness and hue. Grosseteste had a thoroughly Aristotelian theory.

Colour, he said, was the ‘light incorporated with the transparent medium,’ and the range of nine principal colours from white to black was produced by the ‘intension and remission of three factors, namely, the purity of the medium from earthy matter (puritis vel impuritas) and the brightness (clartias vel obscuritas) of the light and quantity (multitudo vel paucitas) of the

\(^{20}\) We will see in the next section that there is at least one dramatic difference.
Grosseteste does not name the colours he proposes as intermediaries between black and white, so it is impossible to determine how radical a departure he conceived this to be. Nonetheless, he does propose seven colours between black and white (two more than Aristotle), all of equal brightness, with maximum colour saturation midway between the two achromatic poles. Colours were increasingly desaturated with increased amounts of white and black. This move ought to have changed, though there is no indication that it did. Grosseteste’s conception of primary (Aristotelian secondary) colours, as foci are realigned in the colour space. Grosseteste’s theory was recounted without credit in Bartholomew’s De Proprietatibus Rerum and so was widely available in the thirteenth and fourteenth centuries.  

This marks the beginning of three important developments in the conceptualizing of colour. First, it effectively creates the modern colour space and allows for the repositioning of hues within it; second, it marks a shift in the meaning of ‘colour’ terms: terms that previously had been hue-value terms, in turn opening up ‘value’; third, it clears the way for colour to be thought of as distinct from objects. Yet it took over four hundred years for the import of these developments to be realized. During those four hundred years, the study of the rainbow and of optics and light were all major preoccupations of philosophers and natural scientists. It is because of the advances made in these areas that the Aristotelian theory ultimately was superseded by Newton’s.

As already noted, as long as hues were conceived as occupying specific locations between black and white, or dark and light, they could not have easily shifted focus (which they must have done in order to conform with modern English). Indeed, we find the persistent identification of blue as dark and red as very light well into the seventeenth century. The Aristotelian colour space is two-dimensional and any movement on the part of one colour category necessitates movement of at least one other category. More specifically, no foci could occupy the same value, as we

21 Crombie further indicates that Grosseteste placed red next to white and blue next to black.
find with the Berlin and Kay green, blue, and grey. Charles Parkhurst and Robert L. Feller note that Grosseteste's formulation allows for the construction of a colour solid with an achromatic axis and an equal value equator. Prior to Grosseteste the focal colours would not all lie on the equator. In fact, only one would. Also, Girolamo Cardano, according to Kemp.

attempted to determine the precise ratios of white to black for each colour. If a value of 100 is assigned to white and 0 to black, the result of a 50-50 mixture is said to be red, while yellow is 65-78% white, and blue contains 75% black.[264]

Presumably, this places red, alone, on the equator.

The second development is the related separation of hue and brightness. Aristotle had equated difference in colour not just with brightness but also with visual acuity. Our vision is finite. Beyond the natural limit of our vision we can only perceive black, regardless of the amount of light falling on objects beyond our limit. In the Meteorologica, Aristotle describes it thus:

(1) white light reflected on a dark surface or passing through a dark coloured medium produces red; (2) our vision becomes weaker and less effective with distance; (3) dark colour is a kind of negation of vision, the appearance of darkness being due to the failure of our sight; hence objects at a distance appear darker because our sight fails to reach them.[374b10]

For Aristotle and his successors colour was a function of dark and light. As either light or our vision diminished in strength or intensity the colour or apparent colour of objects changed. Today we conceive the achromatic grey scale as distinct from the colour space, but on the Aristotelian view they are one and the same. The grey scale, a scale demonstrating different values or brightness, is not achromatic. That objects at a distance take on a blue appearance suggested to Aristotle the placement of blue next to black in brightness, in fact required Aristotle to treat blue as a dark colour. Yellow and red were taken to be the first stage of diminished light because of their occurrence at sun rise and sun set; the rays of the sun are weakened with increased distance of transmission and with increased atmospherics such as mist, haze, clouds, and smoke.
Following Grosseteste there is no such requirement. Yet the Aristotelian model was so pervasive, and the significance of Grosseteste’s modification so little understood, that we still find, for instance, Leonardo after 1506 equating colour and value. Though the arrangement of hues has changed, Leonardo ties colours with elements and arranges them according to value.

And white is given by light, without which no colour may be seen, yellow by earth, green by water, blue by air and red by fire, and black by darkness which stands above the element of fire, because there is no substance or dimension on which the rays are able to percuss and accordingly to illuminate it. [In Kemp, 268]

The separation of hue and brightness follows other simplifications of colour terms. The Greek, Roman, and Medieval terms combining hue with movement, process, and brightness give way to separate terms for hue, movement, material processes, and brightness. An increasing realization that the behaviour of pigments and of

5.2 Three colour systems: Robert Fludd’s colour wheel, printed in 1629-1631, shows a distinct Aristotelian influence. He contrasts black and white describing NIGER as Lux nulla and ALBUS as Nigridinis nihil. The placement of black beside white demonstrates that this is a colour wheel in shape only. Isaac Newton’s colour wheel, though free of the influence of Aristotle’s admixture theory, shows his interest in unifying music and colour. The seven colours of his spectrum, including the peculiar inclusion of indigo, correspond to the seven notes of the scale, shown between the colour terms on the circumference of the wheel. A.H. Munsell’s colour wheel shows an attempt to reconcile the additive and subtractive systems by including both yellow and green and granting these equal weight with red and blue, along with purple.
lig. In art it is at times irreconcilable encourages a further radical shift in the conception of colour, that it is a feature of light and not a companion to it.

Artists tend not to have felt overly constrained by the theories of scientists. Yet artists such as Alberti and Leonardo in the fifteenth century, Lomazzo in the sixteenth century, and François d'Aguilonius in the beginning of the seventeenth century all wrestled with the contradictions between the behaviour of perceived colour, especially as pigments, and the postulates of the Aristotelian theories that suggested other behaviour. No distinction was drawn between additive and subtractive colours until the sixteenth century. In the fourteenth and fifteenth centuries, two techniques for modelling colour were advocated by Cennino. The first technique was to mix black and white pigments with a base colour to produce shadows and highlights. Cennino also advocated the use of shot colours (mixing a variety of coloured pigments with the base colour to produce shadows and highlights according to the value of the added pigment). The first technique meant that saturated colours only occurred in the shaded areas, the second that colours changed hue as they changed brightness. The use of black and white pigments should have demonstrated that there is at least a great brightness range of colours in addition to the primary and secondary colours - though these would have been conceived of as colour compounds, not as simple colours of differing values. That light or atmospheric colour should exhibit or be held to have these properties is quite a different claim. No clear and consistent distinction was drawn between additive and subtractive phenomena. Conversely, the phenomenon of complementary colours appearing in shadows must have been problematic for those painters who were keen observers of the world. Shot colours in part conform to this experience. Pigments certainly would not have been available exclusively in brightnesses that corresponded with Aristotle's scheme or any later scheme. Children taught the subtractive primaries will identify these primaries in a full spectrum. Their knowledge can be contradicted with a demonstration of additive mixtures, yet they will not eas-

22 This is further complicated in a culture where not all 'colour' terms are hue designators. As I have suggested, purple and δολοφύγον could not have been conceptually synonymous if the one referred to a material process and the other to a spectral (rainbow) colour. Most significantly, the separation of hue and value allows for the development or mapping of new categories such as pink and brown, which Berlin and Kay argue fill in areas of the colour space.
ily reject the older, equally demonstrable theory for an unknown new theory nor readily decide that two theories are required.\textsuperscript{22}

Aristotle had postulated that colour was a part of objects, a capacity to transmit light in a certain way.

The visible, then, is colour. Now this is what is on the surface of that which is \textit{per se} visible; \textit{per se} not in the sense of 'by virtue of its definition', but because it has in itself the cause of its visibility. Every colour is capable of causing change in that which is actually transparent, and this is its nature.\textsuperscript{[De Anima 418b]}

The rainbow was the result of reflection. Aristotle described two types of reflection, from smooth surfaces (mirrors) producing images of objects and from uneven surfaces reflecting only the colours of objects and not their form. The rainbow was the product of the latter type of reflection, from the uneven surfaces of clouds. He further explained the distinct bands of colours in terms of his admixture theory and diminution. This meant that for Aristotle colour was strictly associated with objects. Even the rainbow was a virtual image of the sun. While there is nothing in Grosseteste's reconstruction of the Aristotelian theory to suggest that colour was not a feature of objects, it marks a significant step toward the unification of colour and light. On the admixture theory, colour is determined by both light and an absence of light. It is not possible on this model to unify colour and light.\textsuperscript{23} Shortly after the publication of \textit{De Colore}, Albertus Magnus, who closely followed Grosseteste, gave an admixture argument for the shape of the rainbow using a glass ball filled with black ink. Placed in bright sunlight, only the edge of the globe appears bright (passes light). Albertus argued that light from the sun failed to pass through the darker centre of conical clouds, all the visible colours of the rainbow derived from light passing through just the edge of the cloud.

Grosseteste's modification of the Aristotelian system should have been dra-

\textsuperscript{23} In point of fact, only three principles have been advanced since Aristotle to explain the causal relation between the sun and the rainbow: projection, reflection, and refraction. All three are compatible with the theory that colour is a feature of objects and separate from light.
matic, yet it had little immediate consequence. Other striking observations, now granted as forcefully demonstrating the dispersion theory of colour, were viewed as compatible with or supporting the admixture theory. In a series of experiments in the mid-thirteenth century Witelo refracted light using hexagonal crystals, but concluded that the resulting colours were the product of admixture. The crystals acted as prisms, so that light entering one side obliquely was refracted and dispersed. Witelo explained that, as the light passed through the crystal, it was mixed with the darkness of the crystal. The more of the crystal through which the light passed the greater the admixture of black and hence the various colour shifts.

Early in the fourteenth century Theodoric made a conceptual leap. Though prisms, crystals, and globes filled with water had been variously used to produce spectra for centuries before Theodoric, he was the first to realize the model presented by these globes. Carl Boyer underscores this leap:

Alhazen had made many experimental observations on globes of water, but he was fettered by preconceptions: he thought of the sphere either as a magnifying glass or as a reflector. Never once did the thought seem to have occurred to him, or to anyone (with the possible exception of Albertus Magnus) before the fourteenth century, that a globe of water can be thought of, not as a diminutive spherical cloud, but as a magnified raindrop.[112]

As Boyer says, just so long as we “thought in terms of clouds as the agency producing the bow, no practicable laboratory study seemed at hand. Frequently explanations of the rainbow had referred to raindrops, but it generally was the totality of drops which seemed to be important.”[111] From this initial insight Theodoric gave the thoroughly modern explanation that the rainbow was caused by both reflection and refraction in individual drops of water. Yet, he still maintained the admixture theory. In a discussion of refraction he follows predecessors such as Witelo when he writes that the emergent dispersed light “is differentiated into the four usual colours; and a solid [opaque] body on which it falls is coloured with the same colours...in the same inviolable order by which yellow follows red, and after that comes green, and finally blue.”[In Crombie, 247] His Aristotelian conclusion is that red, yellow, green, and blue are incrementally darker due to the refraction of light.24

24 This seems to suggest that Theodoric at least ought to have held red to be brighter than yellow, contrary to the current sense.
Theodoric's theory moves us a step closer to the modern conception of colour as part of light. Just as his predecessors could not conceive of globes as magnified raindrops because of their notion of the production of the bow (projected on, reflected or refracted by whole clouds), they along with Theodoric could not conceive of colour as an aspect of light. That was Newton's insight.

Newton's rainbow

Newton was not the first to observe the spectrum of colours produced when white light passed through a prism. He was the first to understand the implication of the observation. There is a long history to observations of white or sun light producing spectra. Newton was following a long line of predecessors when he obtained a prism and undertook to demonstrate to himself the much reported effect, what he called “the celebrated Phenomena of Colours”. [In Kemp, 285] However, prior to Newton the phenomena was explained in terms of the Aristotelian admixture theory: the different thicknesses of the prism add different amounts of black to the white light.
The rainbow alone seems not to have produced the sort of physiologically determined categories anticipated by Berlin and Kay. Prior to Newton prismatic spectra also seem not to have had such an affect. However, Newton’s work and the subsequent interest in spectra did lead to colour categorization. While there was interest prior to Newton and his discoveries must be seen on a continuum, he provided the material and conceptual tools to rethink the relation of colour and light. As suggested near the beginning of this chapter, with each advance colour could be increasingly manipulated, observed, and isolated, all under strict conditions with repeatable and recordable results. Newton provided three critical experiments: dispersed light could be recombined back into white light; dispersed light could not be further dispersed; individual portions of the spectra could be combined to form other colours and even white light. Colour terms were stabilizing around spectral colours centuries before Newton. The ultimate choices, based on the observation of spectra, may well have been psychophysically determined. But this stabilization was the result of cultural interest in and technological advances in the study of light and colour. The choices made about spectral categories did not produce corresponding psychophysiological categories of our experiences with ecological colours which greatly predate the interest in colour as colour.

Several theories have been put forward as to why Newton chose a seven colour spectrum. It seems most likely that as with Aristotle, he felt the urge to find regularity in the world. The most compelling explanation is that he

attempted to derive an analogy with the musical scale, a possibility which had first been suggested by Aristotle in De Sensu. Many believe that Newton was influenced by Kepler’s Harmonices Mundi, this doctrine becoming an obsession with 18th-century natural philosophers.[McLaren, 229]

25 The move from the admixture theory to the dispersion theory was aided by technological advances in both the science of optics and the science of pigments. While Newton’s sophisticated use of glass prisms helped to develop the details of the dispersion theory, the work of Le Blon and William Percy further changed the rôle of pigments, a change which leapt forward in the mid-fifteenth and sixteenth centuries with the improvement of oil paints. Increased stability and workability of oil pigments allowed for what Gage calls “the new capacity for the illusionistic treatment of detail” which in turn “slowly led to that devaluation of pigments as indicators of worth in painting”.[1993, 131-132]
In this case, Newton's categorization of the spectrum was in great part determined by cultural beliefs he held. It seemed reasonable to him, and to his contemporaries, that such analogous regularity was possible and warranted.

A particular puzzle with Newton's colour space is his inclusion of indigo. Several theories have been offered to explain this inclusion. It is important to note that in 1708 the inclusion of indigo was not a point of particular curiosity among Newton's contemporaries. It is only later authors who have found this a unique feature. In part this is due to the fact that indigo was a common (popular) colour term in Newton's day. As K. McLaren put it in 1985, "by the early part of the present century indigo had ceased to be a common colour name except in connection with Newton."[226]

Indigo provides a separate demonstration of the cultural component of colour nomenclature and categorization. McLaren compares Newton's wavelength categories with Wratten filters and the ISCC-NBS (Inter-Society Color Council - National Bureau of Standards) categories. Newton's indigo covers much of the same colour space as ISCC-NBS purplish blue. Yet, indigo is strictly blue. The name refers to the resultant colour of a particular dyeing process. This process and colour were adopted by the British navy in 1748 as the standard for naval officer's woollen uniforms. "The world of fashion then adopted navy blue as the preferred name for this color, and eventually navy achieved the ultimate status of being a single-word color name in common usage, at least in the UK."[McLaren, 226] Following 1748 navy and indigo were identical colours. With the adoption of navy as the term referring to a specific colour, the term indigo has changed meaning or extension. A fall 1994 mail-order catalogue arrived at my door offering me sweaters in both navy and indigo. The samples were of two clearly distinct colours, one blue, the other purplish blue.
CHAPTER SIX: VISUAL PERCEPTIONS

We thrive in information-thick worlds because of our marvellous and everyday capacities to select, edit, single out, structure, highlight, group, pair, merge, harmonize, synthesize, focus, organize, condense, reduce, boil down, choose, categorize, catalog, classify, refine, abstract, scan, look into, idealize, isolate, discriminate, distinguish, screen, sort, pick over, group, pigeonhole, integrate, blend, average, filter, jump, skip, smooth, chunk, inspect, approximate, cluster, aggregate, outline, summarize, itemize, review, dip into, flip through, browse, glance into, leaf through, skim, list, glean, synopsize, winnow wheat from chaff, and separate the sheep from the goats. [Tufte, 50]

The claim made by the new universalists is that the Berlin and Kay theses benefit from the current opponent-process theory of colour vision. That the theory of opponency should be useful seems reasonable. After all, Berlin and Kay are theorizing about colour vision and how we categorize our experiences. Hurvich begins his 1981 book, Color Vision, with a nod to just this sort of thinking:

How many different colors are there? Answers to this question differ from one another by more than a factor of a million! For example, whereas some people have claimed that we can see more than a million different colors, others have proposed more modest figures — hundreds of thousands....If pressed to the greatest possible economy of color terms we find that we can describe all the colors we discriminate by using only six terms and their various combination. These are red, yellow, green, and blue, the four universal hues, and black and white, the two extremes of the series of hueless colours.[1-3]

But it is misleading, indeed inappropriate, to draw general conclusions about vision and language without accounting for all the current thinking on vision. Clearly, though the claim is about language, it is also about how we experience the world — the claim is that our physiology constrains the role of our experience (culture) in our conceptualizing in a very particular way.

There is no denying that we are limited by our physiology. But we must ask: how does colour perception, the response of receptors in the eye, dovetail with, or work with, the other visual and neurological mechanisms? So that there is no doubt

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1 Hurvich cites Basic Color Terms at the close of this chapter under Further Readings.
that our colour perception did not evolve strictly to enable us to pick out unique hues or the points of equilibrium between these hues, I will pursue in greater detail the related mechanisms of the visual system. In the mid-fifties Gunnar Svaetichin made startling progress in recording the responses to colour of teleost fish, demonstrating with individual cells that the fish have wavelength specific neurophysiological responses. Hurvich reminds us that

Although we can establish the sorts of wavelength discriminations fish can make using the techniques of animal psychophysics and make various inferences about fish color vision, there is, of course, no way of knowing whether the terms "red," "green," "blue," and so on, have any direct counterparts in the fish visual experience.[139-40]

There are no colours in the head other than the play of light across the retina (just as there are no single or serial pictures or images in the head comparable to photographs). We have seen how the ganglion cells respond to stimulated receptors from overlapping regions of the retina and how each ganglion cell uniquely represents that stimulation - for any given receptor the outputs from different ganglion cells differ.

This chapter extends our discussion of the psychophysiology of perception. I sketch out some aspects of the subsequent higher order cell activity of the visual system as these relate to the opponent-process theory. The thesis that I develop is that detection has much to do with the interconnectedness of visual components (our experiences of our present environment) and our orientation within our environment. At the end of the chapter I begin to outline a broader thesis. My account of the physiology of perception is intended to establish how crucial it is to recognize the role of context at a fundamental level of visual perception. But context here is defined narrowly - generally as the immediate visual array, the play of light across the whole retina across a limited time. This narrow account of context can be broadened. Our intelligent eye is motivated by our knowledge and beliefs about the information-thick world. In chapters Seven and Eight I extend this sense of context with a discussion of perceptual experience grounded in pictures. The choice of pictures, and more broadly, representations, is based on what will be obvious visual connections - however, as indicated at the end of this chapter, I believe the context(s) involved in visual perception open up in several ways.
The fallacy of Misplaced Concreteness

In *Science and the Modern World*, Alfred North Whitehead described what he called the fallacy of misplaced concreteness. He wrote:

The advantage of confining attention to a definite group of abstractions, is that you confine your thoughts to clear-cut definite things, with clear-cut definite relations. Accordingly, if you have a logical head, you can deduce a variety of conclusions respecting the relationships between these abstract entities.[58]

I have focused on two related abstractions, the first made in 1969, the second made subsequent to this. Berlin and Kay confined their attention to spectral colour terms, abstracting these increasingly from aperture, related, and surface colours. In so doing they initiated the second line of abstraction, which has been significantly developed in writings that draw on the psychophysiology of colour vision. Subsequent writers have confined their attention to colour vision, abstracting it from the whole of visual perception. Such strategies of abstraction are legitimate; Whitehead notes both that it is impossible to think without abstractions and that from sound abstractions we may “arrive at a variety of important truths relating to our experience of nature.” Forming abstractions is not inherently fallacious.

However, both these abstractions about colour are instances of the fallacy of misplaced concreteness. Whitehead further writes:

The disadvantage of exclusive attention to a group of abstractions, however well-founded, is that, by the nature of the case, you have abstracted from the remainder of things. In so far as the excluded things are important in your experience, your modes of thought are not fitted to deal with them....[59]

The fallacy is committed when we assume that a particular group of abstractions are exhaustive, that they comprise all that is important. We first make abstractions, and categorize the world in particular ways. We then internalize these abstractions, forgetting that other abstractions, other categories, may also be formed. One current expression of this is captured with the term ethnocentrism. Whitehead cautions that we must be constantly aware that we are making abstractions and that these
do not accurately "represent" the full scope of variability in the world, that in making abstractions we are excluding other important things.

The question Berlin and Kay ask is this. Is there cross-cultural isomorphism of terms used to describe spectral colours? Another question worth asking is this. Is there cross-cultural isomorphism of terms used to describe pigments and coloured material substance? These questions elicit quite different answers. The answer to the first question is that where languages have terms that refer to spectral colours there tends to be isomorphism. Following the discussions in Chapter Five, the answer to the second question is no. Neither of these answers should be surprising. The first question investigates when (not whether) different cultures categorize in similar ways and draw the same abstractions. It is trivial then that they have isomorphic terms for isomorphic categories. Berlin and Kay obscure this distinction by finding spectral terms in a variety of languages and so concluding that they have found similar cultural categorization. Here, similarity of cultural categorization must be understood in a brute sense. As an example of technological and cultural complexity Berlin and Kay suggest that


to a group whose members have frequent occasion to contrast fine shades of leaf color and who possess no dyed fabrics, color-coded electrical wires, and so forth, it may not be worthwhile to rote-learn labels for gross perceptual descriptions such as green/blue, despite the psychophysical salience of such contrasts.[16]

The second question investigates whether different cultures categorize in similar ways.

The two abstractions I have just identified become fallacious when it is assumed that they are comprehensive, that they exhaustively categorize the domain they cover, and that the "truths" derived as a result of making these abstractions are comprehensive. Indeed, it is most likely the case that Berlin and Kay and subsequent proponents fail even to notice that they have made these abstractions, so common is this approach to psychology and science. The crucial mistake made by Berlin and Kay is to assume that an investigation of responses to spectral (and aperture) colours will produce an exhaustive list of basic colour terms. The assumption is that the European and Arab interest in spectral light is not an abstraction from
the broader experience of colour, that the results of this interest are not merely selections from a possible complex of abstractions. The subsequent mistake, closely related to the first, is to assume that the experimental isolation of colour response indicates that categories and terms arise directly from and exclusively to those colour responses. The experimental testing of any feature in isolation ought to be treated as producing special responses, and not necessarily the responses that determine our more common categorizations, those resulting from the more robust stimuli offered by information-thick worlds.

