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Color terms and color perception. Reconciling universalism and relativism

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Abstract The theory postulating that language shapes the way we perceive reality, mostly known as Linguistic Relativity or Sapir-Whorf Hypothesis, has been widely debated in the past years. In particular, an increasing number of studies have dealt with the relationship between color naming and color perception, this being more easily observable than other rather abstract language categories. While some research on this field provided evidence for language effects on color perception, others stressed cross-linguistic universal tendencies in color naming and perception. Although supporters of the two main approaches have struggled to establish their theories rejecting the opposite view for many years, a new reconciling approach between them seems to emerge in more recent literature. On the one hand, this position would acknowledge the existence of universal tendencies in color naming. At the same time, it would posit that there can also be differences in the way languages encode color boundaries, and that these differences may, in turn, affect color perception. As a result, the two views not only seem compatible, but even complementary. According to this interpretation, the present paper aims at providing a review on the recent literature concerning color naming and color perception.

Keywords: relativism, universalism, Sapir-Whorf, basic color terms, color perception

1. Introduction

In the last decades, the relationship between language and perception is a topic that has gained ground in the cognitive sciences. Since the mid- twentieth century, two opposite views have been supported in this concern: the relativistic and the universalistic approach. The former is also known as the Sapir-Whorf Hypothesis, from the surnames of its two pioneering authors, Edward Sapir (1884-1939) and Benjamin Lee Whorf (1897-1941). In their works, Sapir and Whorf supported two main claims about the relationship between language and perception. One claim stated that language categories are arbitrary and arbitrarily vary across languages; the other stated that the way people perceive the world is affected by the language categories of their mother tongues (SAPIR 1921, 1929, WHORF 1956). More recent studies refer to the language effect postulated by the relativistic hypothesis as

‘Whorfian effect’, or as ‘Categorical Perception’ (often shortened as CP), meaning the tendency to perceive and categorize reality based on the language categories we use to describe it. The universalistic approach originated instead from a general theory about language universals by Noam Chomsky (1928-). This approach argued that there are universal tendencies in how humans perceive reality, which are not affected by language or by any other factor, but are reflected instead by universal language categories.
Given the observable nature of colors, color terms have offered a fertile ground for testing either hypothesis. Several authors have contributed to the debate, among the others Paul Kay (1934-), with different methodologies spanning from testing indigenous populations on simple tasks involving colors, to behavioral data measuring reaction times, to online data collected with neuroimaging techniques.
As Regier and Kay (2009: 439) point out, the two key questions underlying the studies on color terms and color perception are:

- Do color terms affect color perception?
- Are color categories determined by largely arbitrary linguistic conventions?

Supporters of the universalistic view would have answered negatively to both questions, while the relativists would have replied positively in both cases. Hence, the two hypotheses have mostly been considered as two opposite options, and the debate seemed to suggest that eventually either one would be discarded. However, in more recent publications, the two theories have appeared to be at least compatible, if not complementary. The present paper then aims at reviewing the most relevant works in the domain of color naming and color perception, showing where and in which terms a reconciling approach between the two hypotheses is to be found, and how the literature has reflected this trend, gradually changing its research focus over the years.

2. Color universalism: Basic color terms

After the works of Sapir and Whorf, the belief that language categories arbitrarily vary across languages and that this may affect the way different populations perceive reality was gaining ground. The universalistic hypothesis represented a reaction against this view. The field that Universalists chose to look for evidence for their theories was mostly that of color terms. The idea they supported implied that all the peoples of the world, regardless of their mother tongue, perceive colors in the same - universal - way. In turn, these universal perceptual tendencies would then result in universal trends in color naming across all the world languages. Hence, they saw color naming as reflecting perception tendencies, implying that the causal relationship between language and perception postulated by the relativists was inverted.
In 1969, Berlin and Kay published *Basic Color Terms: Their Universality and Evolution*, with the aim of showing universal tendencies in color naming. In their work, they claimed that the color continuum is not uniform from a psychophysical point of view, but rather universally divided into ‘focal’ colors, which were maintained to be the most salient and most consistently named across different

