

The emergence of color categories: Variance and invariance

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Abstract

Color is a crucial feature for object detection and recognition. This is why the human visual system constantly attempts to keep variations in perceived object colors to a minimum. It seems, however, that color categorization is more dynamic and flexible. In the present paper, by reviewing recent research, we discuss the emergence and establishment of color categories in language as a result of various intertwined factors playing together at different levels. We claim for an integrative approach that supersedes the rigid dichotomy between universalistic and relativistic perspectives, according to which color categorization is influenced by universal cognitive trends, specific socio-cultural factors, and diverse language uses, such as idioms, which trigger different values in context.

Keywords: color spectrum; categorization; basic color terms; culture; language use

Introduction: Color perception and color categorization

The world we live in is colorful. Color is an extremely important feature that has been demonstrated to facilitate object detection and recognition (among others, Gegenfurtner & Rieger, 2000; Martinovic, Gruber, & Müller, 2014), and improve the memorization of natural scenes (Spence, Wong, Rusan, & Rastegar, 2006).

However, a fundamental question, often posed and discussed by philosophers, psychologists, linguists, anthropologists, and artists, is still being asked: *To what extent can color be considered as a feature of the external world? Or instead, is it to be regarded as a simple construction of the mind?*

In Newton's seminal work (1704) on color perception, *Optics*, it was observed that, strictly speaking, light radiation has no color: it has only the capability and predisposition to induce specific chromatic sensations. In other words, color cannot be considered as a physical property of the world, like, for example, gravity.

Partially divergent explanations of color vision, highlighting either the mind role or the influence of the physical, outside world, are presented in the literature according to different disciplinary perspectives. Following Zeki's approach (1999), we consider color as a property of the brain, though dependent upon physical light radiation. Importantly, even though light conditions change during the day and throughout different periods of the year, the color perception of objects does not vary, but appears

stable in time (Brainard, 2004; Kandel, Schwartz, & Jessel, 2000). This phenomenon, known as *chromatic constancy* (for a literature review and presentation of recent findings, please refer to Kingdom, Angelucci, & Clifford, 2014; Werner, 2014), is obtained by a number of neural processes, mainly based on the examination of 'scenes' related to specific contexts (a common notion in cognitive linguistics, cf. Bazzanella, 2014; Ungerer & Schmid, 1996). Chromatic constancy is an essential mechanism of vision, since it allows us to rely on color appearances for object recognition, independently of varying light conditions.

Even though the human visual system makes systematic attempts to keep variations in perceived object colors to a minimum, color categorization and especially lexicalization appear to be dynamic rather than stable in time and space. In other words, color categories are not fixed entities, merely mirroring physical discrimination, present in the outside world. On the contrary, they emerge from the active interaction between humans and the external environment, that is, from their *embodiment* (Bazzanella, 2014; Gibbs 2005, Puglisi, Baronchelli, & Loreto, 2008), and appear to be modified by geographical and cultural specificities (among others, Wierzbicka, 2008).

Color categorization and chromatic lexicon are traditionally part of the persistent debate on universalism vs. relativism (Bazzanella, 2014; Taylor, 2003).

From the universalistic perspective, Berlin & Kay (1969) first presented the hypothesis of a common trend of color categorization, proposing their implicational hierarchy composed of eleven basic color terms: white, black < red < green, yellow < blue < brown < pink, grey, orange, and purple. In the following years, their initial assumption was supported by further experimental observation and partly revised (Kay, Berlin, Maffi, & Merrifield, 1997; Kay & Maffi, 1999, 2005; Cook, Kay, & Regier, 2005; Kay & Regier, 2006; Kay, *in press*). However, the original idea of the presence of a universal pattern regulating the emergence of color categories has mainly been preserved.

From the relativistic viewpoint, several scholars have pointed out the pivotal influence produced by social, cultural, and linguistic factors on the categorization process (among others, Casson, 1997; Cook et al. 2005; McNeill, 1972; Wierzbicka, 2008). As Sapir (1949, 27) claims: "Distinctions which seem inevitable to us may be utterly ignored in languages which reflect an entirely

different type of culture, while these in turn insist on distinctions which are all but unintelligible to us”.

Interestingly, recent research suggests an approach that combines universal trends and cultural-specific factors (Cruz & Plebe, 2013; Regier & Kay, 2009). In accordance with previous studies (Bazzanella, Salvati, Ronga, 2012; Ronga, 2009; Ronga, Bazzanella, Strudsholm, Salvati, 2014), here we adopt an integrative framework, which, in considering both common trends and cultural specificity (§ *The emergence of color categories, focal colors, and interlinguistic variability*), refers also to socio-cultural-historical parameters and the use of a given color term (§ *Socio-cultural aspects in the history of the BLUE category in Europe and the use of azzurro in Italian*). Both of these aspects are relevant to the discussion on color categories and their dynamic processes (§ *Color and typical exemplars: Universalism and relativism*).

