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# Blues in Two Different Spanish-Speaking Populations

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Several studies investigating color discrimination across languages have shown a facilitation effect in groups that employ more than one term to refer to a given color. While Uruguayans use "*azul*" to refer to dark blue and "*celeste*" for light blue, Spaniards use "*azul*" for dark blue and the compound terms "*azul celeste*" or "*azul claro*" for light blue. In this study, Uruguayan and Spanish participants discriminated between pairs of color stimuli that lie at different distances from each other on the blue color spectrum in three different sessions: a session with no interference (basic task), one with verbal and one with visual interference. Only the Uruguayans were more accurate at distinguishing between stimuli associated with different color terms. Furthermore, while both Uruguayans and Spaniards showed a category effect in response times, the effect was strongest for Uruguayans when items were closer to each other on the color spectrum (i.e., more difficult). This study is unique in that we observed different Whorfian effects in two groups that speak the same language but differ in their use of color-specific terms. Our results contribute to the discussion of whether and to what extent language or other cultural variables affect the perception of different color categories.

**Keywords: color perception, categorical perception, linguistic relativity, Sapir–Whorf hypothesis, cross-cultural cognition**

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## INTRODUCTION

To what extent do language and/or culture affect the way we process and organize the information and experiences that make up our world? The work of Sapir, Whorf, and others sparked this famous debate at least a century ago, and these questions continue to interest academics across fields to this day (Whorf, 1956; Lucy and Shweder, 1979; Kay and Kempton, 1984; Vygotsky, 1987; Lupyan, 2012; Levelt, 2014).

Most investigations addressing this topic have been characterized as either descriptive, simply reporting interesting differences between two or more languages, or aiming to explain how observed disparities are associated with different cognitive processes (Zlatev and Blomberg, 2015). These two perspectives are also associated with weak and strong versions of the Sapir–Whorf hypothesis (language and thought are interrelated vs. language determines thought, Brown, 1976). Both hypotheses have been criticized for being trivial and non-informative (weak version) or theoretically and/or methodologically wrong (strong version) (Bloom and Keil, 2001).

Zlatev and Blomberg (2015) propose approaching each investigation according to whether the focus is on the structure of language or on its implementation (discourse). Traditional cognitive approaches focus on abstract structural aspects of language and search for innate universal features. On the other hand, linguistic relativism concentrates on how the phenomenon of categorical perception (CP, Harnad, 2005) is affected by different contextual factors, such as language and culture.

According to Lucy (1997), there are three "logical components" that are typically taken into account when studying linguistic relativity: (1) the distinction between language and thought, (2) the mechanisms explaining the instantiation of a possible influence, and (3) the identification of other factors involved in the phenomenon.

Regarding the first point, relativists often agree with a broad definition of *thought*, not just as a conscious reflective process (as understood in folk psychology) but also involving less aware, automatic processes, such as perception and categorization. Moreover, language and perception are not understood as isolated modules—as in classic cognitivism (Pylyshyn, 1999)—but are thought to interact with a myriad of processes. Thus, the role of verbal labels affecting perception and categorization is a key issue in contemporary approaches (Thierry, 2016). How basic cognitive processes are influenced by implicit recovery of linguistic (but also contextual and sociocultural information) is another key question, which involves points 2 and 3.

Therefore, the key notion leading the research on linguistic relativity is not whether minds are dependent on a given language but how verbal labels and categories interact with cognition across different contexts (Thierry, 2016; Zhong et al., 2017). Topics currently being studied include: cross-cultural comparisons (i.e., Boroditsky, 2001; Casasanto, 2008), the exploration of categorical effects under different interference conditions (i.e., Roberson and Davidoff, 2000; Gilbert et al., 2006; Winawer et al., 2007), and the time course of the effect, which informs whether perception or higher cognitive processes are involved (Mo et al., 2011; Clifford et al., 2012; He et al., 2014; Forder et al., 2017).