This also marks a common third mistake in the approach taken in the study of colour terms: that of assuming that colour perception can be analyzed in isolation from other visual perception tasks. Our response to spectral colours can be studied in isolation from other perceptual tasks, but is a part of our response to colour in general and must be considered in the broader context. So, too, the study of our response to colour in general must be considered in relation to our responses to the whole visual world and particularly the separate mechanics of perception. The title of this chapter refers to the different visual pathways which handle distinct visual tasks, such as movement, form, and colour detection, and stereopsis. It is more meaningful to consider visual perception as a complex of perceptions, of different perceptual tasks, often kept quite distinct until reaching different areas of the brain where they are cognitively assembled, but also informing each other on route. Designing experiments that isolate and test specific features of, in this case, vision can be misleading if not subsequently integrated back into the whole visual system where a consideration of the functional task can be undertaken. That is the approach recommended here: a fuller accounting of visual perceptions and the various integrations of these tasks demonstrates the limits of colour vision.

**A fuller accounting**

Claims that colour opponent supports the Berlin and Kay theses have generally disregarded the relation of this opponent to the spatial element of vision and the various roles of the separate visual pathways. I suggest that a fuller accounting of this recent psychophysiological work does not supply the hoped for support. In recent years electro and neurophysiologists have demonstrated that the visual
systems in primates involve a high level of segregation of various functions. Subdivisions at all levels of the visual system, from the ganglion cells to the highest cortical stages, discretely handle the tasks of identifying colour, form, movement, and depth. Initially, this may seem to suggest that there is a legitimacy in drawing universal conclusions about colour categorization from a treatment of colour perception in isolation from the other visual tasks. But in context, colour discrimination is not sufficient to successful visual negotiation of the world in which we live. These distinct visual pathways, each handling different kinds of tasks, work together, each enhancing the inadequacies of the other tasks. But the nature of the structures found here are also suggestive of the relative role that colour vision plays.

A consequence of the opponent-process theory is that we should expect to perceive physiologically unique (and dominant) hues along the spectrum, that at the greatest possible economy we need only six terms. The rainbow is perceived as comprising fairly distinct bands of colour, and not a continuous gradation from short to long wavelengths (though as noted in the last chapter the distinct bands do not correspond with subjective unique hues). The argument about language, then, is that it encodes these three physiological features, so we have terms for black and white, red and green, yellow and blue. And the argument against the linguistic relativism thesis (and specifically claims about arbitrariness) is that, as all humans have pretty much the same visual apparatus, we can expect that colour nomenclature across languages and cultures will encode these basic partitions of the spectrum. Additional salient colour terms indicate mid-value positions of the colour space (taking into account the achromatic components): grey, orange, purple, pink, and brown. There are two physiological components that need to be considered before claiming colour opponency supports the biological predominance in colour categorization: the spatial component of the visual system and the subsequent partitioning of visual signals. Colour opponency is only a part of the visual system, and two related aspects of this system ought to be considered; first, the spatial aspect of ganglion cells and the evidence this offers for a joint computation involving the retina and brain, and second, the separate visual pathways for colour, movement, form, and stereopsis.
As I have partially discussed the spatial aspect of receptive fields of the ganglion cells in Chapter One, I will first address the structure of separate pathways. My argument is based on the simple notion that while we can learn much about anatomy, physiology and basic perception by studying these distinct functions, to understand the unified perception (and higher cognition regarding that perception) we had best consider the interactions of these separate parts in relation to some fairly robust context of practice. So in considering in what ways languages encode colour perceptions, we need to look at the rôle of colour discrimination within the broader context of the visual system.

The opponent-process theory of colour perception is not the whole story. Livingstone and Hubel note that though "our perception of any scene usually seems well unified", our visual system "is subdivided into several separate parts whose functions are quite distinct."[740] In summarizing the current state of research into the physiology of vision, they indicate that our visual system comprises separate
and independent pathways. These pathways begin at the eye and remain distinct throughout the visual system (though there is some interaction), terminating at different parts of the brain. These pathways “differ from each other in the kinds of visual information they carry”: information about colour, acuity, contrast, stereopsis, form, line, movement.

The colour-sensitive cones along with the colour-blind rods together constitute the receptors of the eye. These send signals to the ganglion cells which in turn send signals along two distinct pathways to the lateral geniculate body: one to the magnocellular layers, the other to the parvocellular layers. These layers have quite distinct features: the magnocellular is colour-blind, fast to respond to signals, has high contrast sensitivity, and low resolution, while the parvocellular is colour-selective, slow, has low contrast sensitivity, and high resolution. This is not just the widely understood difference between the colour-blind, movement-sensitive peripheral field and colour-sensitive, high resolution fovea; for as Livingstone and Hubel note:

We can at least be reasonably certain that the two components must both derive their inputs from the same rods and cones and that the marked differences in response properties must therefore depend on the way the photoreceptor inputs are combined.[741]

To try to keep this simple and short, the main point is that these two pathways, and their distinctive features, continue through the visual system, terminating at different parts of the brain. The outputs from both types of lateral geniculate layers go to and continue through different subdivisions of the primary visual cortex (which handle form, colour, and movement) and of the visual area 2 (which handle form, colour, and stereopsis). One path is magnoptic → 4Cα → 4B and on to the middle temporal lobe both directly and via the subdivision of visual area 2 which handles stereopsis. A second is parvo → 4Cβ → interblob and on to the subdivisions in visual area 2 which handle form, and on to an undetermined area of the brain. Finally, a third path is parvo ( + magnoptic) → 4Cβ → blob and on to the subdivision of the visual area 2 which handles colour and on to the visual area 4.

Livingstone and Hubel continue:
There are strong suggestions that these channels remain segregated through still higher levels in the brain. From lesion studies Pohl and Ungerleider and Mishkin have defined two functionally distinct divisions of visual association areas: the temporal-occipital region, necessary for learning to identify objects by their appearance, and the parieto-occipital region, needed for tasks involving the positions of objects, a distinction they refer to as “where” versus “what”.

This distinction between where and what captures what I take to be the central reason for considering the role of the social and environmental context in colour discrimination and categorization. I will turn to this later. The upshot of these two psychophysiological components is that the detection of colour (and subsequent nomenclature) has as much to do with the whole visual array, with the peripheral as well as the foveal field, and with the detection of movement, form, and linear perspective.

Higher-order cell activity

In what immediately follows I outline the cell organization at higher levels of the visual system with the aim of drawing out three features of this organization, all specific tasks performed by the cell and cell compounds. I am particularly interested in end-stopping, border detection, and scanning. From the lateral geniculate body signals are sent to two kinds of cells in the primary visual cortex; simple and complex. As with lower-order cells in the retina and geniculate, simple cells in the visual cortex receive signals from a field, in which a pinpoint of light will trigger either an on or an off response. The shape of these fields differs from those of the lower-cell receptive fields. While the lower fields are circular, those in the primary visual cortex are elongated, divided lengthwise into either two or three regions. Most typical is an on centre strip and two off outer regions. Within the whole field stimuli are spatially summed: the more field affected by the stimulus,
the greater the response. There is also a mutual cancellation of responses when more
than one region of the field is affected. This means that the three types of cells (denot-
ed by their fields) each respond best to long thin
light, long thin dark lines, and dark-light edges.
The size and orientation of these fields varies
across all regions of the retina.

Complex cells, which far outnumber
simple cells, are like the simpler versions in
responding to specifically oriented lines except
that stationary stimuli seldom produce a sig-
nificant response. Rather than having excita-
tory and inhibitory regions, complex cells
require the movement of the stimuli across
their fields in
the proper
orientation. Hubel describes the difference thus:

If the properly oriented line is swept across the
receptive field, the result is a well-sustained
barrage of impulses, from the instant the line
enters the field until it leaves. By contrast, to
evoke sustained responses from a simple cell,
a stationary line must be critically oriented and
critically positioned; a moving line evokes only
a brief response at the moment it crosses a
boundary from an inhibitory to an excitatory
region or during the brief time it covers the
excitatory region.[74-75]2

Ten to twenty per cent of the complex cells in
the visual cortex are direction selective. These

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2 It is not entirely understood how these fields are built up, but it seems likely that
their elongated fields receive signals from overlapping and identically oriented cir-
cular ganglion and geniculate fields.
cells are only stimulated by properly oriented lines moving in one direction and not the other.

There is another feature of interest exhibited by these cells called end-stopping. Some cells are sensitive to the total length of the stimulus line. For some cells a line of any length properly oriented and corresponding to the type of cell sensitivity (a light or dark line, or border) will produce a response. With other cells there is an optimal length, past which the response will begin to diminish, either partially or completely. Working with non-end-stopped cells, completely end-stopped cells will differentiate between long and short lines and curved or contour lines. A contour with proper orientation in the excitatory region will curve away from the optimal orientation in the inhibitory regions. A contour stimulus may cover the whole receptive field for a cell, yet will only effect that portion in which it approximates the optimal orientation.

The visual pathway is remarkably well ordered, especially considering the jumble of nerve axons forming the optic nerve. Signals are transmitted from the retinal ganglion cells to the lateral geniculate body and on to the visual cortex in an orderly way, such that inputs on specific local regions of the retina can be traced through to individual simple and complex cortical cells, and cells are topographically organized - contiguous regions in the retina are contiguous in each of the sub-
sequent layers. Each level of the visual system is like a plate, stacked on the lower stage. The spatial component that is evident in the receptive fields of ganglion cells is also present in the primary visual cortex. In addition, the simple and complex cells of the cortex handling a variety of distinct tasks are grouped in layers according to task, rather than randomly dispersed through the cortex. Hence, the functional paths described in the previous section are mappable in both the geniculate and the cortex. One consequence of this is that the primary visual cortex cannot be the locale where cognitive images are "assembled" from the various cell responses, as discrete information about movement, colour, form, etc. remains discrete in the visual cortex and is transmitted from the cortex to different areas of the brain.3

The visual cortex is composed of a whole complex of topographically arranged and overlapping receptor fields of all orientations. Any simple visual field or partial field will stimulate specific cells, depending on the orientation of particular information in that field relative to the orientation of the fields ultimately triggered by the retinal cells. Much has been written on how the visual system constructs or aids in the construction of cognitive views of the world from these specific task-oriented cells. What is clear is that the visual "scene" is constructed by means of the particular biases of the components of the visual system. In this regard, it is important to note what kinds of tasks are performed by higher-order cells at the various "higher" stages of the visual system, and how these tasks are integrated. This will provide some insight into how colour sensitivity is integrated into our whole experience of the world, and how this may affect our higher cognition of the world. It turns out to be the case that a concession to the opponent-process theory and pre- and sub-linguistic categorization does not indicate any comparable linguistic and conceptual categorization.

3 While the processing at higher levels is less understood, it is generally conceded that cells cannot continue to handle such specific or increasingly specific tasks. The dubious consequence, dubbed the grandmother cell theory, is that individual cells respond to indefinitely specific stimuli. The speculative response to this is that constellations of cells are triggered by grandmother, that the cells in this constellation are widely distributed throughout the brain, and that any one cell may belong to numerous constellations.
End-stopping is important for movement and form detection. Complex cell fields are important for the detection of borders. Together they are critical to the process of scanning, both of the three dimensional world and the two dimensional world of pictures and surfaces. As noted in Chapter One, Yarbus demonstrated that our eyes move in two distinct ways, in a series of directed saccades and in involuntary and continuous microsaccades. The purpose, or at least advantage, of microsaccades is to avoid adaptation to light inputs. Images stabilized on the retina fade and disappear. This may be a measure of economy, but it has the consequence of increasing the importance of movement and border detection. A visual field without borders (luminance or hue differences) - which is also as a consequence a field without movement - would remain undetected by our visual system, it would present no stimulus and elicit no response. Yarbus, and many others, have shown that perceiving a visual array involves either saccadic scanning or tracking. Both of these processes involve borders. To scan is to jump from one border to another, and to track is to follow an object as its borders successively occlude and reveal more distant borders. The detection of movement is of fundamental importance to our survival, so it comes as no great surprise that so much of the higher-order cell activity of our visual system is devoted to this task. I next want to place colour vision within this whole multifunctional system.

4 Things are somewhat more complicated than this. An object moving against a uniform and featureless (borderless) background will register as moving. If we fixate on an imaginary point on the background, the object will ‘move’ across our retina, engaging new receptive fields. If we track the object our eye and head movements signal the visual system of objective movement.
Luminance, colour, and the world before us

Livingstone and Hubel argue that the electrophysiological evidence demonstrates the independence of several visual pathways. But independent pathways do not necessarily mean the independence of tasks - tasks performed in isolation from each other. If tasks work dependently, then tests designed to isolate any particular task fail to generate the appropriately complex response. Following their summary of the separate and independent pathways Livingstone and Hubel begin their conclusions about human perception thus:

At early levels, where there are two major subdivisions, the cells in these two subdivisions exhibit at least four basic differences - colour selectivity, speed, acuity, and contrast sensitivity. At higher stages the continuations of these pathways are selective for quite different aspects of vision (form, color, movement, and stereopsis), thus generating the counterintuitive prediction that different kinds of visual tasks should differ in their color, temporal, acuity, and contrast characteristics.[744]

The topographic, plate-like arrangement of the optic system defines the parallel pathways - electric lines moving from plate to plate for the most part do not interconnect.5

The structure of the cortex and the structure of higher-order simple and complex cell systems underscore the relative importance of the various visual tasks. These structures favour detection of movement, form, and stereopsis. These structures also provide evidence against particular theories that cognitive "judgements" are determined at still higher levels of the visual system and the brain. The visual world is a manifold of information. Yet as Tufte says, we thrive in that information-thick world, and our marvellous and everyday capacities, not all of which (as he lists them) are cognitive functions, are well documented in the psychophysiological literature. How do these tasks and the joint operation of the parallel pathways allow us to make sense of the constant two-dimensional play of light on the retina?

5 Livingstone and Hubel note that there may be some interaction of fields in the parvo + magno system (indicated with a question mark), though they acknowledge the inclusion of signals from the magno in this system is uncertain.
The literature survey presented by Livingstone and Hubel nicely demonstrates two points. First (the point they are after), it makes clear that tasks are segregated in parallel pathways. But second (the point I am after), most of our perception functions are not colour selective, while those functions that are colour selective are inextricably linked with other functions. Livingstone and Hubel, in point of fact, are not content to demonstrate the segregation of visual pathways. They are also concerned to demonstrate that, and the way in which, these pathways are interdependent. This interdependence is striking and possible only because of the segregation of tasks. Once separated they can be combined, or effectively worked together, in unexpected ways. Colour perception is also dependent and interdependent, and like the other functions shares common electro and physiological mechanisms. Like the predominant functions of movement and form detection, colour perception is spatial, combining signals from different receptor fields at each level of the visual system.

Perception of movement (real and apparent), depth cues (ranging from contour and occlusion to parallax and perspective), and what the Gestalt psychologist H.B. Barlow called linking properties are all reliant on magno system functions (contrast sensitivity or temporal resolution) and not colour selectivity. Orientation and shape discrimination, and colour determination and flicker photometry are the only visual functions that do seem to employ colour selectivity and share other parvo and parvo + magno? system characteristics. An important question is: when do the various functions fail?; what are the conditions under which they are ineffectual in making sense of the information-thick world? Changes in colour do not influence the effectiveness of most functions - most functions fail at equiluminance, though dramatic changes in colour themselves provide cues and are assessed by other functions.

This is a significant finding regarding the functions of the visual pathways, of our visual perceptions. Livingstone and Hubel note that “different tasks can have very different sensitivities to color and brightness contrast.”[744] In fact, the two major pathways divide over just this difference: the functions of the magno system are unaffected by changes in colour but generally fail at equiluminance, while the functions of the parvo and parvo + magno? systems are unaffected by equiluminance but fail with particular colour changes and combinations. The literature
### MAGNO SYSTEM

<table>
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<tr>
<th>Physiology</th>
<th>Colour Selectivity</th>
<th>Contrast Sensitivity</th>
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### PARVO SYSTEM

**PARVO → INTERBLOB PATHWAY**

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<th>Temporal Resolution</th>
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**PARVO + (MAGNO?) → BLOB PATHWAY**

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6.7 Testing features of the parallel pathways: a check indicates that the psychophysical results are consistent with the physiology, and a blank indicates that such an experiment has not been done. All functions have been tested for colour selectivity. This also graphically demonstrated the features of each pathway. (After Livingstone and Hubel.)
review demonstrates that the functions of movement, stereopsis, depth from motion, from parallax and from object motion, shading, contour, occlusion, and perspective all fall or are greatly reduced at equiluminance.

In 1985, P. Cavanagh and Y. Leclerc rediscovered what painters have known, in fact debated, for centuries about shading: “In order to produce a sensation of depth and three-dimensionality, shadows can be any hue as long as they are darker than unshaded regions of the same surface.”[746] Schools of thought and technique differed among painters, whether for shading to use broken colours (the mid-tone with black added) or colours complementary to the mid-tone or colours “picked up” by light within the represented scene. The same, in fact, holds for highlights. Since shading is almost by definition difference in luminance, this is not entirely surprising. Chiaroscuro techniques involved drawing or printing on paper using various combinations of three tones - with the paper as either the light, middle, or dark tone and two pigments providing the other tones.

Somewhat more startling findings reached by Livingstone and Hubel themselves include that “when images with strong perspective are rendered in equiluminant colors instead of black and white, the depth sensation is lost or greatly diminished.”[746-747] Of movement perception, they note that

First, it is impaired for patterns made up of equiluminant colors....Second, movement perception is impaired at high spatial frequencies, consistent with the lower acuity of the magno system....Last, movement can be vividly perceived with very rapidly alternating or very low contrast images.[745]

This first impairment has been used in equiluminant optical paintings, such as Larry Poons’ Nixes Mate, which produce ambiguous and difficult figure-ground effects. And for stereoscopic depth perception, “subjects could not see depth in equiluminant color-contrast random-dot stereograms even though the dots making up the stereogram remained perfectly clear.”[745]

Depth and movement functions are strictly carried by the magno system and are integrated components used in the organization of visual elements into discrete objects (along the lines discussed by Gestalt psychologists) via “linking features”: 
common movement, common depth, collinearity, and common colour or lightness. It turns out, Livingstone and Hubel argue, that luminance contrast, rather than colour difference, is used to distinguish objects. They cite literature that concludes that common movement and collinearity break down at equiluminance; at equiluminance differently coloured fields and fields suggested by lines cannot be linked. Figures that produce the perceptual experience of a border in the absence of a real border, illusory contours, fail at equiluminance, but not when hue is altered. This raises a further important point, regarding the cognitive interpretation of the information-thick world and the levels in the optic and brain system at which information begins to be "processed." I turn to this next.

Parallels between the pathways

Despite the number of functions performed by the magno system it is the smaller of the two; fewer ganglion and geniculate cells are devoted to the magno system than to the parvo system. That many of the tasks performed by this system require large complexes of cells suggests that the parvo system has a dominance in cells devoted to colour selectivity. In neither case should this suggest that deciphering hue or non-hue phenomena is a more important practical function of vision - it may only mean that the processing of one or another kind of this information requires more complex systems, or at least a greater number of similarly complex systems and operations. There are great similarities between the physiology of colour processing and, for instance, motion and form processing. Indeed, it is primarily this similarity that leads me to claim that in the practical manipulation of the information-thick world colour holds a place of more limited importance than other forms of detection. By this I do not mean to suggest that colour is not important to us. That would be obviously false. Hubel begins his chapter on colour vision in this way: "The hundreds of dollars extra that consumers are willing to pay for color TV in preference to black and white must mean that we take our color sense seriously."[159] By claiming that colour has a more limited importance than other forms of detection I mean simply that the mechanics of vision are so structured as to process the continuous flux of light across the retina in biologically useful ways. The characteristic of light itself and the sensitivity of our photopigments means that colours, and changes in colours, are often exceedingly obvious to us. We in turn have used this to our advantage. At the base level, though, how we process infor-
mation about colour is the same as how we process information about movement, line, form.

Livingstone and Hubel suggest, without passing judgement on the relative importance of either, that the two parallel pathways may have different evolutionary histories. This seems reasonable. The magno system is adept at interpreting spatial organization. It provides the information that tells us, in brute terms, where things are. The parvo system, found in a significant state of development predominately in primates, allows us to scrutinize those things. The magno system seems particularly maladroit at analyzing the component parts of things, given that it is required to link spatially distinct areas of the visual world and that this is not a cognitive skill, as Livingstone and Hubel suggest, but an automatic one:

Illusory borders have been called “cognitive contours” because of the suggestion that the perception of the border is due to a high-level deduction that there must be an object occluding a partially visible figure. We suspect that this is not the case because the illusory borders disappear at equiluminance, even though the real parts of the figure are still perfectly visible.[747]

The same holds for illusions of size (equal-sized figures on a grid of converging lines, for instance).

As with movement and stereopsis, the most startling aspect of this phenomenon is that even though the sensation of depth and the illusory distortions due to inappropriate scale all disappear at equiluminance, the lines defining the perspective and the individual elements in the image are nevertheless still clearly visible. This seems to us to rule out high-level, cognitive explanations for depth from perspective and the illusions of perspective; if you see depth because you merely know that converging lines mean increasing distance, you should be able to perceive the depth from the converging lines at equiluminance.[747]

Hering was a master of attending to psychophysical phenomena and at devising careful experiments to demonstrate and test these phenomena. He let the psychological evidence of our experiences dictate the perceptual theory, though this

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6 Hubel’s opening comment could be posed in another way - the hundreds of dollars extra that consumers are willing to pay for colour computer monitors that reproduce thousands of colours rather than hundreds of colours must mean that we take our colour discrimination sense seriously.
led him to propose a theory of inhibitory mechanisms in the absence of any physiological evidence. In the introduction to their translation of his *Outlines of a Theory of the Light Sense*, Hurvich and Jameson describe Hering's response to the multiplicity of visual contrast phenomena:

these contrast phenomena meant that the visual system could not be regarded as a mosaic of stimulus elements. The visual system must, he reasoned, be conceptualized in terms of tissues of interrelated, rather than independent, elements. Thus the activity in each element must depend not only on its own external stimulus in relation to its momentary internal state, but also on the activities in the neighboring and related elements of the integrated tissue. [viii] 145

The integration of the on-going processing in the separate pathways enables the visual system to provide an initial ordering of the world.

Although conditions of widespread equiluminance are quite rare in our daily lives, it is clear from the literature surveyed by Livingstone and Hubel that spatial comparison of the visual scene is essential to the determination of form, movement, depth. This is evident at the electrophysiological level where cell complexes at the retinal and lateral geniculate levels compare and sum greater numbers of cells. It is also evident as a precognitive phenomenon where the issue of invariants is played out, where we unthinkingly make determinations about linkages. The same is true of colour perception. It was Edwin Land who most clearly demonstrated this. In the fifties, Land did a vast number and variety of experiments in colour vision. He wished to discuss one of these experiments, which incidentally, was central in providing groundwork for the Polaroid colour system. The early formation of this experiment was a modification of one originating with Newton. The modification that Land made involved passing two narrow and distinct bands of light through two nearly identical black and white photographic transparencies. The recombination would then function as a test of colour vision under natural conditions, that is, with a complete image rather than a simplified test field. The photographs differed only in that they were taken through different colour filters, so as to produce "colour" separation between the transparencies - in effect, different wavelengths struck the photographic material. As the transparencies were black and white this amounted to variations in silver density in corresponding locations of the transparencies. Placed in a projection mechanism which, using calibrated light sources, aligns and focuses the two slides upon a screen, Land's modification of Newton's experiment
is complete.