The emergence of color categories, focal colors, and interlinguistic variability

Categorizing is a complex and flexible process that is grounded in the brain as an essential property of human cognition. It is dependent on context and culture (among others, Barsalou, 2008; Bazzanella, 2014; Cohen & Lefebvre, 2005; Smith, 2005), and characterized by emergence, that is, dynamic interaction between various components, as well as between organisms and their environment (Clark, 1997).

The categorization of color and its lexicalization in world languages is faced with the contrast between continuity of the spectrum and linguistic segmentation, and alternates between universalistic and relativistic perspectives. From a perceptual point of view, Berlin & Kay (1969) showed that, even though category borders may be fuzzy and not invariably defined in different languages, the centers of color categories (i.e., *focal colors*) are not subject to interlinguistic variability. This evidence has been repeatedly validated by subsequent studies (Taylor, 2003).

On the contrary, from a linguistic point of view, color lexica show both diachronical and diatopical variability.

Considering European languages, categorizing criteria drastically changed in Ancient Greek and Latin, on the one hand, and Romance languages, on the other (among others, Capell, 1966; Lyons, 2003). Latin and Ancient Greek mainly distinguished between high and low luminosity (Garcea, 2003; Bradley, 2009), whereas Romance languages have focused more accurately on hue discrimination (Grossmann, 1988; Pastoureau, 2002).

Profound modifications of the color categorization system may be observed even in relatively recent times, as demonstrated by the case of Japanese, presented by McNeill (1972). Nowadays, mainly because of the influence of Anglophone culture and the adoption of synthetic dyes, Japanese has a standard 11-category system of colors (Berlin & Kay, 1969). However, McNeill showed that during the nineteenth century, the present

categorization system progressively replaced a more traditional system, derived from the natural pigments used to dye fabrics and based only on three-color categorizations (namely *akane* corresponding to a hue between orange and red, *hanada* a turquoise blue, and *kariyasu* yellow).

From a diatopical perspective, the number of categories of basic colors varies in different languages. For example, Dani (a people of Western New Guinea) have only two basic color categories. On the contrary, most European languages have at least eleven color categories (corresponding to the number of focal colors listed by Berlin & Kay, 1969). However, publications related to the *World Color Survey* (among others, Kay & Maffi, 2005) have pointed out that over half the languages in the world express only one color term for the GREEN and BLUE categories (the so-called GRUE languages; see also Walter, 2011), thus possessing ten out of the eleven color categories.

The categorization of the BLUE spectrum: An exception to Berlin & Kay's pattern

It is interesting to note that some European languages can be considered an exception to the Berlin & Kay pattern of categorization, since they have more than eleven color categories, even if Berlin & Kay's following criteria are used to evaluate the basicness of a color term:

- (i) Monolexic.
- (ii) Its signification must not be included in that of any other colour term.
- (iii) Its application must not be restricted to a narrow class of objects (eg., *blonde*).
- (iv) It must be psychologically salient for informants.
- (v) The doubtful cases should have the same distributional potential as the previously established basic terms (cf. Berlin & Kay, 1999 [1969]: 6-7).

For example, previous linguistic research suggested that Czech may have two basic color terms describing the RED spectrum: *cervená* and *rudá* (Nagel, 2000, in Uusküla, 2008). However, Uusküla (2008) did not confirm this hypothesis, suggesting that *rudá* cannot be considered as a basic color term.

With regard to the BLUE spectrum, the English BLUE category is often split into two or three color words, competing for the status of basic color terms: Italian, Catalan, Arabic, Turkish, Modern Greek, Maltese, Russian, Hungarian, Kashubian, Ukrainian, Belarusian, Lithuanian, and Udmurt (an Uralic language) have twelve or thirteen color categories, since they all present further segmentations of the BLUE domain (among others, Al Rasheed et al., 2011; Borg, 2011; Ronga, 2009; Winawaver et al., 2007).

Russian divides the BLUE domain into two different terms, *goluboy* vs. *siniy*. Importantly, according to various scholars, these two color terms represent two independent basic categories (Winawaver et al., 2007; Paramei, 2005, 2007). Modern Greek seems to have a similar category

system, since it distinguishes between *μπλε* [blé] ‘blue’ and *γαλάζιο* [galázjo] ‘light blue’ (Borg, 2011).