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languages. Thus, openly against the relativistic theories, the authors argued in favor of universal perception tendencies that are reflected in universal trends in color naming. Berlin and Kay's research included data collected from native-speaking informants of twenty languages from different language families and from any kind of written texts in other seventy-eight languages. The native-speaking informants were involved in color naming and color grouping tasks. Stimuli consisted in 329 standardized color chips. Participants were first asked to name the basic color terms of their language and then to map the focal points and the outer boundaries of each basic color term with the chips provided by the instructors. After this, they had to point at all the color chips that they would name with a certain term and say which ones would be the most prototypical for each category. The task was repeated at least three times. In order for the color terms mentioned in the experiments to be considered 'basic', these had to fulfill specific requirements, such as being monolexemic, being among the first color terms named, and not being contained in the meaning of other basic color terms. From the data they collected, the authors found eleven basic color terms, namely white, black, red, green, yellow, blue, brown, purple, pink, orange, and grey. However, not all of them were named in all the languages they encountered. The authors thus suggested that languages encode color terms following a mandatory and universal temporal sequence, which is summarized in Fig. 1. In the first phase of the sequence, white and black are the only color terms available. When a language reaches the second step of the sequence, red is additionally encoded. The third phase adds yellow and green. In the following phase comes blue, then brown. Finally, in the seventh and last phase, purple, pink, orange, and gray are encoded. While modern European languages have already reached the final stage of the evolutionary sequence, other less developed languages may still find themselves in a less advanced phase. Once a stage is reached, all the color terms previously encoded permanently remain as part of the vocabulary of the language, so that if a language includes a certain color term, it necessarily also includes all the preceding ones.

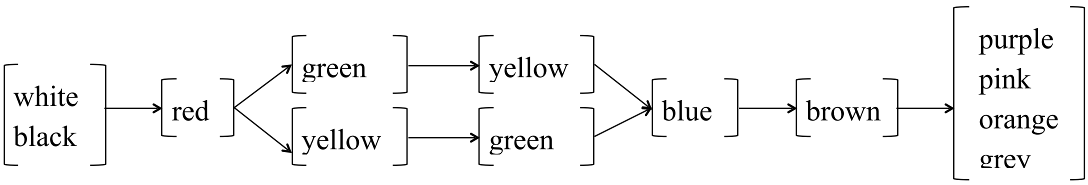

Fig. 1. – The evolutionary sequence of colors by Berlin and Kay (1969: 4).

As for the grouping tasks, the study showed that colors were not randomly categorized and that all the languages under observation had similar foci of basic color terms. While the placement of category foci seemed highly reliable, category boundaries appeared to be more blurred, even for the same speaker along the repeated trials. The data collected on the written sources of other seventy-eight languages confirmed the results of the experiment.

The model of the basic color terms and the evolutionary sequence were later partly modified (KAY 1975; KAY & MCDANIEL 1978). Important improvements in the model were brought by the World Color Survey, a project started in 1976 by Brent Berlin, Paul Kay, and William Merrifield, which also provided further evidence for the universal set of basic color terms. Results of the project were later published in several papers (KAY *et al.* 1991; KAY & MAFFI 1999; KAY 2006; KAY & REGIER 2003).

3. Color relativism: Against basic color terms

A series of papers published at the shift between the twentieth and the twenty-first century rejected the universalistic theories about colors and their idea about universal tendencies in color naming, arguing instead in favor of the effect of language on color perception. These studies were inspired by the linguistic relativity hypothesis, although Sapir and Whorf had never mentioned color terms in their works.

The first studies on relativism addressed the two questions mentioned in the introduction, thus both arguing against universal color tendencies in favor of arbitrary color categories and claiming that color terms influence color perception. These two questions were then considered as strictly related.