One line of research within this debate concerns the way in which different languages divide color space. The key question within this work is whether these varying linguistic representations affect performance on tasks that are seemingly non-linguistic. In other words, does the way in which a particular language categorizes colors affect the way its speakers think about and organize color in their minds, even in the absence of an explicitly linguistic task? One special case—that of the color *blue*—has been studied by researchers across a number of languages, including Greek (Androulaki et al., 2006; Athanasopoulos, 2009; Thierry et al., 2009), Italian (Bimler and Uusküla, 2014), Japanese (Athanasopoulos et al., 2010), Korean (Roberson et al., 2009), and Russian (Witthoft et al., 2003; Winawer et al., 2007). These languages share a common feature that distinguishes them from English: they divide the color blue into two distinct linguistic categories, one depicting lighter blues, and the other depicting darker blues. In the above studies, speakers of those languages were relatively better than English speakers at distinguishing between color samples along the blue color spectrum when the samples' names came from different linguistic categories, even though the task did not require linguistic output.

This kind of implicit linguistic effect is explained by theories arguing that linguistic labels can aid in the discrimination of stimuli that are hard to categorize (Lupyan, 2012) thanks to a predicting coding process in which "every level of the hierarchically organized system that constitutes the brain works to predict the activity in the level below" (Lupyan and Clark, 2015, p. 279). In such a predictive framework, the brain's function is to produce a percept that fits the best hypothesis regarding the state of the world that is being conceived (Lupyan and Clark, 2015). That is acquired through an interplay of top-down knowledge about the world and incoming bottom-up sensory information (Bar, 2003). In Lupyan's view, labels work as hubs of perceptual, semantic and contextual information related to specific categories. Their function is to reduce prediction error by enhancing the perception of typical categorical features. Therefore, verbal labels can be elicited to foster predictability and support cognition.

Aiming to clarify this issue, several studies include a verbal interference condition. That is, they introduce a concurrent task demanding linguistic resources (e.g., remembering a string of digits). This interference is expected to disrupt categorical effects (advantage for the discrimination of stimuli pertaining to different categories) if linguistic processes are necessary for CP to occur. For instance, Winawer et al. (2007) showed that when an additional task requiring verbal memory was included, the categorical effects found for the Russian participants vanished, suggesting linguistic resources are used by Russian speakers in this seemingly non-linguistic color perception task. The authors also presented a spatial interference condition that did not alter categorical effects, further supporting the view that the a disruption of the CP advantages was in fact due to a disruption in linguistic processing and not to the heavier cognitive load imposed by any interference task.

In the current study, we compared two groups of speakers of the same language that employ different verbal labels for the same color. This comparison is interesting because, unlike previous studies where groups of speakers spoke different languages, differences between the current groups should be much subtler, and may reflect cultural variations that affect the frequency of use of such labels.

Similarly to the languages investigated in previous studies (Androulaki et al., 2006; Winawer et al., 2007), in some variants of Spanish, the color blue is associated with two different linguistic terms: dark blues are *azul* and light blues are *celeste*. However, the Spanish language presents an interesting case, in that different populations of Spanish speakers differ in the way they implement this distinction. Namely, in some South American countries such as Uruguay, the term *celeste* (light blue) is used on its own. By contrast, in Spain, the term "*celeste*" is used as part of a compound word, i.e., *azul celeste*, making *celeste* a subcategory within the larger category of *azul*, or (regular or dark) blue. The word (and color) *celeste* also carries significant cultural weight in Uruguay, given that it is found on national emblems and by extension, national sports team uniforms. A recent study conducted by our group confirmed the use of *celeste* as a separate basic color term (BCT) for light blues in Uruguay. Thirty healthy participants were given 2 min to write down as many color names as they could remember while keeping their eyes closed (Elicited List task: Corbett and Davies, 1997). Following Berlin and Kay's (Berlin and Kay, 1969) work, one would predict that only 11 different color names would be elicited in more than 50% of the lists produced by participants. In this study, however,

