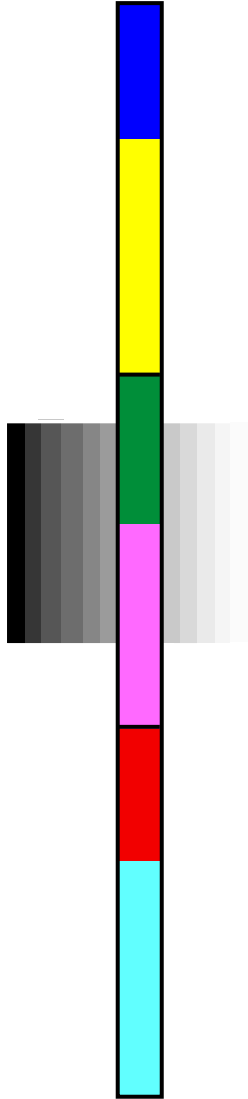


Roles of Complementary Colours in Colour Perception

Ralph William Pridmore



PhD Thesis
Macquarie Centre for Cognitive Science
Macquarie University
Australia
2008

TABLE OF CONTENTS

TABLE OF CONTENTS	1
DECLARATION BY CANDIDATE	4
ACKNOWLEDGEMENTS	4
SUMMARY	5
INTRODUCTION	6
Definitions of Complementary Colours	6
Early Research of Complementary Colours.....	7
Modern Research of Complementary Colours	10
Current Worldview of the Role of Complementary Colours in Vision	14
Indications of Other Roles for Complementary Colours	14
Aims of the Thesis	19
Introduction to the Research Papers.....	20
Appendix: Definitions	22
References	25
 PAPER 1. COLOUR CONSTANCY FROM INVARIANT WAVELENGTH RATIOS:	
I. THE EMPIRICAL SPECTRAL MECHANISM	238 (34)
Abstract And Introduction	238 (34)
Corresponding Colours: Data And Analysis	238 (34)
Complementary Wavelength Pairs	243 (39)
Discussion	244 (40)
Conclusions	247 (43)
Appendix A: Definitions	247 (43)
Appendix B: Physiology Of Complementary Colours	247 (43)
References	248 (44)

PAPER 2. RELATIVE WAVELENGTH SCALE FOR THE COMPLETE HUE	
CYCLE: DERIVATION FROM COMPLEMENTARY WAVELENGTHS	46
Abstract And Introduction.....	46
Hue Cycle Interval	50
Complementary Interval Ratios And Wavelength Scales	59
Corroboration of Metric.....	63
Conclusions	67
Appendix A: Complementary Wavelength Distribution	67
Appendix B: Other Illuminants And Visual Fields	69
References	71
PAPER 3. COLOUR CONSTANCY FROM INVARIANT WAVELENGTH RATIOS:	
II. THE NONSPECTRAL AND GLOBAL MECHANISMS	73
Abstract	73
Introduction	74
Wavelengths Of Constant Hue: Formulation	78
Linking Nonspectral Equivalent Wavelengths To CIE Colorimetry.....	87
Discussion And Conclusions	91
Appendix A: Harmonics In Brief	94
Appendix B: Basic Relations In The Colour-Constant Hue Cycle	94
References	96
PAPER 4. CHROMATIC INDUCTION: OPPONENT COLOUR OR	
COMPLEMENTARY COLOUR PROCESS?	77 (98)
Abstract	77 (98)
Definitions and Discussion	78 (99)
References	81 (102)

PAPER 5. COMPLEMENTARY COLOURS: THE STRUCTURE OF WAVELENGTH DISCRIMINATION, UNIFORM HUE, SPECTRAL SENSITIVITY, SATURATION, CHROMATIC ADAPTATION AND INDUCTION	103
Abstract	103
Introduction	104
Structures And Scales	107
Spectral Sensitivity And Chromatic Adaptation.....	116
Chromatic Induction	121
Wavelength Discrimination	124
Uniform Hue	128
Saturation Discrimination	135
Discussion	137
Appendix: Equivalent Wavelength For Nonspectrals	141
References	143
CONCLUSION	147
General Discussion and Conclusion	155
References	160

DECLARATION BY CANDIDATE

I state that this thesis has not been submitted for a higher degree to any other university or institution.

Ralph W. Pridmore

1 May 2008

ACKNOWLEDGEMENTS

I take this opportunity to thank David MacAdam (Optical Society of America), William Thornton (Westinghouse research laboratories, USA.), and Jozef Cohen (University of Illinois, USA) for encouraging my early study of complementary colors, with patience and technical and moral support. Without their encouragement, this thesis would never have taken root and flowered. I thank Gershon Buchsbaum (University of Pennsylvania, USA) for first recognising (and telling me!) that some of my graphs of complementary colours data represented more than general chromatic adaptation but a mechanism of color constancy. I also thank my thesis supervisors, Max Coltheart and Anina Rich, for their encouragement and valuable advice.

SUMMARY

Complementary colours have been studied in science for over 300 years but little is known of their role in colour vision. Complementary colours are defined as a pair of colour stimuli which, with appropriate complementary wavelengths and ratios of radiant powers, admix a selected white (e.g. that of the illuminant). The thesis aim is to find and describe roles of complementary colours in colour perception. Only one role is generally accepted in the scientific literature: a colorimetric role in colour mixture and matching. A second role, in chromatic induction, was widely accepted until (erroneously) usurped 50 years ago by the opponent colours theory of chromatic induction. This thesis stemmed from signs that the visual system structures various visual functions from complementary colours.

Complementarism is shown to structure ten functions. For six of the functions, math models are formulated from complementary colours. The first three, closely related, papers describe three roles in colour constancy (see Appendix: Definitions), hue cycle structure, and hue cycle relative wavelength metric. Paper 1 describes complementary wavelengths' central role in a spectral mechanism of colour constancy, where constant hue and its complementary constant hue form parallel straight lines. Paper 2 establishes the roles of complementary colours in forming hue cycle structure and its wavelength-based metric. Dominant wavelength is extended into the nonspectrals/purples to form a *relative wavelength* scale over the whole cycle. Paper 3 utilises this scale to extend Paper 1's spectral mechanism of colour constancy into the nonspectrals to complete the global mechanism. Paper 4 argues that chromatic induction is governed by complementary colours rather than opponent colours. Paper 5 formulates math models for six roles, in chromatic induction, wavelength discrimination, uniform hue, spectral sensitivity, saturation, and chromatic adaptation, from the ratio of *either* complementary wavelength intervals *or* of complementary powers; a seventh role, in three-dimensional color discrimination, is described. The total eleven varied roles (including the known colorimetric role) have a wide influence over the visual process from cones to cortex. These discrete roles indicates an overall role of complementary colours is structural, in shaping functions to a trimodal framework (RGB peaks and complementary CMY troughs), whose implicit purpose is to adapt functions to the illuminant. Thus, it is concluded the general role is colour constancy.