The art of colour harmony: the enigmatic concept of complementary colours

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ABSTRACT

This paper explores the theory and practice of colour harmony based on the equilibrium of complementary colours. For centuries artists relied for their colour choices on studio experience and artistic knowledge handed down from master to apprentice while "scientific" colour theory remained mostly the preoccupation of scholars and philosophers. Many of the latter kind of theory were based on a comparison of visual harmony with theories of musical harmony, astronomy and mathematics (Kemp 1990; Gage 1993, 1999). This paper presents some reflections on those theories and argues that they have led the research of the aesthetics of colour astray for centuries.

1. INTRODUCTION

Complementary colour is a concept that is often referred to in textbooks on colour and in discussions on colour harmony. Complementariness in colours is sometimes described as oppositeness, although strictly speaking complementariness and oppositeness are two different concepts. Since ancient times artists and designers have either intuitively or consciously exploited the phenomenon of oppositeness in colours to achieve highly different visual effects. Some have aimed at maximum visual tension, others at harmony through equilibrium. Colour educators have tended to seek universal laws and principles or empirical evidence that would explain "scientifically" the phenomena and effects of colour experience. The principle of harmony through balance of opposites or of complementaries is an integral part of numerous colour harmony theories (Munsell 1905; Ostwald 1917; Itten 1961). What is meant by opposites or complementaries varies from one theory to the other and thus necessarily affects the interpretation of harmony in those theories.

The concept of harmony – and hence of colour harmony – is historically entwined in mathematics and theory of music and is not free of these associations even today (Arnkil 2013). The notion prevails that colours are separate entities belonging to an *a priori* system, and that they have fixed physical identities and locations in a system rather like the 12 tones of the diatonic scale in Western musical harmony. But what could harmony through equilibrium mean? Colour has no measurable weight, area or mass, which is perhaps why in art colour harmony has been understood as balance of metaphorical visual forces. (Kandinsky, Klee, Munsell). A scientific view of equilibrium presupposes a precise identification and quantification of energy, power, mass, etc. In the case of colour these forces have sometimes been identified as complementary wavelength distributions or opponent neurobiological processes. (Pridmore 2009). The latter type of investigation can contribute to the development of more sophisticated mathematical models of human colour vision, but is unlikely to deepen our understanding of the aesthetic function of colours in art and design. As artists through the centuries have shown, it is possible to identify balancing, opposite or antagonistic relationships in certain types of colour combination without attempting to pin down a precise calculable definition of those relationships. Such relationships need not lead to a “harmonious” visual outcome, but offer instead multiple expressive possibilities. The outcome depends always on several visual factors and variables of colour that cannot be left of the equation.

2. A SCIENTIFIC FOUNDATION FOR THE ART OF COLOUR?

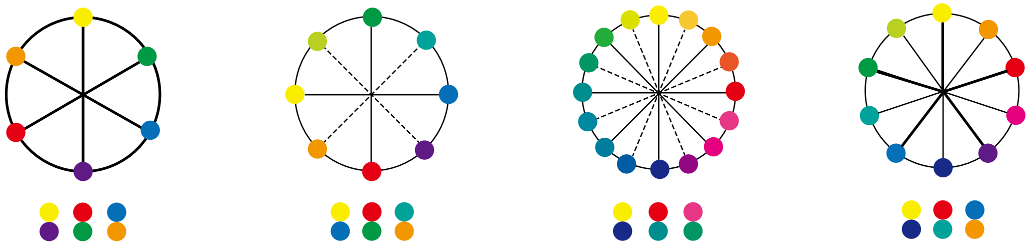

Figure 1. Schematic illustration of some colour wheels and their complementary hues. From left to right: Delacroix/Chevreul/Blanc; Hering; Ostwald; Munsell.