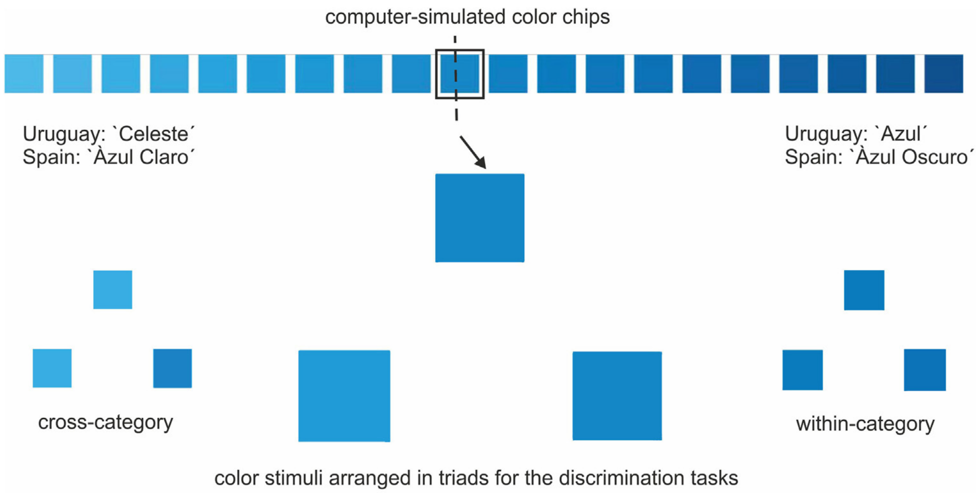


**FIGURE 1** | Illustration of the stimuli employed in the experimental tasks. Top: color chips ranging from light blue to dark blue. Bottom: middle: example of a triad used in the discrimination task; left: example of a cross-category comparison; right: example of a within-category comparison.

Uruguayan participants consistently produced 12 names, as they included *celeste* as its own color category. In fact, both *azul* and *celeste* were consistently found among the first BCTs reported by Uruguayans (Lillo et al., 2016).

For the current experiment, we tested Uruguayan as well as Spanish participants on a color discrimination task we designed using stimuli along the *azul-celeste* boundary. Since cultural as well as linguistic differences have been used to explain Whorfian effects across different populations, the Uruguay-Spain comparison is interesting because the two populations come from different cultures but use the same language and very similar color space partitions. That is, when asked to assign segments of the color spectrum to different color terms, Uruguayans and Spaniards coincide perfectly on all terms except for *celeste*: the space Uruguayans call "*celeste*" falls into the greater category of "*azul*" for Spaniards (Lillo et al., 2016). Given the presence of the 12th BCT for the Uruguayans, we hypothesized that this group would display a relatively stronger categorical advantage than Spaniards.

## MATERIALS AND METHODS

### Participants

A total of 73 individuals participated in this study: 35 were recruited from the Universitat Autònoma de Barcelona, Spain, and 38 were recruited from the Universidad de la República in Montevideo, Uruguay. All of them were native speakers of the Spanish spoken in their country, and 22 of the Spanish participants were also Catalan speakers. Nine participants (2 from Spain and 7 from Uruguay) who produced more than 25% errors and RTs < 200 and >3,000 ms were excluded from the analysis, for a final group of 33 Spaniards (mean age = 25.1, SD = 3; 18 female) and 31 Uruguayans (mean age = 22.5, SD = 3.2; 17 female). Groups did not differ significantly from each other in terms of gender or age [$F(1,62) = 0.802$, $p = 0.374$].