When light of specific and differing wavelengths is passed through these two transparencies and combined, the surprising result is a full spectral colour image, including non-spectral colours such as brown and purple. By running a series of tests with modifications to the narrow bands of light transmitted through variously differing photographs Land discovered several constancies:

Color in natural images depends on a varying balance between longer and shorter wavelengths over the visual field. We have also been able to mark out the limits within which color vision operates. It turns out that there must be a certain minimum separation between the long-record wavelength and the short...Any pair of wavelengths that are far enough apart (and the minimum distance is astonishingly small) will produce grays and white, as well as a gamut of colors extending well beyond that expected classically from the stimulating wavelengths.[In Teevan and Birney, 170]7

Full spectrum white light can be used in both projectors if one is fitted with a red filter. The projector with the red filter will emit consistently longer wavelengths than the projector emitting white light. Such an arrangement coupled with transparencies will produce a full colour image. Critical is the variation between long and short wavelengths and not the colour or intensity of light.

Now suppose we replace the transparencies with two gradient filters, at ninety degree rotation one to the other. The projector with the red filter projects an even gradation, right to left, from an absence of light up to its maximum red intensity. The full spectrum projector produces an even gradation, bottom to top, from dark to white. As Land points out, the resulting image is what Newton would have expected, for:

With both projectors turned on we now have an infinite variety of red-to-white ratios on the screen, duplicating all those that could possibly occur in a colored image. However, they are arranged in a strictly ordered progression. There is no randomness. And on the screen there is no color - only a

7 Though Land’s subsequent Retinex theory has fallen out of favour, his initial experiments remain elegant demonstrations of the spatial component of colour vision.
graded pink wash.[176]

Only when the densities are randomly distributed on the slide will a colour image result. This demonstrates the importance of what Land calls *natural images*. Determination of colour in a natural scene, in objects, requires a random mix of long and short wavelengths.

The spatial component of colour vision is even more dramatically demonstrated with "Mondrian" stimuli, an array of coloured patches, illuminated with three slide projectors of differing narrow wavelengths, one long, one medium, and one short. Regardless of the actual light falling on any given square, it will appear as it would in daylight. By measuring separately the intensity of light reflecting from our chosen square for each individual projector in turn we establish a three-number base representing the light reflected from the patch and striking our eye. If we now select a patch of different colour and adjust the intensities of the projectors so that the reflected light from the new patch corresponds with that from the original patch we would expect it to appear the same as the original. The objective intensity of light from the two patches is the same: if the first patch appeared green, so should the second. Yet the patches being actually different in colour will still appear different in colour.

The findings of Land are confirmed and more fully explained by the recent electrophysiological work outlined by Hubel (and Livingstone and Hubel). Hubel compares this colour constancy to the more commonplace appearance of a white shirt, first in sunlight and then in shade. In both cases the shirt appears white even though it actually has quite different reflectances. The reason is that the visual system determines the colour or brightness of the shirt by comparing it with the rest of the visual surround. Crudely, those things that are the brightest are the whitest (this obviously does not account for how the visual system actually determines hue, saturation, and brightness). By drawing input from concentric overlapping cell fields the whole visual field is ultimately compared. That this is what happens for colour determination as well as for the determination of other cues such as movement and motion is clearly evident from Land's work and the more recent electrophysiological work. Semir Zeki, following Land's lead, has done work on the different areas
of the brain that actually process signals from the retina and visual system. As Oliver Sacks and Robert Wasserman describe it:

Land proposed a model - an internal color computer. Zeki has actually located this computer by inserting microelectrodes into the brains of rhesus monkeys while they view “Mondrians” in differing lights. He finds that there are cells that respond to different wavelengths in the primary visual cortex, but cells that respond to different colors in the visual association cortex (in areas that he labels “V4” and “VA4”). These latter cells themselves show color constancy, each cell acting as a Landian computer, or (if you will) a Helmholtzian judge.[32]

This also accounts for the experience of dark yellow when viewing brown through a limiting tube such as Hering's viewing device. For the issue of colour language, it demonstrates the importance of the information-thick environment present to the retina. As noted previously, many colours (brown, iridescents, many blues) are only perceivable in rich contexts, just as Land's gradation slides show that mere difference is not enough. So, as with the other methods of detection in the visual pathways, the colour determination compares signals from the whole field.

In addition to the spatial component of colour, it also functions by drawing on information from the other visual perceptions. Livingstone and Hubel describe situations in which depth cues, linking properties, and illusions of "cognitive contours" fail. None of these situations involve the failure of colour determination. But there are real cases where such failure does occur. Animals in a jungle setting use natural camouflage to avoid detection. Soldiers, their vehicles, and ships all adorn camouflage. A leopard with its spots uses both (near) equiluminance and camouflage. Peering into the jungle foliage will not reveal a motionless cat. When one function fails we "automatically" rely on other functions.

Consider briefly just two aspects of the interconnection of these separate visual pathways: movement and equiluminance. This example is not intended to have universal applicability or explanatory powers; it only demonstrates how different facets of the various pathway components outlined by Livingstone and Hubel may operate in context. In keeping with my line of argument here, it follows that there are other ways to employ current psychophysiology in the debate about basic colour terms. Here, then, is something the leopard should know:
Since both motion perception and stereoscopic depth perception are lost at equiluminance, we suspected that the ability to use relative motion as a depth cue might also be lost. Relative motion is a very powerful depth cue: when an observer moves his head back and forth around in his environment, the relative motion of objects provides information about their distance. Thus depth from motion, both from viewer parallax and from object motion, seems also to depend on luminance contrast and could well be a function of the magno system. Consistent with this idea, we could see depth from motion at very low levels of luminance contrast. [746]

Yarbus and planar images

The functional split between where and what in the visual system largely maps onto the split between movement detection and object analysis. Movement detection and object analysis partly, though only partly, map onto the split between foveal and peripheral vision. The perception of movement involves either detection of movement or tracking of movement: things either move across our retina or we track them (fixate) as they move across our visual field. There is no mechanism for scanning stationary objects. Object analysis involves fixating (relocating the fovea relative to the object) on successive points. The movement between consecutive points is saccadic, not fluid. In the 1950s and 1960s, Alfred Yarbus conducted significant research into the nature of these movements and the role they play in our observations of the world. Yarbus made two key innovations to the extant technology in this field. He constructed a special “cap” that locked onto the eye, resulting in a greater degree of fixation of image relative to the retina. With the aid of a small mirror affixed to the cap and a thin beam of light he also recorded on photo-sensitive materials the movements of the eye. With these two devices he was able to record accurately the eye movements involved in observing two-dimensional images such as paintings and photographs, and the three-dimensional world.

The results published by Yarbus are significant to the present study in three ways. First, he provided extensive study of the saccadic movement of the eyes. As discussed in Chapter One, microsaccadic and saccadic movement is essential to vision: images stabilized on the retina disappear in a matter of seconds. When fixating on one point, the microsaccadic movement of the eyes prevents this desensitivity without producing consciously visible fluctuations of the visual field or area of
More significantly, Yarbus found that fixation on stationary objects involved several kinds of eye movement:

the eye moves in three ways during fixation: by small involuntary saccades [microsaccades], equal for the two eyes; by drift, slow, irregular movement of the optical axes in which, however, some degree of constancy of their position is retained; and by tremor, an oscillatory movement of the axes of the eyes of high frequency but low amplitude.[127]

Though we consciously believe ourselves fixating on one point, our eyes are in constant and varied movement relative to that point. Saccadic movement is complemented by other movements that provide a varied stimulus to the receptors, but also provide more robust information about the world. This movement places the point of fixation in a larger context.

Yarbus' further research on eye movement demonstrates how we study objects that are stationary relative to our bodies, by a process of successive fixations that provide little detailed information of the transversed space: "During perception of stationary objects, at the moment of the saccade no visual images are formed because the high velocity of the retinal image leads to "blurring" of everything falling within the field of vision."[144] We do not smoothly scan objects or surfaces obtaining information on all contiguous points. We relocate the fovea, failing to sense information between non-contiguous points.

Second, Yarbus demonstrated that the movement of eyes from one point to another is driven by several functions. We neither scan the whole surface of a picture, nor trace prominent outlines with our eyes. So:

Analysis of the eye-movement records shows that the elements attracting attention contain, in the observer's opinion, may contain, information useful and essential for perception. Elements on which the eye does not fixate, either in fact or in the observer's opinion, do not contain such information.[171-75]

Yarbus provided varied instructions to observers of the same image. Different instructions elicited different eye movements: the observers looked to different elements of the picture to find the pertinent information. The amount of detail in any element of a picture does not determine the length or frequency of fixation. In a pic-
ture of bears in a forest, though they have far less detail than the leaves and grass around them, they are the prominent focus of attention. In one test Yarbus produced dissimilar records of eye movements based on seven different instructions to the observers:

1) Free examination of the picture....2) estimate the material circumstances of the family in the picture; 3) give the ages of the people; 4) surmise what the family had been doing before the arrival of the "unexpected visitor"; 5) remember the clothes worn by the people; 6) remember the position of the people and objects in the room; 7) estimate how long the "unexpected visitor" had been away from the family.[174]

Purpose and knowledge of the surrounding picture determine the direction of saccadic leap.

Consider again Hubel's claim that we take our colour sense seriously. Yarbus demonstrates that colour is not a driving force in our study of two-dimensional objects, unless we are given specific instruction to observe colours.

For many observers one color is more pleasing than another, and sometimes
the expression “my favorite color” is heard. Most of the reproductions used in my experiments for free examination by the subjects were colored. Sometimes both colored and black-and-white reproductions of the same size taken from the same picture were used. However, in no case did the corresponding records reveal any appreciable influence of color on the distribution of the points of fixation.[183]

This also holds for observance of tonal disparity:

the brightest or darkest elements of a picture are not necessarily those that attract the eye (if the brightness of these elements is considered alone). All records of the eye movements show that neither bright nor dark elements of a picture attract the observer's attention unless they give essential and useful information.[182]

Third, Yarbus concluded that the perception of two-dimensional objects and three-dimensional ones differs only in the provision of one additional physiological fact:

Examination of objects situated in a room or examination of a sculptured head in which a change is made from points of fixation situated at different distances from the observer is accompanied by convergence and divergence on the optical axes, and differs from perception of flat objects only in this new type of movement (i.e., convergence of the eyes).[190]

This in fact would not even hold for objects at infinity, or on the horizon. The manner in which we “scan” the world before us has much more to do with our interests, beliefs, and expectations than it has to do with brute facts of colour, contrast, relative illumination, and detail of perceivable information. Yarbus has given us a description of how we look at things in the world. We “look at” discrete portions of the visual array by directing our foveas to specific and quite small elements of the array. Yet we remain aware of the rest of the array, for this awareness determines the direction of the next saccadic leap. In effect, we position ourselves in the world, we know where we are relative to the array that surrounds us, whether we are momentarily interested only in a small rectangle before us or not.

Implications for research

The context in which colours are found play a pivotal rôle in the identification of colours and objects. The experimental method of Berlin and Kay and their
followers is inherently flawed, only eliciting what appear to be universal terms from the respondents. Whitehead's point was that we must be conscious of both the abstractions we draw and the universality of claims derived from those abstractions. At the outset of this chapter I introduced three mistakes of generalization regarding abstractions (made by Berlin and Kay and the new universalists). The first was the assumption that an investigation of spectral and aperture colours would produce an exhaustive inventory of basic colour terms. The second was the assumption that generalizations about colour could be drawn from special testing situations of colour perception. The third was the assumption that generalizations about colour perception could be drawn in isolation from other perceptual tasks. These three generalizations violate Whitehead's criteria. The complexities of the physiology of vision discussed in this chapter underscore how badly formulated are the questions Berlin and Kay ask, and any subsequent research programmes based on their assumptions. The persistence of these mistakes lies at the core of the philosophical and anthropological dispute over the stability, cross-culturally, of colour terms and categorizations.

Hardin says, "biology determines phenomenology and, in consequence, a piece of semantic structure."[156] The relativist counter-argument is that purposes and contexts differ between language groups and cultures, and that these differences determine phenomenology and therefore semantic structure. If true, the conclusion that colour terminology and partitioning of the spectrum will differ between language groups and cultures seems equally supported by current psychophysiology. If an important daily task is watching for the movement of a leopard, perfectly camouflaged in the undergrowth, then terms which reflect movement sensitivity are more important than colour terms. (Or, terms which describe variegated "colour" are more important than spectral hue colour terms; and there is substantial documentation of the existence and importance of such terms.) We may think of it this way: biology provides side-constraints but not end-constraints. Biology determines the limits - for instance, we cannot visually perceive infrared or ultraviolet rays, or under special circumstances we have a proclivity to perceive unique hues. Within these constraints and beyond the physiological limits purpose and context, even knowledge and desire, determine phenomenology. To this extent I agree with Hardin: biology does determine a piece of semantic structure. The historical review in chapters Four and Five indicates how small a piece this is.
Field research on the world's disparate languages is important. So also is the experimental and comparative research which is claimed by evolutionary psychologists as support for strong cross-cultural stability of cognitive "nodules". The urgency of undertaking this research cannot be overemphasized given the continuous cross-cultural exposure of even the most remote peoples and the effect of this exposure on colour (and other) concepts. There is a legitimate desire for this work to be standardized, at least to the degree where different research data can be compared. Too often the simplicity of the Berlin and Kay assumptions encourages researchers to gather incomplete information. To study colour categorization and terminology in a robust context, including cross-modal categorizations (colour and movement, colour and form, variegated or textured surfaces), is far more complex and cumbersome. Yet incomplete and biased information has limited practicality - it can even be detrimental.

The current understanding of visual physiology lends support to other claims about colour categorization. Heider's lesson with the Dani is that we must be comprehensive; Ratner and McCarthy's work with colour and form demonstrates the more complex relation between visual tasks; field work cited by and done subsequent to Berlin and Kay demonstrates the complexity of categorization and language along non-strict colour lines, with references to the details of the physical environment, the social, cultural, and sustenance activities, and the technological skills of the language users.

I have construed context in two ways. In a narrow sense and now in a broad sense. Narrowly construed, context plays a role in the constitution of visual perception. Context, in this sense, refers to the physiological and psychological locatedness of visual perception, to the interrelationship of the various functions and pathways, and mechanics such as surround fields. It also refers to certain cultural facts: the natural environment of colours of the sky, forest, grasses (recall the Beaglehole's description of the Pukapuka visual environment) or the colours of available pigments and hence the artificial environment. Now we can begin to identify the broad construal of context. Building on the work of Yarbus we can develop context to include rich experiences of information-thick worlds. We experience the world pragmatically, aesthetically, intellectually. These experiences
equally play a role in our visual perception — our knowledge of the visible world before us and the purpose to which we intend to put that knowledge and the world itself condition or modify our experiences of the world.

The article by Sacks and Wasserman, in which they discuss the higher cell and brain activity of vision, is their well-known "The Case of the Colorblind Painter" published in The New York Review of Books. This case demonstrates that damage to very localized areas of the brain can result in startling alterations to ‘normal’ vision. The painter suffered no damage to any of this visual equipment, and tests that isolated components of the various stages indicated that all worked well. Only that part of the brains “immediately abutting ‘V4’” that encodes colour, was damaged in Mr. I. So, he could not “see” colour:

The varied symptoms that Mr. I. complained of, and showed, finally led us to test him on a color-Mondrian, with illumination of different wavelengths, in precisely the way that Land’s subjects are tested. And this showed us with great clarity how his ability to discriminate different wavelengths was preserved, while his color perception was obliterated, how there was a clear dissociation of the two.[31]

In his recent Color Codes, Charles Riley postulates that Sacks and Wasserman would never have been as successful had they not taken a multidisciplinary approach to the puzzle.

[This] was the secret to the success of Sacks and Wasserman as color theorists as well as diagnosticians. The thinking behind it owes as much to Wittgenstein as it does to Helmholtz or the neurological and optical textbooks, which are outnumbered by aesthetics and philosophy books in the bibliography for the article. If Sacks and Wasserman had not known their Scriabin, they would not have unlocked the synesthetic wing of the problem, and of course it took more than a passing acquaintance with the aesthetics of Modern abstract painting to track the progress of the patient from one style of painting to the next.[319]

In this case, a ‘multidisciplinary’ approach indicates background assumptions and knowledge that guide Sacks and Wasserman in original directions.

Indeed, publishing the article in the popular press rather than a scholarly journal may be a significant part of this approach. Only in a publication as popu-
lar and reputable as The New York Review of Books could the authors reach a comparable multidisciplinary audience. Here psychologists, neurologists, philosophers, aestheticians, and artists could be expected to read the same article. This is the approach I advocate for an appropriate recombination of our visual perceptions, for

Though one may separate out a small part of the visual cortex as an isolated unit, as is necessary in a physiological approach, the visual cortex is part of the brain, and the brain is part of the organism, and the organism - every organism - has a world of its own in which perceptions become infinitely more than information carriers, become an integral part of the subjectivity, the feeling, the style of the individual.[33] 156

I want now to turn to broader cultural features of the information-thick world.
CHAPTER SEVEN: WORLDS PERCEIVED

It was in the Renaissance that a picture came to be described - a central text is Alberti’s Della Pittura - as a framed window through which the viewer positioned at a certain distance sees a virtual world - three dimensions on two - in which human figures proportionately displayed in a legible space enact significant narratives. [Alpers and Baxandall, 8]

In Chapter Five I argued against the traditional abstraction of the new universalists on the grounds that the world of humans is a complex construct of both artifacts and the natural environment. Indeed, I have inherited a long history of interest in colour and light phenomena, and of artificial worlds I live in and am surrounded by many worlds. The worlds that we create are sensory environments. We manipulate the natural environment to form thousands of alternate information-thick worlds; visual worlds of paintings and drawings, of sculpture and architecture, of photography, of cinema, theatre and dance. These latter are also audible worlds of speech and music. Every day we experience and interpret a multitude of worlds.

I do not mean this !: a casual sense. We modify our world, creating new worlds to live in, and we live differently in those different worlds. We may imagine we are white water rafting, but we are actually sitting in a chair, in our living room, watching television. We may be sitting simultaneously with thousands or millions of others. Study after study show that we may sit in this manner ten, twenty, thirty, forty hours a week. That is a new and different world, sitting, in the gloom, with a cathode ray firing varying light quanta at our eyes.

It should be no surprise to claim that many of the worlds we experience are pictures. Yet these picture environments are still treated marginally, even within the culture in which they are most dominant. The evidence of picture making, in many cultures at many levels of technological achievement, is widely known. Though such archaeological and anthropological work is difficult, there is wide-spread, if not in-depth, knowledge of cave paintings, pictograms, petroglyphs and other surface markings and arrangements. These constitute deliberate, artificial picture environments. It is likewise widely known and accepted that most, if not all, cultures, societies, and human groupings have engaged in such manipulations of the natural
world. What is less widely acknowledged is that for many human societies in the late twentieth century the experience of picture environments is rampant. At the present, due in large part to the development of techniques and technologies, picture environments are central to our visual experiences. Perception of these special though prevalent environments is special and prevalent.

**Picture environments**

This and the next chapter deal with the particular visual experiences of pictures. My aim is to further draw out the complexities of vision. My means are to treat this prevalent kind of seeing by considering how my general thesis relates to it. This and the next chapter therefore turn away from colour perception. What I engage is a realm of visual perception large and important enough to merit a consideration here. Colour perception is inextricably integrated with the rest of visual perception. While the detection of colour and form and movement, etc. can be studied in isolation from each other, and can function in isolation from each other, to understand completely how visual perception and cognition work we need to study the interactions and the integration of these components of vision. Vision, after all, is not about colour detection or about movement detection. As Livingstone and Hubel demonstrate, the natural world is so organized as to evade the scrutiny of any single aspect of vision. This holds equally for the artificial world of imagining which, I will argue, underlies many picture perceptions. Physiology of perception is likewise integrated with psychology. We often respond emotionally to the world and to the events we perceive around us. Those events may be natural or artificial, as when we look at a painting or film, or read a book. Our sense of danger or of arousal is determined by our psychological response to the world around us and by our physiological response; the automatic quickening of our heart affects our psychological state.

There are two facts about the modern pictorial environment that must be stressed. First, this environment is culturally pervasive. For various reasons, Western culture is a picture culture. There may well be a common urge among all humans to make pictures, but the European-Western culture has been particularly successful at satisfying that urge (if satisfaction is measured by number and vari-
ety). The present technological world has been harnessed in the production of pictures. Look around - we are surrounded by pictures. Second, there is a general tendency in Western picture making toward perceptual immersion. Our pictures are often designed to encourage us to 'look past' the picture surface, to engage psychologically and imaginatively with represented environments. There are, of course, lots of exceptions to this tendency (it is general, not universal), but the most common goal is immersion. Evidence for this claim is to be found in the technologies and techniques that we have developed and used to this end. Immersion is not the goal in many other cultures, where, in some instances, surface ornamentation is. Both these features of picture environments are culturally specific - a particular kind of picture environment pervades our culture.

In the introduction to *Art and Illusion*, Ernst Gombrich traces a history of the rise and study of artist evolution. Gombrich argues that pictures look different because the intentions of the makers change - historical context determines in part the use, aim, and look of pictures. As part of his discussion he traces the development of this idea in his predecessors. For instance, in 1901 Alois Riegl. in his *Spätrömische Kunstindustrie* argued that

ancient art was always concerned with the rendering of individual objects rather than with the infinite world as such. Egyptian art shows this attitude in its extreme form, for here vision is only allowed a very subsidiary part; things are rendered as they appear to the sense of touch, the more "objective" sense which reports on the permanent shape of things irrespective of the shifting viewpoint.[18]

Gombrich finds evidence in Riegl and other art historians of a thesis of the history of visual art as tracing a movement from touch to vision. Whether or not these historians had an accurate theory, the fact that they had a theory of change demonstrates the culture variance in the look of pictures: these historians were attempting to explain this variance. There is no shortage of such theorising. Likewise there is no shortage of evidence that whole cultures show little or no interest in one or both of the two features of picture environments just described - namely, pervasiveness and a tendency toward immersion. There is nothing necessary or universal about either. For instance, images that owe their causal history to the sense of touch rather than vision would, consistently, not be perceptually immersive.
Further, such interests and tendencies cannot be considered on a positivist model of advancement for, within cultures that are highly interested in representation and depiction pictures, such interests and tendencies can be (rationally) supplanted. Consider the shift in China following the Mongol invasion of 1279, when the development of illusionistic pictorial representation was abandoned for a form of self-expression that incorporated the extant techniques in a new image making. The art historian Wen Fong writes in the introduction to his recent book on Chinese painting, Beyond Representation, that:

while Sung painting took the representation of the objective world as its subject, Yüan painting marked the end of objective representation; the real subject of Yüan painting is the artist's inner response to his world. Because it was believed that the meaning of a painted subject, made complex by personal and symbolic associations, could no longer be expressed without language, the painter began to inscribe poems on his works....Painting, for the Chinese, is a graphic sign or diagram (T'u-Tsaí) that conveys meaning.[4]

Fong's thesis is that, because of the social change following the invasion, Chinese artists and critics came to think of the painting in new terms, as having a new purpose, and to fulfill this purpose it had to combine word, image, and calligraphy. Fong contrasts this with the developing interest in mimesis that bloomed with the ancient Greeks:

...Western pictorial representation was directed at once toward the conquest of realistic appearance and the fulfillment of an idealistic classical norm of beauty. Pictorial representation for the Chinese, on the other hand, attempts to create neither realism nor ideal form alone.[4]

The Chinese were following a similar development with similar interests in picture environments, which included "the creation of illusionistic space, with foreshortening and an integrated ground plane in spatial recession."[7] When they turned from this interest they ushered in "a new era of greatly increased complexity and sophistication."[315] The new representation was an amalgam of word and image, both becoming equated with calligraphy "as realistic representation of nature gave way to symbolic images of single trees, bamboo, and flowers".[60] As with style in our own culture, this was not a homogenous style, but as one critic declared: "Anyone who judges painting by form-likeness shows merely the insight of a child."[60]
The new Chinese painting was still representational. It incorporated images of plants, animals, and building, and displayed these elements in perspective, in naturalistic or realistic fashion. It also made use of the surface of the painting. The surface was inscribed with words and the images stylized so that often they appeared as ornament or decoration on the surface. Such picture-making was pervasive and did not encourage perceptual immersion (though, as we shall see, it seems to have encouraged participation in ways similar to Greek mimetic imagery). James Cahill, in *The Compelling Image*, points out that European critics of the new Chinese painter were disconcerted by the elimination of illusory depth:

Matteo Ricci wrote in his journal: "The Chinese use pictures extensively... but in the production of these... they have not at all acquired the skill of Europeans... They know nothing of the art of painting in oil or of the use of perspective in their pictures, with the result that their productions are likely to resemble the dead rather than the living."[72]¹

Cahill further notes that "it was not until the twentieth century, when the rejection of illusionism became general among occidental artist, that the nonillusionistic art of the Chinese began to make sense." Here, then, is a well developed pictorial culture that, like our own, shows an extensive interest in representations and picture environments, but, unlike our own, rejects - deliberately - the pursuit of perceptual immersion.