Almost every colour primer that says something about complementary colours makes reference to a colour wheel, stating that colours found diametrically opposite on the wheel are complementary to each other. (Itten 1973: 34, 78; Hope & Walch 1990: 89; Holtzschue 2002: 52–53; Hornung 2005: 15; Stone 2006: 236). Some textbooks insist that these relationships are extremely precise, because of their scientific foundation (Itten 1973: 34). Others, while forwarding a colour wheel -based harmony theory, admit that this principle is made rather uncertain by the fact that the colour relationship depends entirely on how the wheel is constructed. (Feisner 2006: 50). The origin of the various colour wheels, their differences, and their potential problems for predicting colour harmony are thoroughly discussed in Westland et al 2007. The wheel or circle as a symmetrical symbol of perfection suggests in itself completeness and harmony. This symbolism was idealized by the early Romantic painter Philipp Otto Runge in his spherical representation of the harmony of colours. 150 years later Johannes Itten modelled his own colour sphere and colour star on Runge’s sphere and made them an iconic image of colour harmony in his book *Kunst der Farbe/The Art of Colour* (Itten 1973), The book was originally published in 1961, but is still immensely influential in colour pedagogy.

The two most famous colour systems that have made claims about both scientific colour ordering and colour harmony are the now forgotten Ostwald system and the still thriving Munsell system. Wilhelm Ostwald based his uniform hue difference scale on complementary wavelength pairs (Pridmore: 234), thus placing the concept of complementaries at the centre of his theory of colour harmony. Although Munsell also put great emphasis on “balance” in visual aesthetics, he abandoned in his hue circle his initial “compensatory” colour pairs in favour of perceptual uniformity. (Kuehni & Schwarz 2008: 115). The fitting together in one and the same colour space of perceptual uniformity of colour difference and symmetrically opposed complementary hues remains and unresolved challenge for colour science.

2.1. Opponent colours and opponent processes

In 1872 the German psychologist Ewald Hering (1834–1918) presented his theory of colour opponency which stated that a colour cannot appear both red and green at the same time and that there can be neither bluish yellows nor yellowish blues. It was first thought that Hering's opponent colour theory was irreconcilable with the Young–Helmholtz theory of trichromacy, but gradually it was realized (and proven also empirically) that they describe two different levels of the colour vision process. (Kuehni & Schwarz 2008: 100). Could Hering's opponent colours be called complementary and if so, does their complementariness have a neurological basis? Hering hypothesized that the neural opponency of red with green and yellow with blue was based on antagonistic physiological processes (Valberg 2005: 279). At first there seemed to be no evidence to support this hypothesis but the discovery of opponent-process colour-coded cells in the 1950s and 60s, first in the retinas of fish, then in primates and later in the human visual cortex seemed to finally prove the neurobiological basis of complementariness in these colours. It is worth remembering, though, that an important role of that process is not to only to provide us with good discrimination of reds from greens and blues from yellows, but to pack the signals from the three cone receptor channels into a more economical form through a process of signal subtraction. Hence we are much more attuned to colour *differences per se* than to *absolute* colours in any sense of the word.

Building on Helmhotz's and Hering's legacy, the CIE has produced ever more precise colour difference models. Do these improved scientific models contain the answer to complementary colours and colour harmony? Professor Anders Hård showed in 1985 in his article *Är komplementärfärger mer olika än andra färgpar?* (Are complementary colours more dissimilar than other colour pairs?) how ambiguous the concept of complementarity is even within a scientific frame of reference. He also concludes that artists "grasped the new scientific theories of subtractive complementaries, complementary stimuli and simultaneous and successive contrasts, as acceptable explanations, proof or definitions of phenomena *that they had since long ago known and worked with*." (Hård 1985, my italics). In a more recent article by Anders Hård and Lars Sivik the authors say:

> In color literature and encyclopedias, the concept "complementary colors" is defined in several different ways … As far as we understand, it is not possible to decide whether simultaneously perceived Color Elements are complementary according to any of these definitions unless one has acquired, through specific experimental learning, the knowledge of the particular definition in question. (Hård & Sivik 2001).

Hård and Sivik also point out that in their experiment carried out with 35 architecture students of architecture, showed no evidence that complementary colour combinations are experienced as more harmonious than other combinations: "The colors that were hue (Φ), chromaticness (c), and redness (r) identical, on the other hand, were judged as more harmonious than all the others, while the constellation where all the colors were completely different was judged as least harmonious." Neither were the complementary colour pairs perceived as more different than other combinations. The experience of difference depended rather on NCS lightness difference. (Hård & Sivik 2001: 26). The findings of Li-Chen Ou and Ronnier Luo corroborate these findings: in their 2003 study, equal hue and moderate lightness difference were among the most important contributing factors in harmony and there were no results for complementary colours. (Ou & Luo 2003).