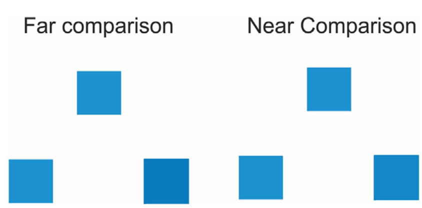


**FIGURE 2** | Examples of far (left) and near (right) comparison triads.

### Stimuli

We created 20 computer-simulated color chips that ranged from light blue (*azul celeste* in Spain and *celeste* in Uruguay) to dark blue (*azul oscuro* in Spain and *azul* in Uruguay) (**Figure 1**). Stimuli coordinates (Commission Internationale de l'Eclairage, *Yxy*) ranged from $Y = 29.26$, $x = 0.217$, $y = 0.274$ for stimulus 1 to $Y = 4.18$, $x = 0.182$, $y = 0.167$ for stimulus 20. Stimuli varied primarily in the luminance axis ($Y$) and the $y$ chromaticity axis, and were selected taking into account previous research on color categories in Spanish (Lillo et al., 2007) as well as cross-linguistic comparisons (Winawer et al., 2007; Roberson et al., 2009). The color squares measured 2.5 cm per side, and subjects viewed the screen from a distance of 60 cm. In addition, there were two categories of deviant stimuli: near and far. "Near" stimuli were colors that were two chips away from the target stimulus while "far" stimuli were four chips away (**Figure 2**). Discrimination between "near" stimuli was expected to be more difficult than between "far" stimuli.

### Procedure

Prior to participation, an investigator explained the study to participants, who then signed an informed consent form. All study procedures were conducted with the approval of the Research Ethics Committee of the Department of

Psychology at University of the Republic (Uruguay) and the Department of Basic Psychology at the Autonomous University of Barcelona (a separate ethics approval was not required as per the Autonomous University of Barcelona guidelines and as per Spanish regulations) and were in accordance with the Declaration of Helsinki. Participants viewed three color squares arranged in triads (1 above and 2 below) (**Figure 1**) and were asked to decide which of the two lower squares matched the one on top. The side (right or left) on which the distractor was presented was counterbalanced across trials. Each participant completed three blocks of 136 color discrimination trials: one regular block (Basic Task), one block that also included a secondary spatial interference task, and a third block that included a verbal interference task. Half of the comparisons included "near" stimuli and half included "far" stimuli. The two interference tasks (one verbal and one spatial) were included, following Winawer et al. (2007), to test whether either type of interference affected any observed categorical effects, thus shedding light on the type of processing employed by participants during the basic task.

## Interference Tasks

(a) *Spatial interference:* participants viewed a 4 × 4 square grid in which four randomly chosen squares were shaded black (**Figure 3**) and were instructed to maintain a picture of it in mind until tested. A two-choice test was presented every eight color discrimination trials.

(b) *Verbal interference:* participants were shown an eight-digit number series (**Figure 3**) for 3 s every eight color discrimination trials and were asked to rehearse it while completing the color discrimination task. Their recall was then tested by having them choose between the original series and a foil that differed by one digit.

## Participants' Boundaries

Following the categorization tasks, participants also completed a *Border detection task* designed to test each individual's color boundary between dark and light blues. Participants viewed the 20 stimuli (which appeared 10 times and in random order) and pressed a key to indicate whether each color was *celeste* or *azul* (for Uruguayans) and *azul celeste* or *azul oscuro* (for Spaniards). They were asked to make all judgments as quickly and accurately as possible.

Overall, 36% of participants identified Stimulus 10 as the categorical boundary, 24% chose Stimulus 9, 20% chose Stimulus 8, 14% chose Stimulus 11, and 6% chose Stimulus 7. All Uruguayans categorized Stimulus 1 as *celeste* (light blue) and stimulus 20 as *azul* (dark blue), while all Spanish participants categorized Stimulus 1 as *azul celeste* (sky blue) or *azul claro* (light blue) and Stimulus 20 as *azul oscuro* (dark blue). Each participant's score was determined individually by using his/her color boundary to classify the color discrimination trials as either cross-category or within-category. This classification was made individually (i.e., not based on the group average).