In the following, I discuss some prevailing practices of and views on pictures in our culture. Our techniques, technologies, and theories of pictures aid and encourage both the pervasiveness of pictures and the general tendency toward perceptual immersion. In fact, pictures and especially immersion displays are more pervasive now than at any other time in history. As with many other cultural features of the West, this one has been, and continues to be, spread throughout the world. Cahill’s book is, in part, about the reintroduction of immersion and renewed interest in it by the Chinese, following increased trade and travel with Europe. Despite the pervasiveness of picture environments in our culture, they are still largely marginalized by perception theorists. An example relevant to the preceding chapters is that vision researchers have yet to realise the extent of this visual experience.

Pictures tend to be used in research for their convenience and as a means to isolate variables, yet they are still treated as a special and infrequently encountered environment. Pictures are not often investigated in themselves, as a dominant locus of visual environments in our culture.

Whatever the culture, pictures, generally, are made with particular ends in mind. The goal of a picture may be decorative, ornamental, illusionistic, religious, secular, iconic, symbolic, mnemonic, instructive. Pictures may be made as prompters, as manifestations, to provide substantive presence, to sell laundry suds. In our culture, one technical aim, more often than not, is perceptual or psychological immersion. However, pictures may encourage immersion to achieve any of these other ends. This specific technique raises specific technical challenges and subsequently raises specific philosophical questions. Whole cultures have no need to address these challenges and questions. Many pictures within our own culture also do not invoke these issues. I am concerned here with that large subset of pictures that is directed at immersion and with some of the specific challenges and questions this raises. Given that the aim of this subset is immersion, we should expect that some technologies and techniques will be frequently employed and others seldom or never employed. Further, those technologies and techniques that we do find frequently used will bolster my claim about this general tendency toward immersion. We may assume here that we reuse those techniques and technologies that successfully aid in achieving the desired ends. One of the central techniques employed in achieving immersion is perspective. I turn to this first, describing the standard view and an instructive exception.

Two technical questions

Two related issues are at the forefront of current discussion of immersion strategies employed in our culture. One I will call the rivalry view, the other the robustness view. The rivalry view refers to our perception of two dimensional surfaces in three dimensions. The claim of proponents of this view is that there is a perceptual rivalry between the two experiences such that awareness of one inhibits awareness of the other. This position is given early expression by Kenneth Clark and Ernst Gombrich. Early in Art and Illusion, Gombrich sets up the rivalry thesis
by relating Clark’s attempt to see both the surface and the depiction:

Looking at a great Velázquez, he wanted to observe what went on when the brush strokes and dabs of pigment on the canvas transformed themselves into a vision of transfigured reality as he stepped back. But try as he might, stepping backward and forward, he could never hold both visions at the same time, and therefore the answer to his problem of how it was done always seemed to elude him.[6]

This is a theme that runs through Gombrich’s book. The rivalry, stated clearly, is that to “understand the battle horse [depiction] is for a moment to disregard the plane surface. We cannot have it both ways”[279], and “as we scan the flat pigments for answers about the motif ‘out there,’ the consistent reading suggests itself and illusion takes over.”[329] More recently, Kendall Walton, Patrick Heron, and Richard Wollheim have used or endorsed versions of this thesis.2

The second view directly relates to the first. How, if perception of the illusion takes over from perception of the surface, are we able to view the surface from an oblique angle, that distorts the illusion, and still perceive the illusion? This is a problem specifically, though not exclusively, for images drawn using the rules of linear perspective, which seem to suggest that there is one optimal viewing station. When a researcher such as Yarbus places a photograph, print, or painting before us we are able to look at the picture in two fairly unique ways. First, we are able to view the whole work at once. Second, we are typically able to do so from a position directly in front of and near the picture plane; we observe the picture from a position very close to or at what is (variously called) the construction, projection, perspective, or observation point. This is an imaginary point geometrically determined by the method of constructing perspective on the picture plane.3 What is unique about this clinical observation is that otherwise we look at representations from vantages that often fail to afford us a complete view or (more often?) fail to

2 See Maynard’s “Seeing Double” for both a good account of the different approaches taken to this problem and an original development of it. Other important writers on the issue cited there are Richard Gregory, Michael Podro, and Susan Feagin.

3 The assumption here is that the prints and paintings are constructed in some significant way according to the rules of some standard perspective. As I will insist, this is not equivalent to having the same construction as a photograph.
conform to the mathematics of perspective construction. The second of these points is the issue of the second thesis: why is it that our automatic visual systems are so forgiving of the rules of projective geometry; why is visual perception robust? 4

The fact is that most people in most cultures seldom have difficulty in experiencing partial and oblique surfaces as the intended representations. In our culture this is both an important technical issue and an important theoretical one. As we are interested in immersing ourselves in illusionistic pictures (in a way, for instance, that the Chinese of the fourteenth century A.D. and the Egyptian of the fourteenth century B.C. presumably were not) the creation of immersion spaces on planar surfaces is a serious goal. The development and dispersion of the principles of linear, geometric perspective facilitate this goal. As such, these principles have concerned makers and thinkers of art in the Western tradition for centuries. The use of perspective in Western art and drafting has been dynamic, following the successive developments of techniques as well as the attitudes and skills of individual practitioners. There is, then, no standard perspective. Nonetheless, I will refer to representations that use linear perspective to enhance illusion and immersion as demonstrating 'standard' perspective, regardless of the state of the craft and the skills of the practitioner.

The short answer to this question of our robust visual system is that projective and perspectival geometry make no requirement that the observer be at any specific observation point, even though such a point is created (if not identified) in the process of such a construction. Further, though we may not be able to reproduce eidetically the space of the construction, we are able to "understand" it. In the quote above, Alpers and Baxandall describe the thinking behind this problem. Perspective pictures are, supposedly, transcribed onto surfaces as if they were projected onto them from behind; viewers imagine looking beyond the surface. 5 Just as artists used drawing devices like cameras lucida to locate their eyes relative to the

4 See Cutting, Niall and Macnamara, Arnheim [1977], and Kubovy, chapter four.
5 We do not look beyond the surface as with mirrors, we physically focus our eyes on the surface and so must imagine (in some sense) that we look beyond the surface. We also imagine we look in front of the surface. I have more to say about in what sense this is.
picture surface, subsequent viewers are required, according to this theory, psychologically to view the work from the appropriate position. Viewers either are at this position or, in a more sophisticated modern version, imagine themselves to be at this position. This is explicit, for example, in Richard Wollheim’s distinction between the spectator of the picture and the spectator in the picture. The spectator of the picture is free to move around the space in which the picture exists (the museum room, for instance). This is our place in the world - the picture is only part of our environment. The spectator in the picture imaginarily (but only imaginarily) stands at the projection point:

What the issue turns on is how much of the represented scene he can see and in what perspective: what matters is how his visual field relates to the picture’s representational scope, or (the same thing) how his standpoint relates to the picture’s point of origin. [1987, 102]

How our visual system does adjust for the visual environment is a matter of some debate. A division tends to be drawn between the supposed automatic activity of vision and the conscious activity of seeing, with the former engaging before the latter.

Alpers and Baxandall describe as bossy painting that in effect perceptually or psychologically forces the viewer to the central perspective point (more explicitly, to a central orthogonal axis). From this axis we are allowed forward and backward motion, and from there the entire image is legible. The repositioning of the viewer at a “certain distance” occurs regardless of where the viewer actually is:

It is a curious fact of what has been called the ‘robustness’ of the perspectival image that legibility persists even when we depart from the centre of the projection. The field of control, then, is expansive. Under such pictorial conditions to move is in effect no different from standing still.[8]

No matter where we stand in relation to the picture and the centre of projection, we

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6 This distinction is made in his Painting as an Art, drawn from his 1984 Mellon lectures, especially chapter 3.

7 This point is also made by Kubovy. He claims that we must locate the centre of projection to geometrically reconstruct the scene, but not to psychologically reconstruct it. “I call this violation of our geometric expectations by our perceptual experience the robustness of perspective.”[54]
view the represented world as if from the centre of projection. More than one account has been given of perspective as a progressive learning of the rules of occlusion.‘Standard’ perspectival painting, bossy painting, is constructed to occlude from one, transfixed (and monocular) vantage point. The seeming puzzle in this is that viewing paintings from oblique angles, away from the central projection point, distorts the geometry of the construction but does not diminish our ability easily to interpret the representation. The explanation lies in our ability to see also the surface of the work, to be aware that we are viewing obliquely a planar surface.

Yet pictures - including many Renaissance ones - are constructed using a variety of perspective methods, sometimes even by misusing, consciously or not, perspective methods. With some methods there just is no single point of origin. Not all paintings so constructed appear constructed or jumbled. The alternatives to ‘standard’ perspectival painting are not limited to construction by medieval iconographic hierarchy or Chinese calligraphic symbolism or Cubist inverted geometry.

Our place in the world

Alpers and Baxandall present a compelling discussion of the method employed by Tiepolo, a method with results familiar enough that the authors feel the need to argue Tiepolo was not merely the last of an old school:

His role, when he is seen to have one, is simply that of marking a tradition’s end....Tiepolo is cast in the role of an old-time believer in heavenly illusions

8 This is essentially how Gombrich describes it in Art and Illusion when he says that perspective “rests on a simple and incontrovertible fact of experience, the fact that we cannot look around a corner....as long as we look with one stationary eye, we see objects only from one side and have to guess, or imagine, what lies behind.”[250] Pirenne defines linear perspective as defining “the size, shape and disposition of the objects as drawn in the picture, with their foreshortening and the apparent overlapping of some near objects upon far objects, for one eye in a given position - and for this position only.”[72]

9 In “Perspective’s Places”, Patrick Maynard describes how Dürer “blundered” in both his description and use of the new ‘laws’ of perspective he had learned about in Italy.[36] In his St. Jerome In His Study he seemingly unknowingly offsets the perspective point so that the ‘appropriate’ viewing position lies on the right hand edge of the print, not near the centre.
that are no longer supportable by a Goya, the representative of the new, modern world.[6]
viewed. Along with most competent painting decorators, he understood that, though paintings could be constructed by 'standard' rules of geometric perspective, viewers seldom were actually at the specified viewing point. This understanding itself is probably not unusual among Tiepolo's contemporaries. What is unusual is that his masterwork, the ceiling at the Treppenhaus at Würzburg, cannot be seen as a whole, lacks a narrative centre and to see it one cannot stand still but must be on the move - climbing towards now this part then that, before arriving at a platform on which one walks both beneath and across from extended friezes of figures.[1]

It is on this work that Alpers and Baxandall concentrate, providing an engaging account of painting in situ. Here is a painting that the artist knew could not conform to the perspective rules of observation credited in part to Alberti. Tiepolo, at least, acknowledged the robustness of perspective.

7.2 Tiepolo's Treppenhaus: As if. Moving about the gallery produces dramatic effects of animation as people seem to move their limbs.
For our purposes here there are two notable features of Tiepolo's approach to the Treppenhaus. In designing and executing the ceiling, he essentially both denies the rivalry view and endorses the robustness view, while advancing the pervasive trend toward immersion. First, he utilizes the existing light sources, incorporating light that both illuminates the ceiling and obscures it via glare:

Tiepolo's negotiations with the intricacies of [the architect Balthasar] Neumann's light theatre - the areas more lit or less lit, the areas of unstable light, the areas of dead light, the areas immediately above a light source and so both shadowed and adjacent to glare, the extraordinary facility offered by the northern diapason, the maverick afternoon lights from the west - are themselves so intricate as to defy complete analysis, particularly since they accommodated special cases which fall outside even the broad viewing conditions just described.[118]

Second, he utilizes the existing space, realizing that at no point can the ceiling be seen in its entirety in a manner consistent with projective geometry. The ceiling has a shallow vault so that from the gallery all but the opposite frieze will be distorted; the staircase itself obscures much of the ceiling so that when the viewer occupies the geometric viewing point only an incomplete view of the work is possible:

Tiepolo's ceiling can never be seen as a whole. There are photographs taken with a wide-angle lens which seem to present the ensemble. They are useful as maps of Tiepolo's world and heaven but, like Mercator's planar projections of the globe, they are a view of the object no one - not even Tiepolo - ever at any moment has seen.[115]

Tiepolo was familiar with the space of the Treppenhaus, having worked in another room of the residence for the previous year and a half. When it came time to design and execute the painting he demonstrated a thorough understanding of the architectural particulars of the space. The only way to see all of the ceiling is to move about the room. Because the room is a stairwell, movement forces different views of the ceiling - first from afar of only the centre of the ceiling, next from a mid distance of one end and then of the other as the viewer mounts the stairs, finally of the opposite friezes from the gallery. Though the work is seamless, different parts of it play to the different viewing situations. Finally, the four friezes anticipate the movement of the viewer around the gallery - because of Tiepolo's use of the vaulting, figures seem to change position, moving, for instance, their limbs, as the viewer moves around the gallery.
If we think of the work as a flat easel canvas, then it has at least four horizon lines— the four continents, each parallel to one edge. This experience can of course be had at The Metropolitan Museum of Art in New York where the sketch for the Treppenhause ceiling hangs on a wall. If we were to lie on our backs with the sketch mounted on the ceiling we could easily imagine the four edges parallel to one another. Finally, on the vaulted ceiling of the Treppenhause the horizons of the four continents are all parallel to the real horizon and to each other. Yet each, along with the heaven painted in the middle of the vault, is intended to be looked at not from one point on the floor below (which is an impossible position for viewing) but from the natural (architectural) vantage points throughout the room. The viewer does not even imagine being in one centrally located viewing position. Casting our eyes around the room and across the ceiling from any position informs us we cannot view it thus. More, our peripheral vision guides us in this matter— we know as we mount the stair that some aspects of the painting are akilter.

The technique that Tiepolo employed for the Treppenhause, and for other ceilings, he equally employed for easel paintings, and not just studies for ceilings. Tiepolo insisted that the viewer acknowledge that some parts of the canvas were farther away than others. We may put this in terms of Wollheim's theory. 'Standard' perspective occludes all from one given point, such that we gain knowledge of the represented scene as if we stood at that point. The artist depicts (may depict) only that which could be seen from that one point. Tiepolo plays with this in several ways. He does not require of us that we imagine ourselves at that one point, he does not draft his works as if from one point, nor does he treat our perception of the work as equivalent with perception of a real scene. First, the requirement is avoided when he drafts bodies on three dimensional surfaces in such a manner that our movement in front of the surface animates the bodies. Second— obviously in the case of the Treppenhause— he constructs the ceiling with several viewing points carefully selected to coincide with possible viewing points, given the actual architecture. Less obviously, he alters the scale within a canvas so that objects actually farther away either appear larger, and so nearer, or smaller, and so farther.

This is the case with his horizontally elongated oil painting, The Finding of
Moses (cut in half by some later 'art critic') with which Alpers and Baxandall begin their work. The halberdier on the extreme right is much larger than the figures surrounding Moses on the extreme left, so that when the work is considered as a whole he seems misdrawn. Yet, viewed from a position off centre (a positioning made easy by the long horizontal scale of the work) the scaling makes sense - either by placing the halberdier distinctly in the foreground or by moving him closer to the group if viewed from the left. The interpretation that Alpers and Baxandall give is that Tiepolo intended the viewer to move horizontally before the work to observe its entire detail and so move through time.[44] The location of the halberdier is different because the canvas does not capture one instant of time. Rather, the time required to move the length of the canvas is painted into it. This, they claim, is a formal element of Tiepolo's work.

On Alpers and Baxandall's reading, Tiepolo is a sophisticated painter and his work an intriguing response to the puzzles of bossy perspective and our forgiving visual system. Tiepolo has addressed these puzzles, allowing for both aspects, that we are drawn to the central projection point and that we can appreciate the work from other vantages. Tiepolo understands our place in the world. He demonstrates - though again, this could hardly have been an express goal of his - that the psychological experience of three dimensions can be advanced and enhanced by our conscious awareness of the surface and limits of the representation. In Western art prior to and during this century this is a minority view. On the other hand, the dynamic nature of the relation between spectator and picture is one that, in different ways, is of increasing interest in our culture. With new technologies, such as virtual reality, this dynamism is spelled out in new ways. Yet the two technical-theoretical questions still affect the resulting sense of immersion.

**Immersión in virtual realities**

In this century several influential techniques have been employed, using developing technologies, to place the viewer at the central projection point. While representations can be successfully viewed obliquely, this does involve a mediating perceptual activity. Unmediated vivacious perception has been one goal of artists and scientists working with representations. I have suggested that a dominant
Interest in Western culture is with immersion in picture environments. The two technical-theoretical problems discussed above affect the strategies employed in achieving immersion. Those strategies, in turn, affect the kind and degree of immersion attained. One strategy is to efface the picture, to endorse the rivalry view, by deliberately enhancing the illusion and effectively disguising the medium. In this section, I look at some of those strategies and the kinds of immersion they produce.

In various forms virtual reality (VR) has been around since the Second World War, when air force pilots gained flight experience in crude simulators. Not surprisingly, the technology has progressed exponentially in recent years. As with any technology, how far it progresses, how much it infiltrates and ultimatelyreshapes society, depends on how valuable we find it. Many infant technologies have languished for years before finding their niche, and many widely used technologies are supplanted by new and different ones. The pace at which VR technologies are progressing reflects our interest in immersion, their success at meeting this goal. I am concerned here with the manner in which VR differs from and is an extension of other perception. As remarked at the outset of this chapter, what Tufte called the information-thick world may have to be rethought, we may be faced with information-thick worlds. Central to most accounts of VR, by those particularly involved with the development of the technology, is the sense of immersion: it is a virtual reality when you are within the virtual world, not merely observing it. It is this essential feature that I want to address. The goal of VR is paradigmatic immersion. As I will stress, VR aims to immerse us within the representation to the extent that the created world supplants the actual world. In terms of the standard rivalry view, this is to maximize one rival and minimize the other.

Even the use of the word “immersion” has only quasi-technical status. To

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10 The first flight simulators were built in 1929, incorporating a full-size mock-up of a cockpit that pitched, rolled, and yawed, but with no visuals other than instrumentation. In the 1950s video images of scale models were added, and in 1972 General Electric built the first simulators using computer generated imagery.

11 There is no value judgement intended here. Many VR technologies are laudable, such as for medical surgery and remote sensing. Others may not be so noble, but provide pleasure and amusement.
help clarify, we must acknowledge two aspects of immersion – the physical state of immersion, or act of immersing, and that with which we act. There are four kinds of virtual world that we may be within. First, the virtual world may be an actual world, sensed remotely, as when NASA scientists view (negotiate through) three-dimensional computer constructs generated from Viking data transmitted to Earth. Second, actual worlds may also be fictional worlds, based on real situations, but designed as generic world of specific parameters, as when pilots view the constructed worlds of flight simulators – the programmed flight may be of a specific, real airport or of a generic, imaginary one. Third, the virtual world may be a fictional world designed specifically to defy the laws of physics (or chemistry, biology), or dislocate them, as when playing a game of low-gravity racquet ball. Fourth, the virtual world may consist of specific, but fictional events, that largely conform to our standard notions of physics, etc., as when humanoids can fly or we have the skills of a master sleuth. The distinctions between the four are not sharp: I draw them to acknowledge that virtual reality technology has a multitude of applications.

Common to all these kinds is the sense of immersion – being within the represented world, unaware of the ‘surface’ – and located centrally. VR tacitly accepts Gombrich’s rivalry view by moving the viewer, figuratively, behind the picture plane. By doing so, it avoids the rivalry issue. It also avoids the robustness issue, for in virtual worlds, as in real ones, we are always at the centre of perspective. Consider how those closest to the technology view it. Michael Heim, in his book *The Metaphysics of Virtual Reality*, begins his definition of the term thus:

Virtual reality pertains to convincing the participant that he or she is actually in another place, by substituting the normal sensory input received by the participant with information produced by a computer.\[160]\[12

To this extent this definition is equivalent to the general theory of psychological participation with representations.\[13 We could replace “computer” with any number

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12 I provide more of his definition below. Interestingly, this demonstrates the way technological (and ontological) changes affect our thinking about the *je ne sais qua* of sensory experience: from Descartes’s demon deceiver to Putnam’s brain in a vat to the computer programmer’s virtual world.

13 See the next chapter for a detailed account of Walton’s version of this theory.
of other media, such as canvas and paint, and have a description of such participation. The key to the definition is the aim of 'convincing' the participant, and the strategy is the extensive substitution of sensory input. The 'other place' is in the represented world: beyond the picture plane in the world of the picture. Common to Heim's account of VR and, for instance, to Kendall Walton's account of psychological participation, is immersion. This notion of immersion is common to most accounts of VR. What is it to be immersed in a work? and how does immersion in virtual worlds differ from immersion in all other representational worlds, such that virtual reality stands alone?

Heim continues his definition of virtual reality:

This [convincing] is usually done through three-dimensional graphics and input-output devices that closely resemble the participant's normal interface with the physical world. The most common I-O devices are gloves, which transmit information about the participant's hand (position, orientation, and finger bend angles), and head mounted displays, which give the user a stereoscopic view of the virtual world via two computer-controlled display screens, as well as providing something on which to mount a position/orientation tracker [and 3D sound system].[160]

These are the technologies that mark the difference between VR and other forms of representation. VR aims at complete immersion of the participant in the world of the representation, and so is different in kind as well as degree to other forms of representation, including IMAX and OMNIMAX films, Sensorama, and heads-up displays (though I will have to give an argument for this distinction).