In 1999, Davidoff and coworkers reported the results of their research, which compared English speakers to speakers of Berinmo, a language spoken by a population living in Papua New Guinea. While Berinmo does not mark the boundary between blue and green, it has a color boundary that is unknown to English speakers, i.e. that between *nol* and *wor*. The authors analyzed categorical effects on color areas between these two boundaries. Speakers were requested to remember a color and then select the same color from a pair of similar alternatives. The pair was sometimes composed of two hues belonging to the same color category, sometimes of two hues of different color categories. Results showed that English speakers found it easier to identify the target if the pairs were composed of a green and a blue stimulus, while the same happened for Berinmo speakers if the pairs were composed of a *nol* and a *wor* stimulus. This showed that color perception depends on the different distinctions marked in the different languages. Speakers were also asked to learn the distinctions marked in the other language (blue-green and *nol-wor*) and another arbitrary distinction between two kinds of green. The test was then repeated and results showed that Berinmo speakers did not find it more difficult to learn and use the distinction between the two types of green than that between blue and green. The authors concluded that this proved that basic color terms are not universal. A paper published in the following year by the same authors reinforced the same ideas, claiming again that there is no evidence for the linguistic division of color space to correspond to universal tendencies and that color boundaries rely only on language (ROBERSON *et al.* 2000).

In 2001, dealing with the same results, Davidoff emphasized again that perceptual categories are derived from words and are not universal. He also claimed that «the internal color space is not static; some distances within it are "stretched" or "distorted" by the influence of linguistic categories» (p. 386). However, he acknowledged the existence of certain constraints on categorization, which were general perceptual criteria and did not correspond to Berlin and Key's basic color terms.

Roberson and coworkers (2004) later carried out other studies comparing English with Himba children, a population living in southern Africa. From their tests, it

emerged that children gradually acquired the set of categories used by their society and in their language rather than having a universal set of predetermined categories. Only when children of both languages had learned color terms, did they start to have an advantage in memory for such terms. According to the authors, this was yet another proof for the inexistence of universal basic color categories. Another study by the same authors (ROBERSON *et al.* 2005) compared the behavior of Himba speakers tested *in situ* to data elicited from Berinmo and English. It appeared that the Berinmno and the Himba organization of color terms were similar. Thus, according to the universal claims, these two languages would have to show similar cognitive representations of colors, in spite of the very different environments their speakers are exposed to. However, this did not seem to hold true, showing that color perception differs even between languages with similar color categories.
Levinson (2000) also argued against basic color terms. His study was based on Yélî Dnye, a language spoken by a population of Papua New Guinea. It showed that this population did not use basic color terms, since all their color names were complex expressions and most of them directly referred to objects.
In short, the major claims of the research supporting the relativistic hypothesis were: 1) color categories influence color perception; 2) color categories are not universal. Hence, these studies represented a shift back to pure relativism.

4. Reconciling the two views

In the following years, Kay and colleagues criticized the relativistic shift and re-affirmed the validity of their thesis. However, the authors criticized only the rejection of basic color terms, while they confirmed that language terms could affect color perception. This represented a fundamental shift in the debate about color naming, since it suggested some reconciliation between the two opposing positions, making them no longer appear as rival, but rather as compatible with each other. The key point consisted in tackling the two research questions separately: they did not have to be necessarily answered both with a 'yes' or a 'no', since the one did not follow from the other.
In 2005, Regier, Kay, and Cook re-discussed the data from a previous study (KAY & REGIER 2003), providing more accurate results and adding more statistical evidence, this time specifically addressing the role of universal foci within the universal tendencies in color naming. Their tests focused on the data from the World Color Survey. The authors showed once again, on the one hand, that color foci are universal and, on the other, that color boundaries depend on color foci and not the opposite. Nevertheless, they admitted language effects to take place within the constraints imposed by color universals (REGIER *et al.* 2005a, 2005b). This position had already seemed to emerge in a paper by Kay and Kempton in 1984, although not as clearly as here. In the meanwhile, similar studies had already come to similar conclusions (e.g. DAVIES & CORBETT 1997, ÖZGEN & DAVIES 1998).
Kay (2005) also addressed the study published by Levinson in 2000. With the help of statistical methods, he claimed that the data elicited about both Yélî Dnye and Berinmo actually provided evidence for universal constraints rather than against them. Nevertheless, again, Kay reaffirmed the possibility of language-effects on