2.2. Other dimensions of complementary colours

Complementariness is closely related to simultaneous contrast otherwise known as colour induction. (Pridmore 2009). Colour induction is in some degree present in nearly all colour juxtapositions, but it is most dramatic in colour combinations where a colour field of high chromaticness induces an opposite hue in an adjacent, more neutral colour field. This perceptually induced opposite hue is said to be the complementary of its adjacent hue stimulus. Another related phenomenon is that of *vibrating boundaries*, sometimes also called "simultaneous contrast" or "simultaneity" in art parlance. There are several explanations for this phenomenon (see e.g. Livingstone 2002), but it is most often attributed to complementary colours enhancing each other when juxtaposed in the form of hard-edged areas. So-called 'simultaneity' in the form of juxtaposed areas of saturated complementary-type colours in highly rhythmic designs were typical of the works the Robert and Sonia Delaunay. It is debatable whether they can be called 'harmonious' or that either artist even aimed at harmony. The effect is rather of vibrancy and a sense of rhythmic movement. Indeed, the proclaimed aim of Robert Delaunay was the creation of movement and a novel evocation of time and space through colour. (Gage 2006: 36–37) In the Pop- and Op-Art of the 1960s complementary-type contrasts in equiluminant combinations often created a restless, vibrating or kinetic effect whose very aim was the opposite of harmony. Such effects were widely used in advertising and especially in the graphic images of the 1960s pop culture and psychedelia.

Although complementary and antagonistic colours do not automatically create harmony in a colour composition, they may occupy an otherwise special place among colour combinations. Michel Eugène Chevreul (1786–1889) stated that colours appeared to their best advantage when juxtaposed as pairs of complementaries. In Chevreul's colour circle, the three primary colours red, yellow and blue are placed at angles 60° in relation to each other, yielding the complementary pairs: red/green, yellow/violet, blue/orange, etc. Summarizing his findings on various types of colour juxtapositions, he concludes: "*This* [juxtaposition of complementaries] *is the only association where the colours mutually improve, strengthen and purify each other without going out of their respective scales."*(Chevreul 1987: 134). But he goes on to say: "This case is so advantageous to the associated colours, that the association is also satisfactory when the colours are not absolutely complementary. So it is also when they are tarnished with grey." (Ibid.).

3. DISCUSSION

Chromatic contrast not only provides us information about lighting, space and material qualities, but also affords us pure enjoyment and aesthetic pleasure, but sometimes also displeasure. Artists or designers can learn to control these factors only by experience, by tirelessly testing various options and by training their sensitivity to the multiple layers of visual experience at play in any art or design task. Josef Albers has demonstrated how creating with colours has very little to do with rigid rules and much with alertness, flexibility and tactical skill, with "thinking in situations". (Albers 2013: 42, 68). He referred to theories of complementary colours, but never asserted that they were a guarantee of harmony. In fact, harmony was for Albers no more desirable than disharmony. Just as music consists of consonances and dissonances, so must visual art. (Albers 2013: 39–43). In contrast to his former teacher and colleague Johannes Itten, Albers had a deep distrust of formal rules of colour harmony – mainly because of they did not address the relational and situational nature of colour design. (See Albers 2013: 42). There have been attempts even in Albers's time to quantify variables such as surface area, complexity and colour intervals in mathematical representations of colour harmony (Moon & Spencer 1944). However, most of the models are able to include a very limited number of hues or other variables in the algorithm. Even the most sophisticated computational colour harmony models to date leave out crucial factors affecting the experience of harmony. These include the spatial array, cultural context, figuration, symbolism, texture, materiality and evocation of light and atmosphere. Computational rules of colour harmony so far appear to be self-predicting. There is no guarantee of their success outside their own form of presentation and mode of appearance, as even the creators of such models admit. (See: Ou & Luo 2003, Conclusions). A continuation of computational harmony studies with more naturalistic stimuli could be extremely challenging, but perhaps worth trying.