The picture of Italian *blues* appears even more complicated. Italian uses three different color terms to lexicalize the BLUE spectrum: *blu*, more or less corresponding to ‘dark blue’ in English; *azzurro*, indicating a middle blue; and *celeste*, corresponding to the English ‘light blue’ (Paramei & Menegaz, 2013; Uusküla, 2014). While there is no complete agreement in the literature on the basicness of *celeste*, both *blu* and *azzurro* are almost unanimously considered basic color terms in recent research work (Paggetti et al., 2011; Paggetti & Menegaz, 2012, 2013; Paggetti, Menegaz, & Paramei, 2015; Paramei & Menegaz, 2013; Ronga, 2009; Sandford, 2012; Uusküla, 2014; Valdegamberi et al., 2012).

The specific categorization of color expressed in European languages seems to be influenced by historical and cultural factors, such as the history of Malta together with Arabic and Italian influences on its color system (Borg, 2011), trade deriving from the use of natural pigments, and the development of textile manufacture (Casson, 1997; Pastoureaux, 2000; Ronga, 2009).

Interestingly, Italian can be considered as a paradigmatic case of the close intertwinement between universal trends and cultural-specific aspects.

Socio-cultural aspects in the history of the BLUE category in Europe and the use of *azzurro* in Italian

According to several scholars, the Romans did not think of BLUE as a real basic category, but simply as a black hue (Garcea, 2003; Grossman, 1988; Pastoureaux, 2000). It was only after the fall of the Roman Empire that a separate blue category finally appeared in Europe. During the Middle Ages, in explicit contrast with Latin tradition and paganism, the Catholic Church decided to adopt blue as the colour of the Virgin Mary and Christian renovation. As a sign of devotion to the Catholic Church during the thirteenth century, blue became the colour of the French monarchy (that is, *royal blue*; Pastoureaux, 2000).

From a conceptual-linguistic point of view, the social blue revolution was paralleled by an evolution of the classical color categorization system. As a categorical hyperonym, north-west European languages such as French and German adopted the Germanic root **blawa*, whereas south European languages (such as Spanish and Portuguese) the Persian-Arabic root *lāzward*.

Italian, which lies on the border between northern and southern Europe, maintained both Germanic and Persian-Arabic roots, thus lexicalizing two basic color terms for the blue SPECTRUM, *blu* and *azzurro*, together with a third, marginal competitor, *celeste* (Ronga, 2009; Ronga et al., 2014; Uusküla, 2014).

Azzurro was the symbolic color of the Savoy dynasty (i.e., the Italian royal family after the Italian unification in 1861) and nowadays it connotes the Italian national sport

teams. The case of *azzurro* is interesting with regard to the relevance of the socio-cultural and historical aspects in color lexicalization. *Azzurro*, indeed, is found to occur more frequently than *blu* in the *ItWaC* (Baroni, Bernardini, Ferraresi, & Zanchetta, 2009): *azzurro* has 45159 occurrences, *blu* 62554. In addition, it is often associated with a positive connotation. An example of the preference for *azzurro* rather than *blu* when a positive connotation is implied is *Principe Azzurro*, corresponding to *Prince Charming* (other examples can be found in Ronga et al., 2014). Interestingly, some English expressions including *blue* (present both in British and American English) are used in Italian as well, but are expressed by *azzurro*, such as *balenottera azzurra* ‘blue whale’, *alghe azzurre* ‘blue algae’.

Within a relativistic perspective, social-cultural and historical factors are frequently considered in the explanation of the interlinguistic variability of color categorization (McNeill, 1972; Pastoureaux, 2000; Taylor, 2003), while the frequency of color terms, which is strictly related to their saliency (as in the case of *azzurro*), is rarely taken into account.

Color and typical exemplars: Universalism and relativism

When searching for idioms containing basic color terms in linguistic corpora, we often find expressions such as *blue as the sky*, or *red as a strawberry*.

Color categories, due to perceptual vagueness and language indeterminacy (Taylor, 2003; Bazzanella, 2011, 2014), are subjected to *fuzziness*, in the sense that category boundaries are not precisely defined, and the use of chromatic lexicon may vary in time and space in a complex intertwinement of language use, together with socio-cultural and historical factors.

This is one reason why color terms are often associated with natural or artificial referents (i.e., *typical exemplars*, as in the expression *white as snow*). It should be underlined that, even though, at a perceptual level, focal colors are not subject to diatopical variability (Kay, *in press*; Kay & Maffi, 2005), referents indicating the focal point of the category are not always shared by different languages (Ronga et al., 2014).

Within a multifaceted project on color categories, lexicon, and interlinguistic variability (Bazzanella et al., 2012; Ronga et al., 2014), we collected introspective and corpus data on color terms, color-related idiomatic expressions, proverbs, and typical exemplars associated with color terms. Introspective data were obtained through written questionnaires administered to 103 Italian, 38 Chinese, and 25 Danish participants. The questionnaires were composed of four parts:

- i) a color-term list task (subjects had to list as many colors as possible);
- ii) a free-association task (participants had to associate each basic color term with objects or concepts that

typically characterized the color (such as, *snow* for white, *sky* for blue, or *passion* for red in English);

iii) a proverb task and an idiom task (subjects had to list all the color-related idioms and expressions they could remember; for further details about the methodology, please refer to Ronga et al., 2014).