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behavior concerning color perception, emphasizing that this has nothing to do with the existence of universal basic color terms.
To conclude, the most important observation that arose in defending color universals concerned a mistake made by relativists. The latter supported two main theses: 1) language shapes experience; 2) linguistic categories are arbitrary. Universalists emphasized that these two assumptions must not be considered as linked to each other: the evidence that color categories have an influence on cognition does not imply that color terms are arbitrary. This means that the two opposing hypotheses could then be considered as compatible and, to a certain extent, even complementary.
In the following years, several studies were published on language effects of color perception. In such studies, the existence of a universal set of color terms is no longer mentioned. This seems to have been acknowledged, or, at least, it started to be considered irrelevant for the question concerning Categorical Perception. The following paragraphs describe how this change is reflected in the studies coming after this important shift, showing that the debate between universalism and relativism, in this specific field, seems to have been overcome.

5. Further studies on language effects on color perception

After years of debates between the universalistic and the relativistic views, a new approach conciliating the two positions is to be found in the literature. This consisted in no longer considering the so-called Whorfian effect as against universal basic color terms, whose existence was now generally acknowledged or at least no longer mentioned in research papers, which only focused on how color terms influence color perception.
Özgen and Davies (2002) studied categorical color perception on speakers living in the United Kingdom, carrying out four experiments and observing whether learning new color terms resulted in a changed pattern of language effects. The first experiment was a same-different task, with colors differing in hue and lightness. In experiment 2, 3, and 4, the task was similar but it was performed after informants had learned new color names. From the first test, a cross-category advantage emerged (i.e. speakers were faster at discriminating colors belonging to different color categories). However, this was neutralized in the following tests through the learning of new categories, where different cognitive patterns emerged, further proving that it is language that originates the effect, but also showing that color discrimination is not static and can change with the learning of new categories.
Witthoft and coworkers (2003) compared English and Russian speakers on the *siniy*/ *goluboy* ('dark blue'/ 'light blue') boundary, existing in Russian but not in English, wondering whether language could affect perception even when no memory was involved. They designed three experiments, in which three-color samples were shown on a screen and speakers were instructed to indicate which of the two colors at the bottom was identical to that on the top. In the first experiment, performed only by English native speakers, half of the trials additionally involved the performance of a verbal interference task. The task resulted to be easier when the two colors at the bottom had two different names (between-category) than when they had the same name (within-category), yet this effect was reduced through verbal interference. In the second

experiment, performed again by English speakers, a spatial interference condition was added to the task, but this did not have any effect on performance. The third experiment involved both English and Russian speakers and focused on the *siniy*/*goluboy* boundary. Spatial and verbal interference were added to some stimuli. Judgments by Russian speakers across the *siniy*/*goluboy* boundary were affected by the verbal interference task, while those by English speakers were not. The spatial interference task had no influence on either group. Overall, results suggested that color language has an influence on color judgments, even when no memory task is involved, and that this results in cross-linguistic differences in color judgments. In 2007, further research by the same authors yielded similar results (WINAWER *et al.* 2007).

Another language that distinguishes between light and dark blue is Greek, which names them *ghalazio* and *ble*. Athanasopoulos (2009) studied the effects of these two color categories on Greek speakers. He first addressed the question whether learning a second language leads to a cognitive reorganization in the mind of bilingual speakers, carrying out two experiments with Greek native speakers with English as second language. In the first experiment, speakers were divided into two groups according to their proficiency in English and they were asked to name the color of a series of chips (all blue hues) and to indicate the best examples of the two categories, in order to calculate where the boundary between *ble* and *ghalazio* lied. In the second experiment, Greek speakers were asked to judge how similar two colors were on a 10-point scale (1 was maximum similarity and 10 minimum similarity), with the aim of analyzing cognitive representations of the *ble/ghalazio* distinction and then correlating them to the speakers' proficiency in English and comparing them to the cognitive representations of English monolinguals. Results proved that bilingual speakers tend to shift toward cognitive representations that are more similar to those of the native speakers of their second language. This phenomenon was suggested to depend on different factors, such as the level of proficiency in the second language and the length of stay in the foreign country. It was then concluded that language plays an important role in the way people perceive colors, but that culture may also be a key factor.