Heim elaborates his definition of virtual reality by describing seven directions in which virtual reality research has gone. His elaboration follows closely the account given by Pimentel and Teixeira, in their book Virtual Reality, written while working for the Intel computer company. Heim continues:

The definition of VR includes several factors and emphases: artificial reality, as when the user's full-body actions combine with computer-generated

14 Strictly, this 'placement' is figurative, as three dimensional representations often extend in front of the two dimensional surface medium. This is a point Maynard elaborates in "Perspective's Places", p. 25f.
images to forge a single presence; interactivity, as when the user enters a building by means of a mouse traveling on a screen; immersion, as when the user dons a head-mounted display enabling a view of a three-dimensional animated world; networked environments, in which several people can enter a virtual world at the same time; telepresence, in which the user feels present in a virtual world while robotic machines effect the user’s agency at a remote location in the actual primary world.[160]

In his chapter “The Essence of VR”, Heim breaks VR down in another way: simulation, interaction, artificiality, immersion, telepresence, full-body immersion, and networked communications. Of these, the last four are all variations of immersion.

We now have a sense of what immersion means to an industry that defines itself by the term. Immersion is synonymous with our experience of the every day world. We are immersed in the world of our senses, the world present to our senses. VR technologies aim to replace our sensations of the world actually and immediately present to us with another, remote or imaginary, mediate world. The aim is to substitute one set of sensory experiences with another. We may be sitting in our laboratory or living room with devices attached to our body (on our head, our hands, even covering our whole body) but the experience is of flying a space shuttle over Jupiter or Vulcan. We do not merely imagine we are flying a craft over a distant planet, we experience ourselves flying a craft; we may have to remind ourselves we are not. The current technology may fall short of causing us to have such experiences and beliefs, but this is the goal – despite claims by some industry figures that we “successfully suspend our disbelief”.

7.3 Pozzo's St Ignatius from perspective point.

7.4 Pozzo's St Ignatius off perspective point. Moving about the floor produces dramatic effects of vertigo.
It is important to observe that this aim is not new or unique to VR within the tradition of Western depictive technologies. Heim’s definition places complete sensory immersion at one end of a spectrum of immersive states. This distinction is important to my claim of a tendency towards kinds of immersion. Not all picture environments aim for this degree of immersion, though increasingly, many do. Virtual reality stands apart by physically placing the viewer with the work. We may draw a distinction here between two kinds of immersion. Other works rely on psychological immersion rather than physical immersion. Consider a few other kinds of these depictive technologies that aim for a degree of immersion greater than, say, Renaissance painting.

In the mid 1970s, Myron Krueger developed some playful computer and video installations that he called artificial realities:

I created a series of interactive environments that emphasized unencumbered, full-body, multi-sensory participation in computer events. In one demonstration, a sensory floor detected participants’ movements around a room. A symbol representing them moved through a projected graphic maze that changed in playful ways if participants tried to cheat.[19]

For instance, in Videoplacement, a real-time silhouette of the viewer, generated by a video camera, is projected onto a large screen. The viewer is then able to manipulate via computer animation the environment occupied by the silhouette. This manipulation is direct: by merely moving your body in determinate ways that are recorded by additional video cameras and input to computer, the viewer can draw or move video images. This differs from non-interactive art forms such as painting, photography, or sculpture (though of course these all can be made interactive if used as components of a piece). It also differs from virtual reality. Krueger’s artificial realities project the viewer into the art work such that, as with more traditional art forms, the viewer observes the artwork separately. With virtual reality the viewer-participant experiences the work first hand. The experience is of being within the work, not merely of having a remote causal effect on a body, even one self-identified, in the work.

Trompe-l’oeil, also, has such a comparable aim of psychological immersion, though the effect is less encompassing. Usually we believe ourselves in a world which consists of the real space we occupy and the depicted space before us that extends into or beyond the real space (into or beyond the surface on which it appears). The most successful dioramas, with or without accompanying physical foreground objects, convince us, at least momentarily, that the space we occupy extends beyond its actual bounds. M.H. Pirene made famous to discussions of this sort the painted ceiling of Fra Andrea Pozzo, in the church of St Ignazio in Rome.16 The ceiling represents St Ignatius being received into heaven. The actual height of the vaulted ceiling is about thirty metres, but Pozzo has painted additional columns and arches that reach farther toward heaven than the real church structure. The church appears to be open to heaven, at a much greater distance from the viewer than it actually is.17

As is often pointed out, the illusion is only successful from one vantage point, marked on the floor of the nave. The limitations of this trompe-l’oeil are obvious: the heavenly figures are motionless, frozen in the act of receiving St Ignatius, and the illusion is completely and dramatically lost when not viewed from the optimum vantage. The experience of observing heaven is fleeting. The kinds of immersion achieved by VR and trompe-l’oeil work only under specific conditions. Outside these limited parameters the experience fails. Tiepolo and Pozzo painted on curved ceiling surfaces in two distinct ways. Tiepolo anticipated the distortions that curvature causes as the viewer moves about the space. It is this distortion that animates his figures. Pozzo traded off the ability to roam freely about the space for the immediate illusion experienced at the centre of projection. The curvature of ceilings (or any ground) makes more difficult, less automatic, the imaginative viewing from the projection point that, for instance, Wollheim describes. It does this by making

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16 His account of the ceiling in Chapter Seven of Optics, Painting and Photography has become a standard example and testing ground for the rivalry debate beginning in 1970 with Michael Polanyi, “What is a Painting?”, British Journal of Aesthetics 10, 3, July: 225-236 and still used with currency in the recent books of Alpers and Baxandall and Kubovy discussed in this chapter.

17 For a thorough account of trompe-l’oeil in sympathetic terms, I direct the reader to Chapter Four of Kubovy’s The Psychology of Perspective where he draws several distinctions regarding kinds of trompe-l’oeil.
it more difficult to locate the painted surface. The paintings are equally bossy, but the one requires more activity from us.

Two current theories of representation elucidate this difference between physical and psychological immersion. Walton has described our psychological participation (including our emotional and quasi-emotional involvement) with a representation in terms of immersion: we imagine ourselves psychologically present with the represented world to the exclusion of the real world, such as the museum in which we stand. Wollheim has described our participation in terms of ‘seeing-in’ (which amounts to a form of this immersion): we see, and so experience, the represented object in the representation, in the work. Wollheim’s formulation, he claims, allows us to be both non-localized with regard to the representation (“I may see y in x without there being any answer to the question whereabouts in x I can see y…”[21]) and able to observe both the physical world and the objects represented (we are aware of our place in the world). This means we can be both ‘lost’ in the world of the work and aware of the work and our observation and experience of it simultaneously or nearly simultaneously. As remarked above, this is manifest in his distinction between the spectator of the work and the spectator in the work. For Walton, immersion is achieved psychologically, for Wollheim it involves a species of seeing. On neither account do we immerse ourselves in the manner intended by VR. We do not substitute one set of sensory experiences for another, rather we experience or treat part of our sensory input as being different than it actually is. Both these accounts of psychological immersion must address the two theses discussed early, of rivalry and robustness. Walton, who otherwise articulates a strikingly sophisticated and satisfying account of psychological participation, falls into the same trap as Gombrich. He, with Gombrich, believes that we must give up our awareness of the real world (at least as far as the mechanics of the work are concerned) for successful immersion (participation) in the work world.

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18 This theory is most fully elucidated in his Mimesis as Make-Believe: On the Foundations of the Representational Arts, especially chapters six and seven.

19 This theory is best elucidated in his Art and its Objects: Second Edition With Six Supplementary Essays, especially the essay “Seeing-as, seeing-in, and pictorial representation”.
Bigger versus smaller

What then distinguishes VR within this tradition? The answer lies in the difference between physical and psychological immersion. Between physically being within the represented world and psychologically locating ourselves there. One key difference between VR and other illusory representations is size of stimulus. The most common strategy in creating the illusion of presence or of immersion is to make the representation bigger, more encompassing, to make it appeal to more of our senses. This was the strategy behind the diorama: paint on a screen large enough that it could be placed at such a distance that the surface was obscured yet it still filled a maximal area of our visual field. Losing the surface is critical for the success of the illusion, and also fatal to it. As noted above, under normal observation of representations we are and must be aware of the surface, as the experience of the representation is only an approximation of the experience of the represented. That this is not essential to all such observations is demonstrated and employed by illusory representations. The closer the two experiences, the less necessary is awareness of surface. Pozzo’s ceiling works because we initially fail to perceive the ceiling - the representation opens up beyond the surface. It fails for the same reason. Move away from the critical point of observation and experience vertigo.

Before he turned to photography, Louis Daguerre, famous now as one of its inventors, constructed huge (twenty-one metres long by fourteen metres high) dioramas with multiple screens that, through careful adjustment of the lighting, could be made to ‘dissolve’ from one to the other. Pozzo’s ceiling, IMAX and OMNIMAX films, and Cinerama all aim to heighten our sense of presence, by attempting to fill our entire field of vision. Coupled with elaborate sound systems film overcomes the nearly immediate disadvantages of painted trompe-l’oeils. Where paintings are obviously static, film moves; where paintings appeal only to our sense of vision, these film media appeal additionally to our sense of sound. OMNIMAX, using bigger screen areas and viewed with sophisticated 3D glasses, appeals to more of the visual field and further obscures the surface.

20 This is a distinction Walton draws between the world of the representation and what we imagine of that world. See the beginning of the next chapter for a fuller account. Gombrich, of course, says we cannot have it both ways; Michael Podro says the one effaces the other (see “Fiction and Reality in Painting”, p. 45).
In the 1950s and 1960s, Morton Heilig attempted to eliminate all impediments to the illusion of cinema by locating the viewer nearly within the illusion. But he took a fundamentally different tack. At a distance, screens have to be big to fill our visual field. Nearer to us the screens can be smaller but we can see the surface, nearer still and we cannot focus on the images. With the use of optics, however, we can focus on near surfaces, and with 3D imagery we can obscure the surface. Heilig built a device which was used by a single observer, requiring that the observer look through a lens device at a stereoscopic image. He did not stop there. Pimentel and Teixeira describe the Sensorama machine:

It was outfitted with handlebars, a binocular-like viewing device, a vibrating seat, and small vents that could blow air when commanded. In addition, stereophonic speakers were mounted near the ears, and close to the nose, a device for generating odors specific to the events viewed stereoscopically on film.

One of the recorded “experiences” was a motorcycle ride through Brooklyn. The seat vibrated, you felt wind against your face, and you even smelled different odors as you passed along the street....[28-29]

This is the first effort at the less common strategy: create immersion by physically immersing the observer within an array of technological apparatus that generates sensory input. Make the observed world appear bigger by making it smaller; bring it closer and make it appeal to more senses more immediately.

This strategy shows promise. The strategy of making the representation physically bigger faces the seemingly insurmountable problem of the world seeping in around the edges. You can never make the representation big enough, you can never make it so that it appeals enough to all of our senses. By making it smaller, by making it the size of our skin, by having it fit closely over our sense organs, seepage is eliminated. We experience ourselves in the representation, not observing it. In a real sense, we are in the representation. We may look down at our own body and ‘see’ it as part of the representation, even when that involves it being a radically foreign body.

Promise is not success. VR fails to create a total illusion. It fails on two counts. Failure is either manifest, obvious, as a result of insufficient technological power, or detectable only by symptom. Technological failure is conceptually sur-
mountable. Currently, computers are not powerful and fast enough to generate sufficiently complex images at a smooth rate of reproduction. Because feedback is a critical element of VR, the computer images must be redrawn every time we move our head or hands. The slower the computer at generating new images the slower the update rate. Computer speed results in two effects. The scene may be jerky, with perceptible gaps in the smooth flow of objects moving within the scene or of the whole scene as we reorient ourselves within the virtual world. The slower the computer at processing signals from sensors detecting head movement, etc., the greater the lag between our movements and the virtual world's corresponding movement. Both effects, update rate and lag, result in diminution of the illusion. This technological failure may be overcome with further developments of the components of VR systems. Currently there is a trade-off between update rate, image resolution, and image colour.\textsuperscript{21}

However, even an imperceptible lag between our body movements and the orientation of the virtual world can produce inhibitory results. Several ongoing studies in the US and Britain are recording and tracking what is called either simulator sickness or cybersickness. There seem to be two components to cybersickness. The first results from not consciously perceptible microsecond lag due to insufficient computing power. In a recent study in Britain, using inexperienced civilians and physically fit firefighters along with experienced military personnel, prolonged immersion resulted in varying degrees of sickness for 61% of the subjects.\textsuperscript{22} Several civilians and firefighters could not complete the full twenty minute immersion. Symptoms ranged from mild nausea to being sick. These findings are typical.\textsuperscript{23}

\textsuperscript{21} Colour presents two technical problems. LCDs have a low resolution to begin with; adding colour requires cutting by one third the number of available pixels, which control resolution, to accommodate individual scannings in red, green, and blue. To minimize lag and update rates this also requires more computing power. CRTs (cathode ray tubes) that fit head mounted displays are too small for the mechanics of standard colour technology. A process using flickering RGB LCD overlays is promising but requires faster computing (at a minimum of 180Mhz).

In the most sophisticated VR simulators - those used for air force training - experienced pilots report simulator sickness despite no perceptible lag or update rate. Here the failure of VR is detectable only by symptom. One account of the sickness is that even though there is no consciously perceptible lag or update rate both, nonetheless, are greater than our normal experience of the real world. There is support for this. Some pilots report that they can avoid simulator sickness if they rely on instrument flying and ignore the computer generated scenery 'outside' the cockpit window. The solution, on this account, is better technology.

However, simulator sickness is more complex than simple disequilibrium and nausea resulting from a discontinuity between inner-ear stimuli and sensory stimuli. Unlike a ride at the carnival which obviously scrambles the continuity of stimuli, but which produces only short term effect, simulator sickness can last or recur up to a week after the experience. One study of over seven hundred simulator-experienced pilots using eleven models of military simulators reports that "1 in 20 respondents reported disorientation symptoms (dizziness, vertigo, loss of balance) lasting over 6 hours." The authors Lackner and Graybiel also "found that 54% of posteffects (primarily dizziness and postural disequilibrium) following parabolic flight lasted longer than 6 hours and 14% lasted 12 hours or more." That post-effects can occur or recur several hours or even days after immersion, after all immediate symptoms have long subsided, strongly suggests a problem other than high-tech vertigo. Indeed, the posteffect experiences described by pilots have a quite different symptomology. Pilots report long-term visuomotor problems (difficulty in seeing, visual fatigue such as headache or eyestrain), disorientation (dizzi-


ness, vertigo, balance problems), and nausea posteffects. They also report symptoms such as visual flashbacks to the simulator environment that may occur at any time for hours after the immersion. A genuine concern for the safety of pilots following simulator flights has fuelled the research in this area. Visual flashbacks while driving a car are hazardous. Yet it is unclear what the relation is between the experience of simulated or virtual reality and such dramatic posteffects. It may be that the technological shortcomings of VR and simulators produce more complex physiological side effects than we could have imagined given our understanding of psychophysiology. It may be that our psychophysiology resists such brute manipulations as our most sophisticated technology presents. It may be that where the technology fails, at this level of physical immersion, the robustness of vision fails also, being incapable at this level of adequate compensation.

**Psychological Immersion**

As a means of representation, we have been considering VR as a form of trompe-l’oeil. It shares with trompe-l’oeil several important features. Both work in part by effacing the surface of the representation and by attempting to encompass our vision or sensory fields. Both currently fail to convince in a complete and sustained manner. Further, both seem to face pivotal obstacles to their success. Most trompe-l’oeil face just those problems that VR is designed to overcome, typified by incomplete immersion. On the other hand, the more “complete” the immersion realized by VR the more prone it becomes to generating cybersickness. One strategy now employed to avoid cybersickness is deliberately to weaken the illusion (and sense of physical immersion) by using cruder renderings and pixilated update rates. This is to reintroduce the ‘surface’ of the representation. This also draws out a third aspect of immersion, that of perceptual–sensorial immersion. Both physical and psychological immersion rely on the perception of immersion. With VR, our experience is of being within the representation, so we have a perceptual–sensorial experience of immersion. Ideally, in fact, we have a complete perceptual–sensorial experience. With paintings and photographs, our experience is both of being physically before the representation and psychologically within it. Here we have a different

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26 I flag the sense of “complete” to allow that, though cybersickness seems to indicate a fundamental problem with immersion technologies (beyond immediate vertigo and nausea), further technology may solve the problem of cybersickness.
kind of perceptual-sensorial experience, one that, for instance, is enhanced by linear perspective and our perception of the two dimensional surface.

The experience of a picture is analogous to the experience of that represented or depicted. The analogy may be strong or weak. VR, and trompe-l’oeil in general, may be understood as an attempt to make the analogue so strong as to be indistinguishable from the original experience. They may also be understood as rejecting this notion of analogous experience altogether: VR aims to replace one experience, or set of experiences, with another. On either count this certainly makes the look and experience of the work different: it just may not make it better. In aiming to make the experience of the one identical with the experience of the other, these media are committed to maximizing the vivacity of the illusionistic representation. The sensory experience of the representation must be as dynamic and complex as the experience of that represented. Experience of the virtual world must be indistinguishable from experience of the real world. Yet, vivacity has always been a novelty in our culture. Most people are content to watch most movies at home on a small screen with half the picture cut off on the two sides. We do not flock to theaters, demanding Cinerar. . and OMNIMAX scale. We do not insist that televisions be replaced with Sensorama machines. We are content to be aware of the world around us, around the representation, as we engage with it. There seems to be a tension between the obvious interest in such maximal illusions and our obvious satisfaction with disanalogous representations. Is it just that immersion technologies have failed to deliver, and rather, by setting higher standards only made manifest their shortcomings?

Walton, as we saw, suggests that the fullest psychological participation (and appreciation) results from the fullest “immersion” in the game world, in accordance with the restrictions and encouragements of the work world. For Walton, such

27 Walton acknowledges that the fullest participation may not be the best, or most desirable or appropriate for any particular person: But others object to demands for too intensive participation as cheap sentimentality, and welcome the relief afforded by ornamentality. Many works that promote participation most actively, that most effectively engage the appreciator in the fictional world, are, though seductive, anything but profound or great (soap operas? superrealist photographic paintings?).[288]
immersion is to be at the expense of awareness of the real world, of our actual surroundings, in particular of our experience of the work world, the art work itself. To the extent that we are aware that we are engaging in a game of make-believe, aware that the work which prescribes our imaginings is a fiction, an artifice, or to the extent that this is emphasized by the work itself, we are discouraged in our attempts to imagine. On this account, the successes, failures, and goals of psychological immersion are strikingly similar to those of perceptual-sensorial immersion - for both, image-surface rivalry is of central importance. On this point, echoing Gombrich, Walton says.

The conspicuous brush strokes of Van Gogh's Starry Night call attention to themselves and to their record of the process by which paint was applied to the canvas, possibly intruding on the viewer's participation in his game. One can ignore the brush strokes enough to lose oneself in the fictional world.[277]

In his response to Patrick Maynard's discussion of this matter, both writing in the Philosophy and Phenomenological Research book symposium [June 1991], Walton modifies his position somewhat:

Prominent brush strokes....not only constitute a plain indication that what one is seeing is a mere painted canvas, but force this fact on the viewer's attention. But if the appreciator is familiar with styles of painting in which brush strokes are prominent, they will not attract special attention and may not distract from participation in the expected visual games of make-believe....one need not ignore the brush strokes or stand back far enough to obscure them in order to be drawn into the game. Nonetheless, concentrating attention on them, on the fact that they are brush strokes, can distract one from the game.[419]

There is some slippage here in how Walton uses the term "ignore". His amendment

28 Wollheim develops his theory of imagining and, in Walton's terms, psychological partication, in accordance with his theory of internal and external spectators: First, the external spectator looks at the picture and sees what there is to be seen in it; then, adopting the internal spectator as his protagonist, he starts to imagine in that person's perspective the person or event that the picture represents; that is to say, he imagines from the inside the internal spectator seeing, thinking about, responding to, acting upon, what is before him; then the condition in which this leaves him modifies how he sees the picture.[129]

29 I interpret this to mean that if one ignores the brush strokes, then they do not intrude on the viewer's participation.
of his initial usage is to claim that we can internalize dramatic stylistic features through repeated exposure. In this sense, we need not consciously ignore elements of style. However, by internalizing them, we are aware of them - we must be in order to recognize them as familiar. This also holds for the general perception of two dimensional surfaces - we are familiar with the visual experience, so need not dwell on the surface. Failure to notice or to attend to the surface is the key to the success and failure of many trompe-l'oeil. As I will argue, all representations have stylistic features that we must be aware of in order to comprehend them. If it is not prominent brush strokes, it is a compressed luminosity range, bossy perspective, frozen action, symbolic use of colour or scaling or occlusion. It is for this reason that I maintain that the experience of the one must match the experience of the other.

Do brush strokes and other facts of the representation impede our imaginative participation with the object? Must we, or to what extent must we, ignore certain facts of the representation? Do we perceptually or psychologically draw a sharp distinction between the thick impasto and the night sky, in the way that Walton suggests, such that we need to avoid attending to the one in attending to the other? Is it only features as obvious as van Gogh’s brush strokes that impede? Are there features of photographs, films, sculptures, and Dutch masterworks that impede? Where and how does Walton propose drawing a line which distinguishes between features that impede and those that do not? These are still questions concerned with the rivalry debate, and Walton’s modified stance still subscribes to it.

The answers to these questions are important for the current discussion of visual perception of worlds that include representations of one sort or another. It is my intention to extricate these matters of awareness and attention and to give some sense to how these relate to our psychological participation with representations. Part of an answer, I think, lies in differentiating between degrees or kinds of awareness. This is the undertaking at hand. I differentiate activities played out with representations, and outline an analogy regarding how we come to treat representations as the things represented, and how modern imaging technology has obscured this analogue. Walton, for instance, undervalues the role of physiology in psychological participation.
Physiological participation

If we were unaware of our present situation, I contend, we would probably not point to a smudge of paint on canvas and claim it is an elephant, let alone that it is a smudge of paint. When we look at a painting of an elephant we imagine we are looking at an elephant. When we read a novel we can imagine most easily that we are having a certain kind of visual experience: that of reading a text. We do not just unknowingly imagine seeing an elephant upon experiencing the appropriate prop. We must also attend to, be aware of, the prop. If we are not aware that we are reading a book, then we cannot make sense of the claim that we have avoidance tendencies regarding displays of pretending, nor that our actual reading is also to be make-believe reading. Novels frequently (though not always) prescribe either that we imagine we are doing something else or that we imagine we are someone else doing something else, just as paintings prescribe we are looking from somewhere else.

Many novels make explicit use of our actual physiological activity. This is a central point in Walton’s account of how we perceive representations. He argues, for instance, that in reading Gulliver’s Travels, the reader recognizes or accepts, at least implicitly, a principle whereby her reading of the novel makes it fictional that she reads a ship’s physician’s journal, a principle according to which, given her actual reading, she is to imagine herself reading such a journal.[217]

Walton’s analysis is that “pretenders copy the behavior they pretend to be engaging in, and they tend to avoid blatantly displaying the fact that they are just pretending.”[221] Many paintings make explicit use of our actual physiological activity. Many representations, and certainly depictions, make use of the fact that we are looking at them, and so prescribe that we are to imagine that we are looking at something else.