## Errors and Outliers

In order that we only analyzed data from trials in which participants were actively following the interference tasks, we systematically discarded all eight color trials preceding each incorrectly answered interference trial (5.74% of trials).

We also eliminated all trials with reaction times below 200 or above 3,000 ms (2.41% of trials across participants). RT analyses were conducted only on accurate responses (87.5%).

# RESULTS

We conducted a mixed ANOVA with three within-subject factors (Distance × Interference × Category) and one between-subjects factor (country: Uruguay vs. Spain).

## Accuracy

Groups did not differ in terms of overall accuracy: Uruguay (M=86.1, SD=0.61) vs. Spain (M=88.3, SD=0.63), $F(1,62)=1.942$, $p = 0.168$, $\eta^2 = 0.030$.

There were two significant main effects: Distance, $F(1,62) = 303.109$, $p < 0.0001$, $\eta^2 = 0.830$, and Category, $F(1,62) = 5.845$, $p = 0.01$, $\eta^2 = 0.086$. When analyzed together, participants were more accurate at distinguishing between far trials (M = 0.94, SD = 0.04) than between near trials (M = 0.80, SD = 0.09), and between cross-category trials (M = 0.87, SD = 0.07) than between within-category trials (M = 0.86, SD = 0.06). There were also three significant interactions: Interference × Country, Distance × Country and, most interestingly, Category × Country.

Interference × Country, $F(1, 62) = 3.219$, $p = 0.043$, $\eta^2 = 0.049$. *Post hoc* analyses showed that the interference factor was not significant when analyzed separately for each group,

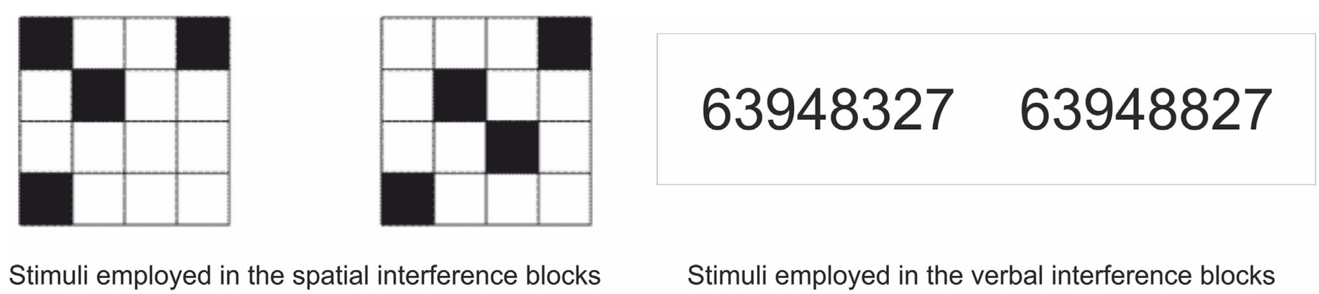


**FIGURE 3** | Example of stimuli employed in the spatial interference block (left), and in the verbal interference block (right).

and that the difference between groups was significant only in the verbal interference condition, $F(1,62) = 2.304$, $p = 0.025$, $d = 0.4$.

Distance × Country, $F(1, 62) = 4.252$, $p = 0.043$, $\eta^2 = 0.064$. Uruguayans had relatively greater difficulty discriminating between near stimuli (near: M = 0.78, SD = 0.13; far: M = 0.94, SD = 0.06) than did Spaniards (near: M = 0.82, SD = 0.13; far: M = 0.95, SD = 0.06).

*Post hoc* analyses (separate one-way ANOVAs for each group) showed that distance effects were significant for both countries, Uruguay.

$F(1, 30) = 157.375$, $p < 0.0001$, $\eta^2 = 0.840$., Spain: $F(1, 32) = 145.353$, $p < 0.0001$, $\eta^2 = 0.820$. Moreover, pairwise comparisons showed that neither near nor far cases showed differences between countries ($p > 0.05$).