Athanasopoulos and colleagues (2011) further researched the effects of bilingualism and compared the perception of the blue hues of monolingual Japanese, monolingual English, and Japanese-English bilingual speakers. Japanese also has two terms for blue, *ao* ('dark blue') and *mizuiro* ('light blue'). The experiment consisted in judging the similarity of pairs of blue hues. Results showed that Japanese monolinguals found two hues less similar if they belonged to two different color categories in their language, while English monolinguals did not show language effects for the Japanese color categories. Japanese-English bilinguals had an in-between cognitive pattern: those more fluent in English distinguished the light blue stimulus from the dark blue stimulus less clearly than those who used English less frequently.

Overall, studies on the light blue/dark blue boundary in different languages represented another proof for language effects on cognition. However, this phenomenon also appeared as something flexible that can change with the learning of a new language. This is why only a moderate interpretation of the Sapir-Whorf Hypothesis seems to be reasonable, and the extreme positions embraced sometimes by Sapir and Whorf are currently widely rejected.

As remarked, basic color terms have not been mentioned again in such studies. This may also not necessarily be due to a final agreement on their existence, but just to the acknowledgment of the fact that basic color terms and the influence of language on cognition have to be dealt with separately.

6. Effects in the right visual field

Some other interesting findings concerning color terms and perception are those postulating lateralized effects. The underlying idea was that, since what people see in the right visual field is processed in the left part of the brain – which is where language is commonly processed – the stimuli presented in the right visual field are more likely to be directly affected by language than those seen in the left visual field. Kay worked exhaustively on this topic, remarking his idea concerning the independence of language effects from basic color terms. Moreover, basic color terms were no longer mentioned in these studies.

Gilbert and coworkers (2006) was the first who put forward the hypothesis about lateralized effects in color cognition forward. In experiment 1 and 2 of their paper, the authors involved English native speakers in a color discrimination experiment. Stimuli consisted in a ring of colored squares (belonging to the green and blue hues) surrounding a fixation marker. All the squares were identical in color except one, which could or could not belong to the same color category of the other squares. Participants were instructed to indicate whether the different square was in the left or in the right half of the circle. The authors assumed that the perceived difference between two color patches would increase if the two colors were named with the same term in a language, while it would diminish if the two patches had two different names although being similar. Hence, they expected discrimination between colors with different names to be faster and discrimination between colors with the same name to be slower. Furthermore, they expected to find this pattern of results only for stimuli presented in the right visual field. In the first experiment, some of the trials were performed with a simultaneous verbal interference task, which was expected to disrupt the influence of language. In the second experiment, a non-verbal interference task was additionally introduced, expecting this not to impact the performance of the task. Results showed a Whorfian effect for cross-category stimuli and that this effect was limited to the target shown in right visual field, were discrimination of colors with different names was faster. This effect, as expected, was attenuated or even disrupted by a concurrent verbal interference task. This study paved the way for further discussion of the lateralized Whorfian effects in the following years. Research focused on various aspects, such as language acquisition or comparisons between different languages.

Roberson and coworkers (2008), for example, compared English and Korean speakers on the perception of two color categories that are distinguished in Korean, but not in English, i.e. *yeondu* (‘yellow-green’) and *chorok* (‘green’), expecting Korean participants to show a language effect at the *yeondu/chorok* boundary. The stimuli and procedure were similar to those developed by Regier and coworkers. Results showed that while the performance of English speakers was the same for cross-category and within-category targets, the performance of Korean speakers was instead faster for the latter targets. This occurred for targets in both visual fields. However, since some Korean speakers had been significantly slower than others in performing the task, participants were further divided into two groups, 'slow responders' vs. 'fast responders'. It then emerged that fast responders had actually had faster reactions for stimuli in the right visual field, while slow responders had reacted with the same pace for both fields. The authors concluded that slower reactions allow information-transfer between the hemispheres, so that language information can also affect processes in the left hemisphere.