30 The exception here is in the case of a successful trompe-l’oeil. We are unaware of the representation as such and respond to the object represented. Historically, such experiences are fleeting and probably do not allow extended responses such as indicating an elephant. VR aims to change this.
Avoiding displays of pretence is part of Walton's account of how we are to make sense of indicative statements about fictional entities.

Why do we so often say simply, "There are several ships offshore." or "A society of six-inch-tall people was living in a strange land," when what we seem to mean is merely that this is so in the world of Shore at Scheveningen or in Gulliver's Travels?[221]

I believe Walton is correct in his answer. In pretending to be a part of the fictional world (participating in it) we make statements about what we imagine and not about that we imagine. The difficulty in attending to the pretense is obvious; what we are then thinking of is the activity of pretending. But this only addresses Walton's weak claim that we tend to avoid blatantly displaying our pretense, and does not address the relation between what we actually do and what we pretend to do. It leaves untouched the issue of whether or not we are in some sense aware of our pretense, aware of the prop and its features. Despite avoiding displays, we are aware that we are pretending. We are actually looking at a painting by Tiepolo, but we imagine we are looking at a figure on an elephant. We also know we are not looking at an elephant because it does not look much like one. For Walton, blatantly displaying our pretense, noticing stylistic elements in paintings, novels, or musical compositions, and engaging in activities necessary to appreciation, which nonetheless are disanalogous to the prescribed imaginary activities, all discourage participation. Yet, this fails to do justice to the complex relation of actual and imagined behaviour and experiences.

Walton fails to draw what I think is the logical conclusion in such cases, both that what we are actually doing and our awareness of what we are actually doing are essential to imaginative activity, essential to our ability to play the game. Notably, Walton consistently under-values the role of physiology in psychology. Rather, he discusses physiological states only to the extent that such states manifest certain psychological states. For Walton, "psychological participation tends to out-run and overshadow physical participation" and this subsumption of the physical is important, for it provides us a means of accounting for our involvement "without supposing that appreciators lose touch with reality when they are immersed in a work of fiction."[240-41] To this end, his focus shifts (particularly as he makes the move from discussing simple games of make-believe to appreciating representational arts)
from such physical states (and so physiological states) as sitting, looking, and tripping to those states which are associated with psychological states such as fear, sympathy, and admiration.\textsuperscript{31} What Walton takes to be important for his broad theory of participation are the relations between psychological states and what we imagine. This under-valuation and the subsequent shift in focus is central to my claims about the relation between psychology and physiology, about the relation between vision and psychophysiology. My claim that we are aware of the medium of representation is not merely to reject the strategy, used in VR research, of avoiding rivalry. It is also to embrace this rivalry. I argue that psychological participation is enhanced by such awareness.

No doubt Walton's move to minimize the rôle of physiology is in part prompted by the fact that adult games of make-believe are much less physically active than the games of children:

Children sometimes treat pictures like dolls or teddy bears, feeding picture tigers and taking them to bed with them, for example, or sitting on pictures of fire engines in order to ride on them....The activities of appreciating representations in normal ways are best seen as truncated variants of children's games of make-believe.\textsuperscript{32}

Physiological states can and do affect mental states, but mental states have the more direct rôle in what we imagine. We say we are afraid, or that it is fictional that we are afraid, not that our pulse and body temperature have increased (and therefore we are afraid). Yet, despite his emphasis on psychological states, it seems impossible to avoid grounding such states on physiological states. We say we are afraid while we experience such physiological activity; when it subsides we 'calm' down.

\textsuperscript{31} In his Chapter Eight on "Depictive Representation", Walton does emphasize the importance of physical perception, as when he draws the distinction between imagining our actual perceptual act to be a perceiving of (for paintings and sculptures) and not so imagining (for novels). However, his employment of this distinction fails to remedy his belief that awareness of such perceptual acts diminishes the vividness of participation.

\textsuperscript{32} Such truncated participation is not necessarily disadvantageous. Walton stresses that an appreciator's game is "more reflective, more contemplative. The restrictions on physical participation shift the emphasis to psychological participation....it is likely to involve a richer collection of fictional truths about his thoughts and feelings."\textsuperscript{228}
If such physiological activity is minimal, then we are only moderately afraid. Our participatory imagining with a horror film involves awareness of physiological states akin to fear, and our psychological imaginings are linked to those states. Walton does acknowledge this grounding; indeed, he bases his account on it. He writes: "If it is fictional that his fear is overwhelming, or that it is only momentary, this is so because his quasi-fear sensations are overwhelming or are only momentary." Walton's account of quasi-emotional states underscores the prevalence of the interaction of physiological activity and psychological activity, even granting that in appreciation the one is outrun and overshadowed by the other.

How does recognition of the role of physiology support my claim that we are aware and must be aware of the props with which we play games of make-believe? Walton's construal of adult games relies heavily on consideration of the representation itself. His denial of awareness is motivated by a slip from consideration of the prop to consideration of the represented object. Avoid this slip and we need feel no commitment to avoiding awareness. This clears the way for a positive argument regarding awareness of the prop. Physiological factors provide the grounding for this argument. The physiological activity which is a part of the games children play is an important feature of the analogy Walton draws with representational arts. The mechanics of perception are essential in our mature ability to make-believe.
CHAPTER EIGHT:
PSYCHOLOGICAL PARTICIPATION

Kendall Walton provides us with a compelling account of pictures, and other representations - why we find them interesting, what we do with them, how we respond to them, what is special about them. In many ways, his account avoids and addresses pitfalls and concerns that have been central to discussions of representation this century. Most of his account is beyond the scope of the present work. However, I believe his account will have a lasting influence on the future of these discussions. Despite Walton’s clear and close scrutiny of representation, he reiterates the mistake discussed in the last chapter as the rivalry view of representation. Since in our culture, and increasingly in other cultures, interest in and experience of picture and immersion environments is growing, it is important to understand more exactly what experience of those environments amount to. Given the importance of these two - representations and the experiences of them - I now take up the task of correcting Walton’s position by clarifying our understanding of them.

Walton draws a distinction between the work world (that ‘prescribed’ by the picture itself) and the game world (the imaginative activities prescribed by what we perceive in the representations of the work). We play sophisticated, imaginative games with works of art. Representations (visual, verbal, musical) are props that function to prompt or prescribe that we imagine in particular ways. Walton likens these imaginative activities to the games of children. In playing a game, children heed a set of rules so as to enliven and share their activity (even just to the extent that playmates are playing the same game). Works, then, such as novels or paintings come (loosely and in extremely diverse ways) with sets of rules that direct our imaginings. As a theory about representations and imaginings, Walton’s is clearly an account concerned with the kind of pictures I have been discussing: those that encourage perceptual and psychological immersion. At a basic level, Walton’s theory bears a relation to my concerns here. Early in his book he claims:

There are fictional worlds of games of make-believe, fictional worlds of representational works, and fictional worlds of dreams and daydreams...We must be careful not to confuse...the worlds of games that appreciators play with representational works with the worlds of the works.[58]
Walton acknowledges that ‘worlds of the works’ may be robust or they may be sparse. With either sort we are able to imagine, to effectively create additional worlds that include the work world and our imaginative activity with and about it.

My position is that Walton’s account of the representational arts draws on an analogy with children’s games of make-believe, but fails to employ all relevant features of the analogue, even though many of these features are identified. Contrary to Walton, I argue we are still aware of what we are doing (and with the props that aid us) when we imagine that we are not imagining, that we must be so aware, and that participation is not at the expense of awareness. My approach is to locate representations within the whole visual array present to us. Sometimes, of course, as with virtual reality, the representation is the whole visual array. More often it is not: trompe-l’œil provides a special case. When representations, particularly two-dimensional ones, comprise only part of our visual field, two distinct visual activities are involved. On the one hand, we respond to the information gleaned from the entire visual array, in the manner discussed thus far: we integrate various visual tasks at both early (low cognitive) and later (high cognitive) stages of the psychophysiological systems. On the other hand, we respond to the information gleaned directly or exclusively from the representation, but do so by placing it within the context of the whole visual array and the accompanying psychophysiological activity.

Walton’s strategy for explaining representations such as pictures is to draw sharply a distinction between that which the appreciator does (imaginative participation) and that which prompts the appreciator. Not all imaginings (our game world) are appropriate or “authorized” responses to a particular work (the set of rules of its work world). This enables Walton to avoid many of the perplexities faced by other theories of representation. Such a theory of psychological participation squares well with the holistic approach to psychophysiology that I have been encouraging. The mechanics of vision and the interrelationship of more general physical states seems to play an important, indeed, key rôle in psychological awareness. I will put off providing a full account of this awareness until the seventh section. First, I want to sketch out some aspects of Walton’s theory of psychological participation that will be useful in my later discussions of immersion and aware-
ness. I give some detailed attention to Walton's theory. Although, as he formulates it, his theory faces serious problems as a theory of aesthetic appreciation, nonetheless it is very well suited to the development of my programme of holistic psychophysiology - to the extension of my programme to limited arrays and aesthetic appreciation. For these purposes, its inadequacies do not matter, though the difficulty with appreciation supports my claims about psychophysiology.

**The analogy from children's games**

In playing a game in the woods, what children are actually doing is important to what they imagine they are doing. A game where tree stumps are to be treated as bears requires encountering (looking at, tripping over) tree stumps, to be at all interesting. Only when the child encounters a stump will it be make-believe that she encounters a bear. Further, the stump will direct the sort of imagining done:

Once the basic stipulation is made, further deliberation may be unnecessary; the characteristics of the stump may prompt all participants to imagine, non-deliberately, a large and ferocious bear rearing up on its hind legs, and each may confidently expect the others to imagine likewise.[23]

Spying a stump in the distance will properly elicit a different response from tripping over one. The child must not merely notice the stump, she must also notice things about the stump; she must be aware of it, as a stump. The size of the stump may make it fictional that the bear is large, or reared up; the shape may make it fictional that the bear is reclining, sleeping; it being under foot may make it fictional that the child is in imminent danger. And the children must notice that it is a stump (really, and not merely fictionally a bear): "They approach the bear cautiously, but only to discover that the stump is not a stump at all but a moss-covered boulder. 'False alarm. There isn't a bear there after all.'"[37]

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1 However, the child is not necessarily interested in the features as features of the stump, but as features of the bear.

When Eric imagines a stump to be a bear, he probably does not have any substantial interest in the stump itself....he is not especially concerned with the thought of that particular stump's being a bear....Gaining insight into the stump is not among his objectives in imagining as he does.[26]

This does not mean that he does not gain such insights.
Walton is quite explicit that there are important relations between real activities and those that we imagine. If a tree stump is carved so as to look (more) like a bear, then most people who encounter it will spontaneously imagine a bear. The children's game requires outlining rules for imagining. However, the choice of tree stumps over flowers or birds no doubt has a lot to do with the ease with which such props prescribe appropriate imaginings. Walton forestalls the criticism that "People can play whatever games of make-believe they like with a given prop....for instance, that reading a description of Emma in Madame Bovary is to count as fictionally scrutinizing her":

It would be awkward at the very least to play visual games with texts as props,...and next to impossible to use them for visual games of any significant richness and vivacity. Some things are better suited than others to serve as props in games of certain kinds. A tree makes a fine mast on a pirate ship. A tunnel or a watermelon would make a terrible one. A game of pirates in which to crawl through a tunnel or to eat a watermelon is fictionally to climb a mast is unlikely to be at all rich or vivid.[303]

The function of a prop is to initiate and guide the course of specific imaginings. A carved bear does so much more readily than a stump or bird plus an appropriate rule of generation ("Let's say that stumps are bears."[38]).

Carving a stump would be comparable to stipulating a rule of generation. But there is a difference, which Walton suggests is important to understanding why we more effortlessly imagine the carved stump, rather than the stipulated stump, to be a bear:

Following instructions is more likely to require reflection and deliberation on the part of the imaginer, especially if the instructions are complicated. One may well respond more automatically to a reasonably realistic "likeness". Heather doesn't need to decide whether to imagine a bear when she confronts the stump, or whether to imagine that it is large or small, facing her or facing away from her, and so on. The stump makes many of these decisions for

2 The child must know that it is playing a game, that the stump is a prop, not a bear, and that this is a game where the stump will be treated as a bear. Upon forgetting this the game becomes a terrifying experience. Consider this Halloween trompe-l'oeil: Visiting a four-year old friend who had not seen me since August, I arrived on the doorstep with an extra eye and two red horns affixed to my forehead. Not recognizing that I was inviting her to play a game, the child let out a wall of fear, and had to be comforted by her father for half an hour.
For this reason I insist that VR stands apart from other more limited representations. VR aims at eliminating all instructions by eliminating the separation between the entire visual array and the represented array. VR, fully realized, is not a limited array. If we have already learned to perceive the (real) world around us, then we have learned to perceive virtual worlds. There are no additional instructions. Walton's emphasis throughout his account of the analogue is that similarity of real activity with imagined activity facilitates imagining. (On the other hand, I contend, perfectly realized virtual worlds do not require or activate imagining.)

So much for children's games. Walton is much less explicit about the relations between the causes of our real activities and those that we imagine, when he comes to talk of adult games involving representations. Looking at a stump is like looking at a bear (to the extent that we have a certain kind of visual experience), whereas reading or listening to instructions is not much like looking at a bear. The children's rule to treat stumps as bears is not complex and may only be stated once, prior to playing the game. Once stated, stumps do guide our actions, make decisions for us. But our own actions, such as tripping over a stump, play a vital rôle in what we imagine. This indicates a relation between actual and imagined experiences, one which I think Walton does not fully appreciate. When Walton turns from child to adult games with representations, he ought to extend this feature of the analogy. We must notice the shape and configuration of the stump, we must notice the shape and configuration (the flatness of the painted canvas and the expressiveness of the brush strokes, for example) of the representation. What we notice and how we notice it (that is, what perceptual tools we use) are important. Some things are better suited to serve as props in games of certain kinds because of the similarity of experiences between what we actually do and what is prescribed that we imagine we do: similarity of experience facilitates imagining.

**Analogous activities**

For Walton, the actual experiences that play a rôle in what we imagine are not just physical activities, but may also be physiological and psychological states. Charles fictionally fears the slime in the horror film he watches (to use Walton's
example). This fictional fear is imagined and is an actual psychological state (Walton’s “quasi-fear”), though linked to his actual physiological state. In discussing such cases, Walton limits his analysis to psychological states, reserving comment on the rôle of physiology for a footnote:

This imagining is triggered more or less automatically by awareness of his quasi-fear sensations. He is simply disposed to think of himself as fearing the slime, when he feels his heart racing, his muscles tensed, and so forth.[246 n.3]

So Walton argues: “Not only do our actual feelings and what fictionally we feel coincide; frequently they tend to be linked closely together in several important ways.”[252] The reasons for pitying or admiring a character may be “imported from the real world”, especially in cases of the portrayal of historic figures with whom the appreciator is familiar. The fictional presentation of actual events may cause tears which are “causally overdetermined, caused independently by what she knows about the victims, and also by her realization of what fictionally is true of them.”[253] Walton grants that actual psychological states parallel and enhance fictional psychological states.

But “sensations” clearly has some reference to physiology. Our actual activity, such as tripping or tensing muscles, is incorporated into our imaginative activity. Indeed, Walton claims that our actions play a direct and analogous rôle in what we imagine. And he argues that the acceptance of such a principle (that we imagine of what we do) needs to be shown. Walton wants to show that appreciators are what he calls “reflexive props” in their own games of make-believe, that they themselves at least implicitly accept a principle that they are to imagine activities which reflect their actual activities, that they are imagining of or about their activities (that these actual activities play a rôle in what or how they imagine). This is an essential principle, and one which sets Walton’s theory of imagining apart from all others. The intuitive appeal of Walton’s theory is rooted in his analogy with children’s games of make-believe. Though our behaviour before a canvas or film is different in degree, Walton contends, it is not different in kind from children’s. His demonstration of this principle, which he works out with the case of Van de Velde’s painting The Shore at Scheveningen, is that

In pretending, one copies the behavior one pretends to be engaging in. In
pretending to refer ["That is a ship", in the painting], one naturally uses words and gestures - demonstratives and pointings, for instance - that are ordinarily used in referring.[219]

This is true: obviously so when children act out the roles they have assumed when playing a game. Walton's formulation here is that we use or imitate the actual behaviour we make-believe we are engaged in; in communicating to you which ship I am talking about, I pretend to point to it, just as I would if there were a real ship on a real sea before us. However, I think this extension of the idea of self-imagining is too limited, particularly as Walton elaborates it. A crucial feature of the analogy is lost in Walton's further account:

In pointing and declaring "That is a ship" Stephen is neither referring to anything nor attributing fictionality to anything....Stephen is merely pretending to refer to something and to claim it to be a ship. This frees us from the supposition that his demonstrative actually picks anything out, or even that there is anything to which he pretends to refer. He only pretends that there is something which he refers to and calls a ship.[219]

But I think Walton's analysis goes wrong here. There is considerable difference between merely pretending to refer and pretending there is something to which he refers. I contend that Stephen is pretending to refer, but not that there is nothing to which he refers.3 More, Stephen is really referring to something and he is pretending he is referring to something else.

Consider the following activities: in tripping over a stump I imagine I am tripping over a bear, in reading a book I imagine I am reading a journal, in looking at a painting I imagine I am looking at a ship, and in referring to a paint smudge I imagine I am referring to a ship. Here are two distinct activities:

1. I attend to (look at, read) x, but I imagine I attend to (look at, read) y.
2. I imagine I refer to y, so I indicate y (or xy).

I attend to paint, but I imagine I attend to ships. I imagine I refer to ships, so I point (indicate). The second describes our specific behaviour in front of The Shore at

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3 I also do not think that Walton thinks there is nothing to which Stephen refers. But this formulation indicates the ambivalence with which Walton treats the matter of the object of perception.
Scheveningen (or any like behaviour), the first our general behaviour with regard to stumps, books, and paintings. Strictly, on Walton’s account in the above quote, he says: I imagine I refer to y, so I indicate nothing. The second is a consideration of the represented object, the first a consideration of the prop or art work. The second activity is dependent on the first. Consider another variation: I see paint, but I imagine I see ships; I imagine I see ships, so I say “That is a ship.” The second is an explanation of why we might be inclined to speak, the first is an explanation of why we do not say “That is a ship in the painting.” It is also a formulation of the principle Walton wants to affirm. The four examples just given (of tripping, reading, looking, and referring) are all instances of the first activity.

Nowhere in this discussion do I mean to preclude Walton’s formulation, which is a component of activity two: in imagining I am referring to a ship, I refer to or indicate a paint smudge. Physical activity is often motivated by our imaginings, but also our imaginings are aided and enhanced by our physical (and physiological) activity. Walton’s denial that there is “anything” to which Stephen refers seems to be a rejection of: I look at paint so I indicate a ship. Walton would agree this is true (or at least, I look at paint and I indicate a ship), but this has no explanatory force. Walton’s aim is to explain, with his account of fiction, how we come to indicate make-believe entities, because this is evidence that we imagine ourselves present with the represented objects not just with the representation. So Walton avoids awareness of the paint. But, as he clearly spells out with children’s games of make-believe, the paint smudge prompts my imaginative activity. My modification of Walton’s account runs in the opposite direction. Awareness of the paint explains why reference to a specific smudge counts as referring to a ship.

Let’s go back to Walton’s own examples, from painting and from literature. Walton began the discussion of The Shore at Scheveningen (and Gulliver’s Travels) by setting out the task as a demonstration that, for instance, a “reading of the novel makes it fictional that she reads a ship’s physician’s journal”[217]; not the reverse, which is: in pretending to read a journal I read a novel. We imagine of what we are doing that it produces some other experience. We do engage in both the above activities, and I suspect that what we actually do and what we fictionally do draw on and reinforce each other. And this, as remarked above, is Walton’s own gener-
al view of visual depiction: “The seeing and the imagining are inseparably bound together, integrated into a single complex phenomenological whole....they must be thus integrated if the picture is to qualify as a picture.”[295] Though “inseparably bound together”, they are distinct. In working out his demonstration, Walton moves from a consideration of looking at *The Shore at Scheveningen*. He moves to a consideration of referring to what is depicted in the painting; from a consideration of the first activity to a consideration of the second activity. And this lacks explanatory force. While the second of these activities is adequate as an account of why we refer to and comment on ships in paintings in the way we do, it does not address the principle that we imagine of what we do. This principle (and it cannot be the only principle) amounts to the following: in pretending, one copies the behaviour one is actually engaged in, or, one imagines of what one is doing, that that activity produces some other experience. This would be my formulation.

Walton’s formulation that one “copies the actual behaviour one pretends to be engaged in” accounts for demonstratives and pointings, but does not demonstrate that we implicitly accept the above principle. This exclusion of our real and, in this example at least, physiological activity is central to my thesis that we must be aware of the representation and of our experience of it while we imagine that this experience is not pretence. We imagine of this experience that it is that experience. This exclusion of physiological activity is where Walton strays from his initial analogy and why his formulation, while correct, is too limited. I will now indicate the effects of this limit.

**Styles of realism: photography**

Walton claims that our imagining, prompted by representations, is of the same kind as the make-believe activity of children. This premise is, I believe, correct. However, his formulation faces two shortcomings. It does not adequately address how on a mechanical level - at the level of physiology - this is done. Nor does it adequately address aesthetic appreciation. These two shortcomings are related. A good account can be given of how Walton fails to appreciate this part of the analogy.
Though it may take different forms, awareness of or attending to the representation or artwork is essential to the activity. In my terms, awareness is any perception that requires some degree of computation, that involves more than mere retinal or ganglion cell firing. Attending refers to conscious consideration of visual phenomena. My account of the physiology of visual perception indicates how we integrate our visual surroundings with our physiological, emotional, and intellectual states. To be aware of or attending to a representation, part of our visual surround, is to be (broadly construed) cognizant of it. Recall that cognitive contours may not result from the highest visual functions, from mind/brain deductions. However, we are still aware of such perceptual activity. We may drive a car for several blocks and have no recollection of having done so, while we daydream of our destination, yet we would still say we were aware of the flow of information present to us. The integration of external phenomena with internal states demonstrates how we can have complex experiences such as quasi-fear. That part of the analogy under-valued by Walton, awareness, corrects his shortcomings. A good account can be given how Walton fails to appreciate this part of the analogy.

The predominance of photographic representations has distracted us from what I take to be a central feature of representations. The success of a representation has more to do with our experience of it than with the match of appearance (realistic ‘likeness’). Consider the earlier discussed experience of Pozzo’s ceiling from the central projection point and from off this point. There is not even a good description of the matching of appearance which does not invoke photography. A “match of appearance” is an approximation to “realism” and to “photographic realism”. The sciences of optics and photography have obscured the difference here, between the experience of a representation and its approximation to the object of the representation. It is generally held that photographs stand as the paradigm of realism because they look like the things they depict. My contention is that they are so highly regarded because our experience of them best (or at least highly) approximates our experience of the things they depict. They also, of course, generally look like the things they depict.
Our attraction to photography is much more complex than this. Photographs are also highly regarded because of the causal relation between object and photograph, and the possibility that we have some sort of contact or presence with distant spaces and past times. The appeal of the causal argument is obvious, since many photographs do not actually look like the world as we experience it (being blurred, unfocused, or with stopped-motion). The aim of VR is to match the experience of virtual worlds with the experience of the real world, though the virtual world may look radically different.