4. CONCLUSIONS

The concept of complementariness in colours has no single established definition. The "harmony" or "disharmony" of colours, whether based on complementariness or other relationships, is not scientifically quantifiable, but a qualitative aspect that requires artistic knowledge, sensibility and attention to several simultaneous layers of experience. The experience of visual balance is not dependent on any precise and quantifiable chromatic relation. The experience of visual harmony depends on multiple factors that can only be addressed through the sensibility, skill and experience of the designer or artist. Rules of harmony that are based on fixed, abstract formulae do not sufficiently take into account the multiple variables involved in real-life applications of colour and do not sufficiently address the needs of contemporary art and design. Complementary, opposite or antagonistic colours can, when used with skill, afford visual balance to the chromatic composition of images, objects or spaces, but they can also result in visual tension, restlessness, even discomfort. The latter effects can be and often are the very goal in today's designs or artworks. Present-day colour harmony research has received little or no attention from artists, designers and architects. The reason may be that "harmony" is too limited a concept for the needs of visual communication, expression and good design in contemporary life. Many of the confusions and misunderstandings concerning the role of colour in art, design and architecture arise from a lack of clearly articulated artistic knowledge about colour. It has sometimes resulted in artists taking recourse to science that they do not understand and scientists applying to art methods and rules which are blind to the multifaceted nature of art. The discussion between science and art in colour research can be useful only when the strengths and limitations of each approach are clearly identified.

References

Arnkil, H. 2013. Colour Harmony: from Dualism to Living Perception. Proceedings of the AIC 2013: 12th International AIC Congress, Newcastle, UK. Lindsay MacDonald, Stephen Westland, Sophie Wuerger (eds.). The Colour Group (Great Britain).

Albers, Josef 2013. *Interaction of Color*. 50th Anniversary Edition. Yale University Press.

Chevreul. M. E. 1987. *The Principles of Harmony and Contrast of Colors and their Application to the Arts*. Schiffer Publishing Ltd.

Feisner, E.A. 2006. *Color: How to Use Color in Art and Design*. Laurence King Publishing Ltd.

Gage, J. 1999. *Colour and Meaning: Art, Science and Symbolism*. Thames and Hudson.

Gage, J. 2006. *Colour in Art*. Thames and Hudson.

Holtzschue, L. 2002. *Understanding Color: an Introduction for Designers*. John Wiley & Sons.

Hope, A. and Walch, M. 1990. *The Colour Compendium*. Van Nostrand Reinhold.

Hornung 2005. *Colour: a workshop for artists and designers*. Laurence King Publishing Ltd.

Hård, A. 1985. *Är komplementärfärger mer olika än andra färgpar?* Färgrapport F31. Chalmers Tekniska Högskola/Skandinaviska färginstitutet AB.

Hård, A. and Sivik, L. 2001. *A Theory of Colors in Combination—A Descriptive Model Related to the NCS Color-Order System*. Color Research and Application Volume 26, Number 1.

IItten, J. 1973. T*he Art of Color: The Subjective Experience and Objective Rationale of Color*. Van Nostrand Reihold.

Kemp, M. 1990. *The Science of Art – Optical themes in western art from Brunelleschi to Seurat*. Yale University Press.

Livingstone, M. 2002. *Vision and Art: the biology of seeing*. Harry N. Abrams, Inc.

Kuehni, R.G. and Schwarz, A. 2008. *Color Ordered: A Survey of Color Order Systems from Antiquity to the Present*. Oxford University Press.

Moon, P. and D.E. Spencer (1944) *Aesthetic Measure Applied to Color* Harmony. Journal of the Optical Society of America, Vol. 34, Issue 4, pp. 234-242.

Ou L; Luo M.R. 2003 *A Study of Colour Harmony for Two-Colour Combinations*. Proceedings: 6th Asian Design International Conference, Tsukuba 6th Asian Design International Conference, Tsukuba.

Pridmore, R.W. 2009. *Complementary Colors: The Structure of Wavelength Discrimination, Uniform Hue, Spectral Sensitivity, Saturation, Chromatic Adaptation, and Chromatic Induction*. Color Research and Application, Volume 34, Number 3, June 2009. Wiley Periodicals Inc.

Stone, T.L. 2006. *Color Design Workbook - A Real-World Guide to Using Color in Graphic Design*. Rockport Publishers.

The Concise Oxford Dictionary of Current English. Seventh Edition 1982. Oxford University Press.

Valberg, A. 2005. *Light Vision Color*. John Wiley & Sons Ltd

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