Franklin and coworkers (2008a) particularly focused on the relationship between the lateralization effect and the learning of color terms. They tested adults and toddlers, showing them a colored target on a differently colored background and measuring the time it took them to start an eye movement toward the target. Targets either belonged to the same color category of the background or to a different one, but they all had the same chromatic separation from the background. Both adults and toddlers were faster at moving their eyes toward the target when this had a different color from the background. In the case of adults, starting an eye movement was even faster when targets were in the right visual field. However, toddlers were faster only for targets in the left visual field, which would suggest that pre-linguistic color categorization is lateralized to the right hemisphere instead of to the left. In order to prove that the shift toward the left hemisphere in adults is caused by language acquisition (in this case, the acquisition of color terms), the same authors (FRANKLIN *et al.* 2008b) carried out further research, this time with toddlers who were learning color terms ('learners') and toddlers who had already learned them ('namers'). The task was identical to that used in the previous study. Overall, toddlers were faster at detecting targets when their color category differed from the background, but there was a difference in the lateralization of the category effect. While 'learners', like pre-linguistic children still showed facilitation effects for targets in the left visual field (processed by the right hemisphere); 'namers', just like adults, already showed the same effects for targets in right visual field (left hemisphere). These findings thus proved that the shift from the right hemisphere to the left hemisphere in language effects on colors occurs when color terms are learned.

Zhou and coworkers (2010) published another study proving that language effects are entirely caused by learned categories. Participants had to learn new color categories violating both universal tendencies in color naming and tendencies in their mother tongue. Colors that were within-category before training became between-category after training. The stimuli were presented in the same fashion as in the study by Regier and coworkers (2006) and the aim of the study was to observe whether pairs of colors that were within-category before training would be distinguished faster after training and, furthermore, if discrimination would be faster in the right visual field. Indeed, results showed that even newly trained color categories could generate a lateralized categorical effect for stimuli in the right visual field, thus supporting once again the role of language in the shaping of cognitive patterns.

7. Neuroimaging studies

Further evidence for language effects on color discrimination came from studies using neuroimaging techniques. Thierry and colleagues (2009), for example, found that brain response (recorded with electroencephalography, EEG) of Greek speakers in a color discrimination task involving the light blue vs. dark blue boundary differed from that of English speakers in the same task. Liu and coworkers (2009) published another EEG study. Chinese native speakers were tested on a visual search task, where they had to detect a target presented either in the right or in the left visual field. The target was a different color among other identical colors, and belonged either to the same language category as the other colors (e.g. a different blue among blues) or to a different language category (e.g. a blue among greens). All colors were either blue or green. The analysis of the EEG recording showed that a component that is typically evoked in similar tasks was particularly large for between-category targets in the right visual field.

Siok and coworkers (2009) used another neuroimaging technique, functional Magnetic Resonance Imaging (fMRI). They recorded subjects' brain activity while they performed a visual search task similar to that developed by Regier and colleagues in 2006. Results showed that brain language regions participated in color perception while speakers performed the task and that this happened only when targets were in the right visual field, thus unequivocally proving language involvement in color judgments. More recently, Brouwer and Heeger (2013) measured cortical activity of human subjects with fMRI during the performance of tasks involving colors. Results showed that neural correlates of color shifted towards categorical representation during the performance of a color naming tasks, which, once again, confirmed the role played by color terms in color perception.

8. Conclusions

In the last decades, color perception has proved to be a fruitful ground for studies about the linguistic relativity hypothesis. As the present paper has shown, the literature about the topic has turned from being a battlefield for opposite theories, with studies showing controversial results, to a domain where a certain degree of agreement has been reached between the counterparts. Evidence from the most recent research has indeed shown that:

- Color lexicon is constrained by universal tendencies concerning color foci;
- Color lexicon influences cognition of color boundaries and, as a consequence, people with a different color lexicon may have a different cognition of colors;
- The influence exerted by the color lexicon is not an irreversible phenomenon and can change when speakers become familiar with a new set of color terms.

More in general then, the domain of color shows that the traditional linguistic debate between relativism and universalism could be overcome in favor of a theory where both approaches coexist. What remains unclear is to what extent a similar reconciling approach can be applied to other research areas where language effects have also been found, such as animal categories (GILBERT *et al.* 2008), grammatical gender (BORODITSKY *et al.* 2003), spatial categories (BOWERMAN & CHOI 2000), and mass and count nouns (LUCY & GASKINS 2003).

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