Photographic realism is often the standard measure of representation (particularly figurative representation). This certainly is the case with VR which employs photographic and computer simulated photographic imagery in striving for realism. Many representations that are not photographic are successful, but those that approach photographic realism are commonly more highly praised. This is certainly a view with which Walton is sympathetic. He argues that:

Continuous single-minded participation, concentration on the visual surroundings in which one fictionally finds oneself, is easier, for example, for viewers of Girl Reading Letter by Open Window by Vermeer, who in the interests of “realism” disguised his own painterly activity and rendered inconspicuous the physical properties of the paint.[280]

We ought, perhaps, to ask what counts as disguising human activity and physical properties. Walton’s general view seems to be that the object of the representation (a girl, a letter, and an open window) is obscured by paint and painterly activity, by representations that are not depictions, and by depictions that are not realistic. The ultimate aim is the kind of immediacy of photographs, as Walton understands this. Walton claims that photographic realism is uniquely transparent; we would see through them, just as we see remotely other rooms via closed circuit video cameras or see the past light of long dead stars via telescopes. A completely successful disguise may well render the artwork transparent. Walton stops short of this position because he believes that the causal relation a photograph holds with that pho-

4 See his article, “Transparent Pictures: On the Nature of Photographic Realism”: “Photographs are transparent. We see the world through them.”[251] He also claims: “to be transparent is not to be invisible. We see photographs themselves when we see through them.”[252]
toographed is also unique - painting, mediated by human actions and beliefs, does not share this causal relation.

I agree with this distinction based on causality. Causal history is not, however, so easy to identify. Digital manipulation of photographs is not photography, and does not share in this unique causality. It is a specialized drawing (marking) technique that aims at imitation, just as other artists (for instance, Chuck Close) have used other techniques. Because this technique is especially good at imitation, the results are confused with photographs both by us, the casual viewer, and by commentators and theorists. Our confusion does not make these images photographs; even when they are imperceptibly identical with photographs. That they cannot, or nearly cannot, be differentiated has led many writers to both worry about the causal veracity of photographs and assume that these works are photographs. Such manipulation must count as successfully disguising the painterly activity (computer manipulation of pixels) and rendering inconspicuous the physical properties of the paint (the colour inks applied according to the digital directions of the computer).

In his discussion of depictive representations, Walton gives some indication of the consequences of failing (purposefully or not) to render inconspicuous the physical properties of artworks when he contrasts realism with (a sketch of a computer done in) sloppy style:

the Sloppy Style sketch contains an intimation of human warmth...which a more precise drawing is likely to lack. This might be understood in terms of an alternative game to be played with the sketch in which fictionally it is drawn by a fallible and feeling and not overly fastidious human being. ....[318-19]

Sloppy style is a deliberate display of artistic activity and physical properties. Walton claims that this display impedes our participation with the work world by generating secondary and competing game worlds and by reducing the games that can be played with the work world: "Once we see that it is in Sloppy Style, we realize that further investigation of the lines of the drawing will not reveal fictional truths about the details of the computer's construction". [319] This would hold equally for van Gogh's brush strokes. This would also hold for impressionist paint-
nings and for all photographs - where inspection is limited by grain size, focus, base fog, movement, etc. Such deliberate displays are ornamental (at least in part - and it is that part which Walton claims inhibits participation). "We should suspect ornamentality wherever representation is significantly "stylized"."[286-87] The reticulation of grain in a photograph is ornamental, and does limit the amount of information we can glean from the representation, but is also inseparable from our emotional response to the photograph, from our psychological participation with it, and the game that we thus play. Different ornamentation results in different games. Walton's position is problematic given that the consequence of his account is a reduction of depiction to realism. Ornamentality results "in the inhibition of participation, in observation at the expense of participation".[288] No doubt speculation plays as great a rôle in construing representations as does inspection.

Disguised and inconspicuous features are, of course, culturally specific and all Renaissance painting, including that of Vermeer, can look mannered. This is how we easily identify a painting as a Vermeer or indebted to him.5 (We neither imagine nothing of Vermeer nor that Vermeer is insallible, unfeeling, and fastidious.) The predominance of photography, and the uniformity of optics, has meant a uniformity of physical features, of mechanical style, in our representations. In writing on photography, Walton is explicit that the realism which photography achieves is not necessarily preferable or superior to the achievements of other media. Nonetheless, he does indicate the importance he grants such realism when he says that

Paintings can be as realistic as the most realistic photographs, if realism resides in subtleties of shading, skillful perspective, and so forth: some indeed are virtually indistinguishable from photographs.[1984, 249]

These are features of realism for Walton. So too are "a correspondence in the order" in which we acquire information from inspecting depictions [305], and that no "normal examination" of a painting

5 This may in fact be exceedingly difficult as the current work of the Rembrandt Research Project demonstrates. A recent show at The Metropolitan Museum of Art called Rembrandt/Not Rembrandt painstakingly details the various techniques by which works come to be included in or excluded from the master's oeuvre; techniques that involve historical provenance, x-radiology, microspectroscopy, and magnetic resonance imaging.
reveals all of the fictional truths that can be extracted from it; there is always more to be found. In this respect looking at the picture in the normal manner is like looking at life.[308]

While “photographic” realism may be as culturally specific as any other realism, its technological uniformity has fuelled the twin myths of an invisible, disguised, or transparent style and a separation of representation and the means of representing. This in turn has obscured the distinction between our experience of the representation and the appearance of the representation. This is especially so as the one frequently incorporates the other. The expectation that our experience of the work world can be unmediated seems to have led Walton to conclude that mediation must hinder participation. Let us investigate further how mediated experiences of the work world have led Walton to conclude as he does, and led me to hold the opposite view: that such mediation can aid and enhance participation.

Immersion and compensation

Let us consider how Walton’s view of immersion relates to the distinctions drawn in the last chapter. In discussing any account of immersion, there are two aspects of physiology that need to be considered. The first is that which Walton identifies, though does not stress: a relation between physiological activity and states and psychological activity and states, and so with imagining. The second aspect involves essentially the mechanics of perception, and rests on the analogous relation between certain limited activities, such as looking at a square of canvas, and less limited activities, such as looking across a bay and shore line from a raised bluff. This is what Walton has left out of his account. The specific case of visual perception of delimited surfaces is like, but not identical with, perception of our actual environment, and requires our psychological construal of those surfaces. To

6 Given his claims about photography as an extension of seeing, like looking through lens, Walton would probably say it is not culturally relative, at least no more than comprehending what is seen through a telescope is. He seems not to be overly concerned with the additional visual phenomena of the picture surface, of photographs rather than optical camera devices. In “Transparent Pictures” he says: One may pay no attention to photographic images themselves, concentrating instead on the things photographed. But even if one does attend especially to the photographic image, one may at the same time be seeing, and attending to, the objects photographed.[253]
psychologically immerse ourselves we must compensate for differences between the analogue and the subject. Depending on the lessons we take from cybersickness, this may or may not be the case for physical immersion. Physical immersion achieves its aim by minimizing the differences between the two experiences (ultimately, with VR, the experiences are the same\(^7\)). Psychological immersion need not make the experiences indistinguishable, though this would certainly not be a hindrance. It just is the case that VR has not reached full bloom, that experiences of picture environments are not equivalent to the experiences of the environments there represented. There is a gap, then, between physiological and psychological activities and states. Further, for specifically psychological immersion, allowance must be made for this gap, as it separates to discernible experiences. The first of these two aspects encompasses both activities discussed above: activity two when psychological activity prompts physiological activity; activity one when psychological activity responds to or copies physiological activity. The second of these aspects, looking at delimited surfaces, is specifically activity one. I look at paint, but I imagine I look at ships.

This case typically requires conscious processes of interpretation as well as fairly automatic processes such as psychological compensation. The latter is more readily obvious with some of the visual and temporal arts than with written fiction. This is in part, as Walton states, because with novels

the games in which these works serve are only minimally perceptual; reading is about the only perceptual action that, fictionally, one performs. If one examines the printed text of *Gulliver's Travels*, it will not be fictional that one examines the handwriting of the logbook or observes the formation of the letters beyond recognizing what letters they are.[354]⁸

In reading, we usually have little opportunity fictionally to copy the activity we are actually engaged in. Activity one seems more often to take the form: I read about a strange land of six-inch-tall people, but imagine I am in a strange land of six-inch-

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⁷ We may imagine a virtual environment that matches identically a real one. Our experience of the two ought to be identical - though, we would now be able to initiate alternative histories by choosing different courses. More often, two kinds of environments are (would be) different, but our experience would be the same in kind.
tall people; or I imagine I see (am present with) Gulliver tied down on the beach. However, I think that a strong case can be made for novels and written fiction analogous with that made more easily with other representational arts.⁹

So, consider Picasso’s Bull’s Head, reproduced on the cover of Walton’s book. Walton says:

The bicycle seat and handlebars of Picasso’s Bull’s Head inevitably draw attention to themselves and to the fact that they are (bronze) bicycle parts, distracting the viewer from their representational function and probably interrupting the participatory experience of fictionally looking at a bull. The seat and handlebars compete with the bull, to some extent.²⁰⁶

Rather, if we did not see that it is (bronze) bicycle parts we would never see that it is (a representation of) a bull, for the reason that, as bulls go, this looks little like one. The activity of looking at Picasso’s bull is so unlike looking at a real bull that we must note this dissimilarity to identify the bull. Yet, the analogy still works. An average stump will not look like a bear unless we are prompted to think of it that way. There is no such rule of generation accompanying Picasso’s bull.¹⁰ If we do not recognize that we are to play a game with these bicycle parts (by the purposeful arrangement of them) we would not imagine we are looking at a bull (except perhaps, and inappropriately, by chance).¹¹ This is not specific to Picasso’s minimal representation. A more replete and “realistic” or superrealistic representation of a bull also will not look much like a real bull. Neither will a colour photograph of a bull. Here is a partial explanation why.

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⁸ True. But with Gulliver’s Travels this is also because of the letter from Captain Gulliver to his cousin Sympson which accompanied the 1735 edition and subsequent editions. If I examine the pages of my Penguin Classic I may imagine I am looking at the umpteenth edition of the printed book by Gulliver, just as I really am looking at the umpteenth edition of the book by Swift. If I examine the pages of a first edition, that by Motte, I may imagine I am looking at the edition of the journal by Gulliver which he was particularly displeased with.

⁹ For more on literary representations I direct the reader to my “Participation, Immersion, and Awareness: Walton on Verbal Representations”, forthcoming.

¹⁰ Well, there is. The title provides just this sort of rule. But it is conceivable that we should encounter the work, without knowledge of the title and with knowledge of non-figurative art, and still readily see it as a bull’s head.
The Shore at Scheveningen has been drafted so to be viewed from one location directly in front of the canvas, at the centre of projection. In employing standard rules of perspective Van de Velde, consciously or not, made this decision. Photographic lenses are ground and cameras constructed according to the same principles. But, as discussed in the last chapter, more often than not we view paintings and photographs from locations and angles other than at the centre of projection. Images viewed from oblique angles seldom look distorted. Imagine arriving late to a popular film and being seated in the front row against the wall. The screen is viewed at an extreme oblique angle and appeals to both peripheral and foveal vision. It will look distorted, but surprisingly we adjust for the distortion after several minutes. In fact, normally we compensate quite quickly for distortions of this sort. The delay in the theatre seems due to the size of the image before us and to the involvement of both peripheral and foveal vision: at first we perceptually fail to identify the borders of the image, fail to identify the "rectangle" bounding the image. Once identified, our visual system compensates for the distortion of this referent and subsequently of the film image.

The relation between physiology and imagining is one that is recognized and employed for profit in IMAX films. Earlier versions of these sensual films had spectators stand in an inflated dome watching (and swaying) to point-of-view projections of roller-coaster riding, hang gliding, auto racing, and so on. The scale of the projection appealed to peripheral as well as to foveal vision; the effective approximation of trompe-l'oeil elicits appropriate attendant physical reactions. A quite practical, and more sophisticated, version is the flight simulator. This technology in turn has been adopted by the entertainment industry. In a cross between such films and VR, a roller-coaster car trundles up the first incline, the spectators’ seats tilting back, then leveling, then tilting forward. Only very slight changes in the orientation of the seats are necessary to cause spectators to grip the restraining bar and shriek

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11 In fact, we do this all the time when we look at clouds or stained walls and see them as other things. We have a facility for this activity. With bicycle parts in the corner of the garage we may see animals, but we are not enticed to do so. Such perception may take little prompting, but if we choose to prompt specific activities with specific props those props must do that job. If the bicycle parts failed to make us think of a bull, we may be inclined to thing Picasso has failed.

12 Perhaps a screening of Michael Snow’s Side Seat Paintings Slides Sound Film.
as they otherwise do not. The experience is of a tremendous change in the orientation of the seats and of a much more vivid make-believe experience. Even subtle physiological states and changes dramatically affect how vividly we imagine. Such experiences involve sitting, looking, and listening and prescribe that we imagine we are sitting, looking, and listening. The point seems to be that as we become less aware of the actual setting and the work itself our actual behaviour and our imagined behaviour tend to coalesce. We have difficulty contextualizing the IMAX screen and begin to orient ourselves (sway) with the film image. Likewise we have difficulty contextualizing the VR experience - we both take it as real and thrash around the real space as we imagine thrashing around the virtual space.

Pirenne has made this point regarding compensation clearly, here in the case of a photograph of a photograph:

the portrait in the background is deformed into something of a caricature, because it has been photographed at an angle. Yet, while most spectators attending the electoral meeting at which this large portrait was displayed were viewing it from a wrong position, they must hardly have noticed deformations of this kind - which would make the use of such portraits defeat its purpose.

When the shape and position of the picture surface can be seen, an unconscious intuitive process of psychological compensation takes place, which restores the correct view when the picture is looked at from the wrong position.[99]

Simple experiments with variously shaped masks will demonstrate that perceptual awareness of the boundaries of the image is important in our ability to resolve the distortion. We must know that we are perceiving a delimited array, that the face is represented two-dimensionally. This recognition enables us to compensate for the distortion. This ability to compensate enhances and encourages our psychological immersion. We look at a two-dimensional object, but imagine we are looking at a different three-dimensional one.

13 My experience of IMAX and OMNIMAX films is not one of a trompe-l’oeil. Rather than losing myself in the image, forgetting that it is a domed screen with a very large image on it, I am fully conscious of my circumstances and of the extraordinary quality of the images before, and above, me.
The process of psychological compensation demonstrated by Pirenne is unconscious. But I do not think there is a conscious-unconscious dichotomy in these matters. It could happen that on first encounter Picasso's Bull's Head appears as bicycle parts, and only later do we work out the representation. This is a common enough experience with clouds and shadows and stains on walls; and it certainly arises when, in looking at a painting, we are initially puzzled by some aspect of it, failing to "see" part of the representation, while fully participating with the rest. At the very least, this process of psychological compensation demonstrates that our successful imaginative activity is based on experience of the image and not (just) on the appearance of it. Nothing stands in the way of laying greater emphasis on the part played by experience - either non-conscious or conscious.

This may be further strengthened. Artists and other makers of representations know that if they are to successfully direct our imagining they must compensate for a great many inadequacies of their media. In addition to the loss of movement, actual three dimensionality, scale, artists must contend with dramatically reduced colour and luminosity ranges. The beauty of Ansel Adams' photographs attests to his practise of visualizing the final photograph at the moment of taking it and to his development of the zone system. At the outset of his book The Print, Adams states:

*Vizualization* is the most important factor in the making of a photograph. Vizualization includes all steps from selecting the subject to making the final print. I emphasize the importance of practice in vizualization - the constant observation of the world around us and awareness of relationships in terms of shape and potential form, value interpretation, and emotional and human significances. All these come together as we develop our ability to visualize, to see as our photographic equipment and materials "see".[2]

Adams credits his success as a photographer to his initial insight about vizualization and his ability to practice it. The insight is based on the difference between perception of the world and perception of photographs, on the phenomenal differences of the two. Adams is only one of thousands of artists who recognize this difference. Working primarily in black and white photography, Adams was keenly aware that the luminance range of photographs is a small fraction of that of the sunlit world. A key aspect of visualization is the translation and compression of the natural luminance range via the zone system to that of the photograph, from a ratio
of darkest to brightest of 1:10,000 down to 1:100. For this reason Adams states: "My work, for example, is frequently regarded as "realistic," while in fact the value relationships within most of my photographs are far from a literal transcription of actuality."[11]

What holds for luminosity holds also for colour. Recall the surprise Cézanne exhibits at Bernard's limited palette. All palettes are limited and like the tonal range of photographs transcribe by compression the millions of colours (hues and values) present in the world. Cézanne's surprise is really at the choices of compression made by Bernard. That such choices are made is obvious. The authenticity of works may be determined by recourse to an artist's known palette. Different stages of an artist's career may be identified with changes in colour choices. What is less obvious is that such choices are forced. Even if they would want to, artists cannot represent all colour hue, saturation, and brightness. Given that they must compress the colour range, artists do so in unique ways. This is well known in computer work - the creation of digital-image archives combines the kind of choices photographers and painters make. In their little book on imaging, Besser and Trant describe the kinds of decisions that must be made to reproduce paintings and prints with a dynamic range of up to 16 million colours as a digital image with a range of 256 colours:

The color palette can be predetermined by the system, and the same 256 colors (the system palette) are used for all images. The appearance of an 8-bit (256 color) image is often enhanced, however, by optimizing the palette used. Specifically selecting 256 colors most representative of those in the work depicted enhances the fidelity of a digital image. Such an adaptive palette can cause problems when multiple images are displayed at one time on a system which can only display 256 colors; the system is forced to choose a single palette and apply it to all the images shown at once.[9]

Representations are only analogous to the things they represent because they compress, transcribe, and select elements of the original with the aim of facilitating our processes of compensation.

Different realities: Gombrich

The problem that Walton's theory faces, acceptance of the rivalry view, and
the incompatibility of surface and image, has its clearest and best known statement in Gombrich’s *Art and Illusion*. Gombrich, in fact, raises two of the themes in my discussion of picture environments. In addition to the rivalry view he also points out the general tendency in Western art, from the early Greeks on, towards perceptual and psychological immersion. Gombrich raised two related points about why representations so convince us. The first point concerns rivalry and the second point concerns our desire for immersion environments. The first he called the “riddle of style”:

Why is it that different ages and different nations have represented the visible world is such different ways? Will the paintings we accept as true to life look as unconvincing to future generations as Egyptian paintings look to us? Is everything concerned with art entirely subjective, or are there objective standards in such matters?[3]

Gombrich was certainly not the first to notice that visual representations use different systems to convey information about the worlds, real or imagined, that they represent. Gombrich argued that different paintings look the way they do because of different uses for which they are intended. Even with representations that may be considered (loosely) realistic there is this stylistic difference. So paintings look different in different times and between different cultures because the peoples of those times and cultures have varying intentions when producing and viewing their works. This holds as well for photographs. The function of art determines in part the content and the look of it. Whether or not the value or worth of a work of art is determined in large part by the artist’s intentions, it is an undeniable fact that artists do have intentions when making representations, or non-representations. To this degree, at least, intentionalist theories are valuable.

Second, in developing his cultural thesis, Gombrich discusses the power of the myth of Pygmalion. Gombrich criticizes Plato for claiming that art aims to imitate nature (for which Plato faults it in Book X of the *Republic*). Plato’s own ancestry “tells of an earlier and more awe-inspiring function of art when the artist did not aim at making a “likeness” but at rivalling creation itself.”[93] Central among the myths of such creation is the story of Pygmalion, given early substance in Ovid’s *Metamorphoses*. For having written it down first, Ovid’s account has been the standard, and the most influential. Pygmalion is a sculptor who falls in love with his own statue of Aphrodite (Venus, to Ovid; to later narrators Pygmalion’s future wife
is named Galatea). In answer to his prayers, the real goddess turns the "cold marble into a living body", whom Pygmalion then marries.

The suggestion of the myth is the possibility of real creation, or what could be called original creation, that is, substance (most often living breathing flesh) out of nothing, or out of no previously living thing. This myth, and the possibility of original creation, has enticed artists, both visual and literary, since Ovid gave it literary form. This is the attraction of physical immersion, in this form as presence with a creation, presence that is indistinguishable from any other experience. Gombrich goes so far as to claim that "without the underlying promise of this myth, the secret hopes and fears that accompany the act of creation, there might be no art as we know it."[94] Echoing this promise, and speaking for novelists, composers, sculptors, the painter Lucien Freud writes

A moment of complete happiness never occurs in the creation of a work of art. The promise of it is felt in the act of creation, but disappears towards the completion of the work. For it is then that the painter realizes that it is only a picture he is painting. Until then he had almost dared to hope that the picture might spring to life.[in EG, 94]

The artist strives, perhaps vainly, for a kind of happiness, described often as that of successfully creating (whether actually a work of art, or metaphorically actual substance). This is echoed in a passage of The Media Lab by Stewart Brand:

"...Computers are a lot worse than real life. You have to be hit over the head with that before you realize how true it is."
"Why bother, then?" [Brand] asked. "Why not stick with real life?" Strassman didn't hesitate: "Because you can't automate real life. I can't get this shrimp to swim if I draw it on real paper with a real brush."
Junior deities, we want to be. Reality is mostly given. Virtual reality is cre- atable.[31]14

Within our cultural history there is not shortage of versions and tellings of this myth.

There is power in this myth. There is the power of the artist to create, and

14 Quoted in Pimentel and Teixeira, Virtual Reality: Through the new looking glass.
there is the power of the art to (what Gombrich calls) “rouse the passions”. Leonardo da Vinci writes of the power of the painter to “so subdue the minds of men that they will fall in love with a painting that does not represent a real woman”[95] — that is, a woman whose only existence is as a painting, an image. In what reads like a modern advertisement, da Vinci writes:

It happened to me that I made a religious painting which was bought by one who so loved it that he wanted to remove the sacred representation so as to be able to kiss it without suspicion. Finally his conscience prevailed over his sighs and lust, but he had to remove the picture from his house.[in EG, 95]

The first power, as the myth itself tells, is limited: the artist is doomed to fail in the act of original creation. The outcome is the more modest act of “artistic” creating. The second power, the power over others by means of just that limited, modest act of creation, is far less limited. Our understanding of just how unlimited this power is, is currently being both debated and extended.

Part of the attraction of the myth is that it suggests that the artist has a real power (that of original creation) where really there is only the power of hucksterism. The myth is both a salve and an advertisement. One can at the same time create a work of art and suggest to the world that the creation is more than in fact it is. Taken together, the riddle of style and the myth of Pygmalion demonstrate the tension between disguising the hand of the artist and making the artwork invisible and our aesthetic appreciation of art and our psychophysiological construal of the artwork. If artists succeeded where Pygmalion failed, their art would fail to represent — it would be.