The occurrence of basic color terms in idiomatic (such as *a white lie*) and comparative color-based expressions (such as *red as a lobster* or *white as wool*) were manually examined, collected, and analysed in four large-scale corpora (ItWaC and ItTenTen for Italian, UkWaC for British English, KorpusDK for Danish; Bazzanella et al., 2012; Ronga et al. 2014; Strudsholm, Ronga, & Bazzanella, *accepted*).

Overall, our data indicate that in all the examined languages, the typical exemplars most commonly associated with color words in idiomatic and comparative expressions are natural referents (e.g., *blood*, *sky*, *night*, *snow*, *milk*, *grass*; for quantitative analyses, please refer to Ronga et al., 2014, Bazzanella et al., 2012, Strudsholm et al., *accepted*).

For instance, British English, Danish, and Italian share the expression *red as blood*, *rød som blod*, *rosso come il sangue*, which is grounded on a very salient natural referent.

English, Danish, and Italian have the very same proverb (with the same idiomatic meaning) referring to the greenness of grass: *The grass is always greener on the other side*, *Naboens græs er altid grønnere*, *L'erba del vicino è sempre più verde*. Even Chinese and Italian have similar idiomatic expressions referring to the weather as well as sky and cloud colors (Bazzanella et al., 2012).

On the contrary, some associations appear related to environmental specificity. While in Italian *rosso come un pomodoro* 'red as a tomato' is widespread, in British English it is pretty rare, while *red as a beetroot* is much more common (UkWaC corpus; Ronga et al. 2014). In both Italian and British English we find expressions such as *blue as the sky*; however, while in Italian the sea is frequently associated with *azzurro* or *blu* ('blue'), in British English, the North Sea is associated with *grey* (ItWaC, ItTenTen, and UkWaC corpora; Ronga et al., 2014).

Overall, the associations between color terms and typical exemplars encompass universal trends (such as the salience of some natural referents) and relative aspects.

Noteworthy is also the fact that there are oscillations in selecting relevant associations, possibly in relation to the vagueness of the referent itself: very often objects such as the *sea* or different kinds of fruit and vegetables are not constant in their 'typical' colors. On the contrary, their chromatic appearance may differ quite drastically in different periods of the year, from day to day, or in different moments of the same day, depending on the light and other external conditions (as in the ripening state of fruit and vegetables). The vagueness of referents allows speakers to focus on different features, highlighting

diverse aspects of the very same object at different moments, according to prior knowledge or the specific context.

Regier & Kay (2009: 444), referring to the possible integration between universalistic trends and the influence of culturally specific aspects, have claimed that the role of social forces in the modulation of universal categorization patterns is still unclear.

With the present paper, we have aimed to find the active link between universalistic trends and relativistic aspects of color categorization.

On the one hand, universalistic patterns of color categorization cannot be denied. On the other, socio-cultural and historical parameters appear to be relevant at each level of color categorization and lexicalization, in the shaping of basic terms, in the selection of typical exemplars, and in the variety and richness of hue terms that distinguish perception and diverse language use.

Conclusion: Category emergence as a dynamic process

In a very elegant paper using the neuro-imaging technique of visual-evoked potentials, Thierry et al. (2009) demonstrated that the presence of a given color category in a lexicon is able to influence the perceptual processing of the corresponding color. As stated above (§ *The categorization of the BLUE spectrum: An exception to Berlin and Kay's pattern*), Modern Greek split the BLUE spectrum into two color terms, one corresponding to light blue and the other to dark blue. Thierry et al. (2009) showed that native speakers of Greek were able to distinguish light blue from dark blue faster and better than native English speakers.

Interestingly, Zhou et al. (2010) showed that a similar influence on perceptual color discrimination might be obtained even with artificially learned lexical categories that are not present in subjects' native idioms. In the first part of the experiment, subjects were asked to distinguish between two hues, both referring to the same term in their native language. In the second part of the experiment, subjects were trained to perceive a new linguistic color category, so that the two hues no longer referred to the same term. After the training, subjects resulted to be faster and better in the hue discrimination task.

These findings are relevant for two reasons. First, these experiments demonstrated how linguistic categorization may modulate perception, thus showing a complex pattern of reciprocal influence between perception, conceptual categories, and language (see also Gong, Shuai, & Wu, 2013). Second, and more importantly, these findings highlight the extreme dynamism of the color categorization process. Color categories appear to be significantly flexible (Lalumera 2013), and able to emerge and adapt very fast, in accordance with the entire pattern of contextual features, meant either as global, *a priori*, or

local parameters, activated by single interactions (Akman & Bazzanella, 2003).

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