Category × Country, $F(1,62) = 2.123$, $p = 0.19$, $\eta^2 = 0.086$. Uruguayans showed an advantage for cross-category trials compared to within category trials (M = 0.87, SD = 0.07 vs. M = 0.85, SD = 0.07); *post hoc* analyses: $t(1,30) = 3.268$, $p = 0.003$, $d = 0.29$. Spaniards, on the other hand, did not show this advantage (within: M = 0.88, SD = 0.06, cross: M = 0.88, SD = 0.07), $p > 0.05$ (see **Figure 4**). All other effects and interactions were not significant (all $p > 0.05$).

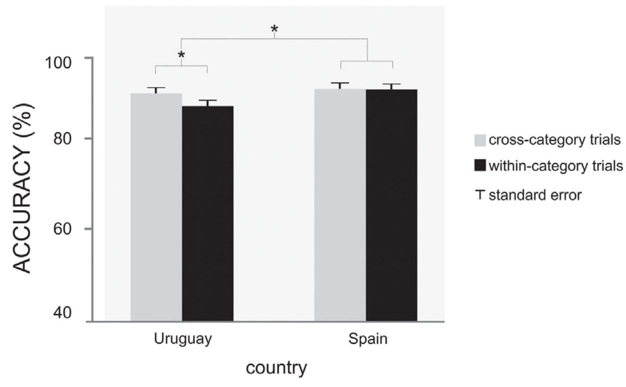


**FIGURE 4** | Mean differences in accuracy between cross- and within-category stimuli by country. Error bars represent SEM.

## RT

Overall, Uruguayans were significantly slower than Spaniards, $F(1,62) = 8.196$, $p = 0.006$, $\eta^2 = 0.117$ (M = 1043 ms, SD = 278 ms vs. M = 900 ms, SD = 287 ms). There were also significant main effects of Distance, $F(1,62) = 267.638$, $p < 0.0001$, $\eta^2 = 0.812$, and Category, $F(1,62) = 27.331$, $p < 0.0001$, $\eta^2 = 0.306$.

In line with the accuracy results, participants were faster at discriminating between far trials (M = 862 ms, SD = 175 ms) than near ones (M = 1,081 ms, SD = 235 ms), and on cross-category (M = 952 ms, SD = 206) compared to within-category trials (M = 991 ms, SD = 198 ms) (see **Figure 5**).

The first-order interaction of Interference × Country was significant, $F(1,61) = 3.517$, $p = 0.033$, $\eta^2 = 0.054$. Sessions with spatial interference, in which Uruguayans performed best, resulted in the Spanish group's slowest responses (Spain: Basic: M = 889, SD = 336; Spatial: M = 941, SD = 328; Verbal: M = 869, SD = 343; Uruguay: Basic: M = 1087, SD = 347: Spatial: M = 994, SD = 342; Verbal: M = 1048, SD = 354).

*Post hoc* analyses showed that differences across sessions were not significant within countries, but results comparing Spain and Uruguay were different for two of the three interference conditions. Differences between groups were significant in the Basic (no interference) session, $t(1,62) = 3.271$, $p = 0.002$, $d = 0.58$, and in the Verbal interference session, $t(1,62) = 2.895$, $p = 0.005$, $d = 0.51$.

Distance × Category, $F(1,62) = 3.769$, $p = 0.019$, $\eta^2 = 0.085$. A category advantage (difference between cross- and within-category trials) was stronger for far ($M_{difference} = 54$ ms) than for near color comparisons ($M_{difference} = 25$ ms).

Nevertheless, *post hoc* analyses reflected that both differences were significant: Far, $F(1,63) = 3.769$, $p = 0.003$, $\eta^2 = 0.129$; Near, $F(1,63) = 3.769$, $p = 0.000$, $\eta^2 = 0.257$. Additionally, categorical effects were significant at both distance conditions.