Awareness

Now I have a promise to keep. I have been quite vague about, perhaps seemingly loose with, my definition of awareness. I think that Pirenne’s notion of unconscious psychological compensation suggests the complexity of what it means to be aware of the prop before us. I have not just followed Walto’s suggestion that “imagining is triggered more or less automatically by awareness of...quasi-fear sensations.” I follow Pirenne’s use of the term when he says “the basis for this compensation must be the spectator’s awareness of the surface of the picture.”[100]
With two-dimensional media we have to be aware of, though not necessarily consciously attentive to, the frame; we are quite capable of the sort of automatic response outlined above. Nevertheless, we are never far from conscious awareness. As the experiments conducted by Yarbus demonstrate, while we attend to one local point of the picture (for instance, one eye of a face) we are aware of the remainder of the picture, and can leap to other points (such as the other eye, or the mouth, or a detail in background). Awareness, then, is not just synonymous with our directing our attention to something, to consciously attending to some feature, though the directed kind is what I am more interested in here. There are different levels of awareness. The objection may be raised that we do not consciously attend to the brush strokes, but rather to the features of the depiction of the south of France that we would see if we stood where van Gogh had stood. But inspect the canvas. Are any such features present? Well, in Tiepolo’s painting Asia such features may be present. How much attention can we direct to those features? Even Walton acknowledges that such inspection has limits. I argue it is far more limited than he allows. The degree of inspection of a representation which is akin to the sort of inspection done before a real vista is superficial. Almost immediately (even with photographs) such inspection gives way to speculation and interpretation, to compensation.

Nonetheless, in cases where we are utterly unaware (or exceedingly unaware) of the prop, unaware that it is a prop, the distinction between psychological participation and living breaks down, as we sway back and forth before the IMAX screen or thrash around in the VR environment. For Walton’s theory to do any work, we must reserve psychological participation for those special cases involving representations and games, as numerous as these cases are. In other cases, of more limited arrays, it is more evident that we must also be consciously aware of the representation; this especially in cases where the experience of the representation is most unlike the experience of that which is represented. We must attend to the work itself in order to recognize that this experience is (these sensations are) to be taken as that experience. So awareness is a matter of degree from unconscious, intuitive, and automatic processes to conscious and semi-conscious processes. To be aware of some feature of the world is not merely to have a particular array of light on the retina. Our visual psychophysiology must process the resulting nerve signals as part of the cognitive construal of the world.
For Asia to be a successful depiction of, in part, an elephant, we must recognize that the paint comprising that part of Asia is not an elephant, that the paint is something else. (The exception would be cases where they are the same, in some reflexive representation-representations.)\textsuperscript{15} It is not the case that trompe-l’oeil pictures or IMAX films instantiate mistakenly perceiving x as y because they have succeeded in making x and y look alike (though it may be at times they really do look alike).\textsuperscript{16} The principle at work is to make the experience of x as much like the experience of y in the right kind of ways. This cannot be a direct correspondence of experiences as demonstrated by the necessity of compression. The aim is to strengthen the analogy between the experiences. Though the effect is most often short-lived, we occasionally really do mistake x for y. But the reason we do is akin to the distortion we initially experience from the front side seat at the theatre. In that case the distortion interferes with our imagining the experience of the film to be the experience of the event filmed or depicted: the experiences are disanalogous. This, it seems, is even the case for VR. For a trompe-l’oeil to be successful the analogy must be strong; we must either view the painting from the centre of projection or the work must compensate for the likelihood that we are not so located.\textsuperscript{17} The boundaries of the work must be obscured in some manner, the perceived distance must be similar to the actual focus of our eyes, etc. Trompe-l’oeil are special cases, not because they look so much like the object represented (though they may), but because we are unaware of the prop, unaware of the fiction. IMAX accounts for these factors by constructing special theatres, with screens that wrap around us, and by careful selection of shots.

\textsuperscript{15} Representations that are ornamental may represent themselves. Such representations may not prescribe that we imagine about fairies, flowers, or people, but they may prescribe that we imagine that that is their function. "Appreciators imagine of the object that it is composed of the material it actually is composed of - paint on canvas, worlds on paper - and that its job is to generate fictional truths about fairies or flowers or people."\textsuperscript{[283]}

\textsuperscript{16} It is because at times the depiction and the thing depicted do look alike, combined with the uniformity of physical features and the subsequent fading from attention, that this difference between appearance (and realism) and experience has been obscured.

\textsuperscript{17} This is often done by representing flat things, such as doors, that match the distortion arising from oblique viewing positions.
On the other hand, the analogy can be quite weak, as with clouds, stained walls, and Picasso's bicycle parts. Sitting in a darkened theatre is not much like hang gliding or floating weightlessly above the planet, but the visual and auditory stimuli we experience in the theatre are enough like what we would experience (or suppose we would experience) in those situations that we quite freely, and even involuntarily, make-believe we are in those situations. The stimuli we do have are of the right kind. VR and 3D OMNIMAX films endeavour to provide us with even more of the right kind of stimuli. Someone yelling "fire" or the film breaking are auditory and visual stimuli of the wrong kind. So too are excessive scratches on the film surface, slashes in the canvas, or missing pages from my copy of *Gulliver's Travels*, but these are not serious counter-examples to my thesis. While these may make us aware of the work itself, they do so by obscuring the work world, whereas noticing and attending to the work world is undertaken to maximize our acquaintance with the work world so as, consciously or not, to recognize the analogy between this experience and the prescribed one.

These experiences of $x$ and $y$ are complex, involving a host of different physiological, psychological, and emotional activities. We should not assume that one set of activities need duplicate another for a representation to be successful, for the experience to be the same. We can approximate experiences by different combinations of activities. The experience of looking at Picasso's bull is quite different from looking at a real bull, but the representation works, we do imagine we are looking at a bull's head (of sorts). In general, the experience of the representation is not the same as the experience of the object. That the two experiences differ should suffice to convince us that identical activities need not underlie representations. The experience of looking at *Asia* or of reading *Gulliver's Travels* is not much like the first hand experience of the things each prescribes, but nonetheless we do imagine something like (enough like) the prescribed states and events. We must attend to, be aware of, the differences.

Walton further suggests that even if we are aware of the representation, of its style or ornament, we may still be capable of participation - of participating with a second work world comprising the ornament, style or deliberate display of "paint and painterly activity". Is this a possible criticism of my claims? Perhaps we play
some sort of game with van Gogh's brush strokes, or more credibly with the evidence of van Gogh's emotional and expressive efforts? So, we play with one or the other of two work worlds.

That I can only see either the duck or the rabbit is not the same as being able to see only the representation or the representing. This is the confusion Gombrich makes at the outset of *Art and Illusion*. [5] Whichever I am seeing (duck or rabbit) I am also aware that I am looking at a drawing. Even if I only ever see the duck and never the rabbit, so never see that it is an ambiguous depiction, I am also aware and must be aware that I am looking at a drawing. Walton repeats Gombrich's confusion when he says that a certain *Newsweek* portrait cover of then President Nixon "depicts Richard Nixon and it depicts an arrangement of magnetic recording tape and reels, but it does not depict both together." [286] But it is only that we recognize that it is an arrangement of magnetic tape (or of graphite, charcoal, ink lines) that we have a hope of seeing that it also depicts Nixon. This picture is quite unlike the duck-rabbit. So, too, is *Starry Night*. The central examples employed by Walton permit of this kind of multiple world interpretation (the imbedded fictions of *Vanity Fair* and the Italian fabric design incorporating a vase and vines [285, 278-281]). But no comparable multiplicity of worlds exists with *Starry Night*. Just as the real attraction of Picasso's *Bull's Head* is that we recognize it is bicycle parts arranged to represent the head of a bull, the real attraction of the van Gogh is the manner he has interpreted the south of France and displayed his response to the clear warm night. So too, the real attraction of the *Newsweek* cover is that we recognize audio tape and Nixon *at the same time*. The cover is not akin to the duck-rabbit, is not about being a Nixon-picture or a tape-picture, and not both. The cover is about then President Nixon's audio recordings of important conversations which pertain to the burglary at the Watergate hotel.

As to Picasso's sculpture, if it were not formed entirely of bicycle parts, it would not be nearly as interesting or inviting. I caution against thinking that the interest we show in Picasso's bull is not participation or not participation of the appropriate sort. The work world is minimal, the game we are to play is minimal: it does not involve running around and screaming, nor does it involve the robust kinds of activities that Van de Velde's painting allows and invites, such as discover-
ing the minutiae of the painting (or perhaps running and screaming through the streets of a Spanish village). But on Walton's account of representation and make-believe we do psychologically participate in a game which Picasso invites us to play. (Such considerations hold equally for concrete poetry and musique concrète.)

Appreciation

In a brief exchange in 1958, the drama critic Kenneth Tynan charged playwright Eugene Ionesco of being "a self-proclaimed advocate of anti-théâtre: explicitly anti-realist and by implication anti-reality as well." Ionesco responded that his aim was just the opposite - with each play he hoped to offer an account, a "testimony", of life as experienced by the playwright: "...I must ask myself what my fundamental problem is, what my most ineradicable fear is. I am certain then to find the problems and fears of literally everyone." [In Esslin, 102] It is clear without rereading this debate that the plays of Ionesco conform to neither theatrical nor cinematic (photographic) norms of realism. Ionesco's insistence that his theatre is a theatre of realism is not unique. This is a common claim made by those playwrights loosely grouped under the rubric theatre of the absurd.

Ionesco's vision of the theatre is not (certainly was not) standard fare. Yet his argument that he is a realist is compelling, and demonstrates an important aspect of immersion and awareness. Writing in *Nouvelle Revue Française* in 1958, Ionesco described his early discomfort with theatre:

> it was the presence on the stage of flesh-and-blood people that embarrassed me. Their material presence destroyed the fiction. I was confronted, as it were, by two planes of reality - the concrete, material, impoverished, empty, limited reality of these living, everyday human beings, moving about and talking on the stage, and the reality of the imagination, the two face to face and not coinciding, unable to be brought into relation with each other; two antagonistic worlds incapable of being unified, or merging. [In Esslin, 109]

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18 Kenneth Tynan, "Ionesco, man of destiny?" *Observer*, London, 22 June 1958, cited in Esslin 100. This was the first in series of letters and articles from members of the theatre world in France, England, and the USA debating the aesthetic worth of Ionesco's theatre.
This is the distinction between the prop and what we are to imagine. As a consequence of his awareness of the discrepancy between the two worlds Ionesco claims: "I read fiction, essays, I went to the cinema with pleasure, I listened to music from time to time, I visited art galleries, but I hardly ever went to the theatre."[108]

It may have been the passion for the theatre that was soon to emerge in Ionesco that prevented him from reconciling the two realities, the two worlds. But it is not that he was unable to ignore the broad brush strokes of the proscenium and limited stage setting. His solution was not to turn to greater 'realism', to experiences that better hid the artifice of their production. Rather, it was to strengthen this, like the d-tectable borders of a painting that make manifest the surface of the painted surface:

...if the theatre had embarrassed me by enlarging and thereby coarsening nuances, that was merely because it had enlarged them insufficiently. What seemed too crude was not crude enough; what seemed to be not subtle enough was in fact too subtle....What was needed was not to disguise the strings that moved the puppets but to make them even more visible, deliberately apparent, to go right down to the very basis of the grotesque, the realms of caricature, to transcend the pale irony of witty drawing-room comedies...to push everything to paroxysm, to the point where the sources of the tragic lie.[113]

The staging for the plays of Ionesco, Beckett, and Genet are sparse, they are not familiar, they make no attempt to mimic or seamlessly to extend our actual environment. As with trompe-l'oeil, efforts to do so fail. The strategy taken is not to make the representation a seamless extension of our actual or experienced space, as with dioramas, VR, and OMNIMAX.

Most of what I have said in this chapter leaves intact Walton's theory of make-believe and participation. My criticism concerns only the nature of participation, and assumes that Walton is mostly correct in arguing that we do play such games. Full participation is not at the expense of awareness. Rather, the differentiation of kinds of awareness untangles our different physiological and psychological activities before representations. This, in turn, demonstrates how we make use of information which seemingly ought to discourage and distract us from the appropriate participation.
A deep problem with Walton's theory is its failure to account for aesthetic appreciation. It explains how we understand representation, and why we are attracted to them (at least to the extent that we understand the attractions of children's games of make-believe). But by denial of the surface, whether that is the paint and canvas of a painting or the silvered screen of the cinema, or the flesh and blood and enclosed space of the theatre, Walton cannot provide an account of representations such as these as the art they clearly are. Put bluntly, we either immerse ourselves in the fictional world of the novel or attend to the material and historical production of the novel. This latter activity is contained in Walton's notion of appreciation. Appreciation without participation results with some representations which "positively discourage participation, especially the psychological participation that would constitute the experience of being caught up in the story."[274] Such works employ a variety of strategies,

deliberately "distancing" the appreciator from the fictional world....For if one does not imagine a proposition, it is unlikely to be fictional that one knows or believes it; and if one imagines it with minimal vivacity, one is unlikely to have the experience of fictionally being concerned or upset or relieved or frightened or overjoyed by the fact that it is true.[274]

On his view, ornamentation, such as embeddedness, reflexivity, and florid or clever style, is always a hindrance. Walton describes two orders of representation: invisible, straight, natural, or realistic representation in which we are immersed without hindrance, without knowing we are immersed, and self-aware, self-conscious or reflective representation, which discourages immersion and participation. In this context, thinking of Vermeer, Walton quotes Frank Stella writing on sixteenth-century Italian art:

projective reality was the goal of painting and...the job of the artist was to effect successful self-effacement, both of his personality and his craft. This, it seems obvious, is the nature of pictorial illusionism - to make the action surrounded and created by painting seem real, and to make the creator of that action and activity seem remote.[280]19

But of course such self-effacement, reality, and remoteness are all culturally relative or conventional: a sixteenth-century painting, successfully executed, may look exceedingly mannered to us.
We may not know the author of a work, but the style, the visible means of production, the scale, surface, use of medium, all provide the basis of aesthetic judgement. This work is better than that because of the emotional use of thick impasto, because the emotional state of the artist is evident in the paint, in the palette and technique of application. This work is better because the artist anticipates our locomotion, using the dynamics of the mobile perception of curved surfaces.

22 It is easy to see that Stella's sympathies lie with Walton, for he follows this paragraph with the observation that:

Painting has always wanted to be real, and by 1600 it Italy it had the means to do so. It had possession of a convincing illusionism. In the face of this accomplishment, Rubens chose to stress artificiality at the expense of reality. He deliberately called attention to himself and his craft and then set out on a desperate adventure[:]
...to allow his perceptions of art to compete seriously with his perceptions of reality. He believed he could bring to the activity of painting itself an imagination that would rival the depicted reality Italian painting had brought to the experience of art....
CONCLUDING REMARKS

There is a general thesis that binds together my discussions of Walton’s theory of psychological participation, Bach’s advertisement for the well-tempered clavier, Berlin and Kay’s theory of colour term evolution, the contrast between Aristotle’s rainbow and Newton’s. current theories of psychophysiological colour opponency, Medieval interest in the process of purple dyeing, virtual reality, and anthropological field work and research methodology. My thesis has to do with a specific application of the traditional and crude distinction between analytic and holistic approaches to philosophy and the sciences. These approaches should not, as is often thought, be considered exclusive. Rather, each enhances, casts light upon, the other. Conclusions drawn from careful analysis of experimental or ‘clinical’ data are prone to error to the extent that they also exclude analysis of holistic and cultural data. ‘Clinical’ data are derived under special testing circumstances - often employing specially designed testing circumstances. Cultural data are less tidy. They require consideration and interpretation of data within manifold cultural activity - they just fail neatly to control variables.

In addition to this thesis there are also several important themes that run through the work. Whitehead’s fallacy of misplaced concreteness is one, and obviously relates to the central thesis. Indeed, my thesis just is an application of Whitehead’s call for vigilance. I have sought out areas of inquiry pertaining to visual perception that run afoul of this fallacy, and attempted to expose and to amend theories that incorporate it. Another theme is the rôle and extent of context in matters of visual perception, particularly as this affects perception and language and perception and representations. A third theme concerns the various kinds of awareness that we employ in negotiating our world, kinds that vary from awareness of whole arrays and fields of colours to awareness of surfaces and boundaries, but that all share in being context-dependent. Finally, a fourth theme is the degree and kinds of sensory or perceptual experience that underpin my discussions of experiences that extend from retinal stimulation to aesthetic experiences of immersion.
The thesis

An analytic approach to perception or colour perception often does reveal interesting data. We can learn that though we have three types of colour receptors, the outputs from these three are handled by higher cell systems in such a way as to differentiate four distinct colours, which do not equate with the peak sensitivities of the three cone types. By carefully constructing experimental situations we can differentiate discrete tasks that are otherwise obscured or hidden to brute observation. We can construct test situations that either reveal unnoticed activities or events or produce previously unmade activities. Projecting an image onto the partially dissected eye of an ox, pointing to individual chips among an array of colour chips, or photographically tracing the eye movements involved in scanning a picture for specific information reveal previously unnoticed activities. Self-adjusting a monochromator, observing light dispersed and recombined with prisms and lenses, or sitting in a mock cockpit observing computer generated images produce previously unmade activities. Each of these situations generates new and interesting data. What are we, then, to make of these data?

Data must be interpreted. It is not enough merely to design experimental situations. To observe the world is to interpret it. Changing the world changes, tests, or strengthens our interpretations. We must remember two facts. First, we change the world only one small part at a time. These changes (experiments and results) must be considered within the context of, in relation to, the rest of the world. Second, experiments designed to test specific activities, designed to produce specific activities, must be interpreted within the broad context of our activities. Like electron microscopes and telescopes, high-speed cameras, cloud chambers, and spectrophotometers, 'clinical' experiments extend our perception of the world. By all these means we redefine the boundaries of our perception, and the level of phenomenal stability of the world. Changing the way we perceive the world changes the world we perceive. X-ray laser microscopes (it is expected) will give us mediated visual access to a level of molecular instability which we do not normally and which we have not previously experienced. We believe the solidity of objects to be energetic, but we do not naturally experience them thus.
What does the special response reveal about our general responses? What does the experimental identification of unique hues reveal about our categorization of colour within the context of our general usage of colour? Forgetting that we observe special phenomena, we are tempted to draw general conclusions directly from these phenomena without the mediation of our broad social and physical phenomena (context). We so forget at the risk of committing Whitehead's fallacy. Careful construction of experimental situations results in useful observable data. Observation of that useful data is no different from observation of more readily available data in the world at large. Abstraction from both kinds of data is akin. Whitehead's caution is that we be 'vigilant' in forming our abstractions, of theorizing, so as not to forget 'the remainder of things'.

The analytic approach to philosophy and the sciences is exemplified by this close scrutiny of minute phenomena, whether it has been deliberately generated or not. Such scrutiny is often, necessarily, detached from consideration of broader contexts, of additional phenomena. Such specialization is requisite for the timely generation of results and theories. The holistic approach, generalization, is requisite for another kind of interpretation of the phenomena. We do want to know which neurons are firing at what time and in what manner, and to what other neurons they send signals. We also want to know how cultural differences develop, how these differences relate to physiological limits and social and physical needs. Theories about the first may be formed in a laboratory, theories about the second must also be formed in a concert hall, or in a museum, a library, a ball park, a dug-out canoe. The two domains of theory formation draw on different though overlapping sets of data, and are essential to each other. Sacks and Wasserman were successful in their diagnosis of the colour blind painter because they kept one eye on the cultural domain and the other on the clinical domain.

I am interested in the latter, cultural domain. I am also interested in the errors produced in this domain by confusing the distinction between the two domains, by the assumption that theoretical claims can be made about cultural activities and cross-cultural differences in these activities by drawing primarily or exclusively on the former domain. As stated in the introduction, my broad thesis, of which this work is a testing, is this: a substantive, comparative study of the his-
torical record demonstrates the inconsistencies of theoretical assumptions based, primarily, on the analytic approach. To be substantive is to look at actual cases (the historical record) of paintings and electronic representations, of anthropological field work on languages, of historical reconstructions of colour terms in Greece, Rome, and Medieval Europe, of current work on psychophysiology. To be comparative is to consider whether or in what way inconsistencies and puzzles within each domain of inquiry (each historical record) may dissolve or be better explained by comparing them with other domains. Theories formed by close analysis of one or few domains of inquiry may be inconsistent with other evidence, with other (closely analytic) theories. I address two theses, based on theoretical assumptions, that are linked not directly to each other but by the evidence I rally in support of my thesis: some of the same evidence applies to both theses.

It is the nature of this sort of thesis that the more cases considered the stronger the evidence in support of the thesis. Berlin and Kay formulate a closely analytic theory. The opponent-process theory seems to support their theory. On fuller consideration it does not. Their theory is about broad cultural activities. The opponent-process theory is not. A more robust consideration of visual perception locates colour opponency within more appropriately cultural activities. In so doing, the seeming support for the broad cultural theses of Berlin and Kay dissipates. So, too, does this support when colour language is considered spatially and temporally. The more cases that are examined the more evidence there is contrary to their theses.

Gombrich and Walton get into trouble over the relation between perception of the surface media and the illusionistic representation. Both confuse illusion with ambiguity. They treat the relation between the surface and the image as the same as between two 'readings' of a visually ambiguous image. Gombrich is correct in his account of ambiguity, that "it can never be seen as such. We notice it only by learning to switch from one reading to another and by realizing that both interpretations fit the image equally well."[249] Two examples Gombrich uses are the Necker cube and the duck-rabbit image. Walton's account of the Nixon picture is equivalent. Such images are ambiguous. The visual experience of them is not the same as, not even analogous to, the experience of surface and image. Immersion in the one, at the expense of the other, is not requisite for the experience. Critics often
talk of the means of the telling or presenting of a representation in assessing the success of the representation, the work world.

In *Patterns of Discovery*, N.R. Hanson asks: *Do Kepler and Tycho see the same thing in the east at dawn?* The question is prompted by one seeing the sun move, the other the earth move. I agree when he answers no. Both have the same retinal experience, but this is not seeing. Seeing is the complex process of interpreting that rapidly changing retinal image. Seeing, as the psychophysiological evidence demonstrates, involves the interpretation and reinterpretation of the original stimulus and additional stimuli in a process that extends from the eye to various areas of the brain. As Hanson argues, while descriptions of the retinal image would be comparable, what is seen depends in part on what is known. To see the arrangement of magnetic tape as Nixon is to know something about what Nixon looks like, what caricatures look like, and what caricatures of Nixon look like. Without this prior knowledge we will not identify the arrangement as (a caricature of) Nixon. To have concepts that differentiate spectral colours from surface colours and patterns is requisite to seeing basic colour terms. In this sense, the psychophysiological tests of unique hue identification are recordings of retinal experiences.

While Kepler and Tycho have the same retinal image, and so at this level 'see' the same thing, Hanson continues, the real contrast is that they observe differences. Their awareness is of different events. They may be fully conscious of this, as when discussing the nature of the celestial orbits or not, as when observing a stick traversing two media at an angle. Though we know the stick is not bent we do not see it as straight. We do, however, on the most casual reflection, realise that we are observing both a stick and an illusion. Consideration of the theory-laden nature of perception and of the cultural contexts that inform the theoretical side of perception demonstrates that perception of colour and of representations is determined in large part culturally. I argue for a gentle cultural relativism that accounts for this integration of higher cognitive functions with basic vision. This approach accounts for, and in turn is supported by, the evidential record of a variety of cultures with regard to the two domains closely considered here: colour perception and pictorial representation.
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231


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