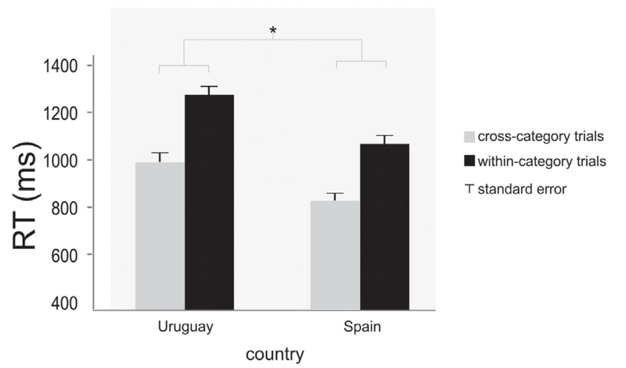


**FIGURE 5** | Mean response times (ms) between cross- and within-category stimuli by country. Error bars represent SEM.

Cross-category: $F(1,62) = 27.811$, $p = 0.000$, $\eta^2 = 0.310$; within-category: $F(1,62) = 62.927$, $p = 0.000$, $\eta^2 = 0.504$.

While the Category × Country interaction was not significant ($p = 0.090$), the three-way Country × Distance × Category interaction was, $F(1,62) = 6.596$, $p = 0.013$, $\eta^2 = 0.096$. Uruguayans showed a stronger categorical effect on near trials than on far trials.

Separate two-way ANOVAs conducted for each group showed that the interaction between distance and category was significant for Uruguayans, $F(1, 30) = 11.041$, $p = 002$, $\eta^2 = 0.269$, but not for Spaniards, $F(1, 32) = 0.635$, $p = 0.902$. $\eta^2 = 0.00$. For the Uruguayan group, RTs were faster for near cross-category trials than near within-category trials (M = 1112 ms, SD = 238 ms vs. M = 1193 ms, SD = 231 ms); *post hoc* analyses were significant: $t(1, 30) = 5.312$, $p < 0.0001$, $d = 0.34$, while far cross-category trials did not differ significantly from far within-category trials (M = 922 ms, SD = 194 ms: vs. M = 944 ms, SD = 198 ms; *post hoc* analyses: $p > 0.05$) (see **Figures 5** and **6**).

*Post hoc* analyses also showed that categorical differences between countries were significant for near trials, $F(1,62) = 6.852$, $p = 0.011$, $\eta^2 = 0.100$, but not for far ones, $p > 0.05$.

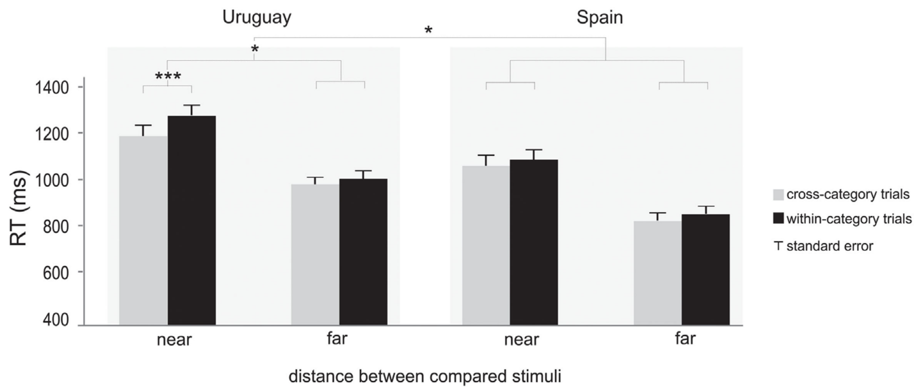


**FIGURE 6** | Mean response times (ms) between cross- and within-category stimuli by country and distance. Error bars represent SEM.

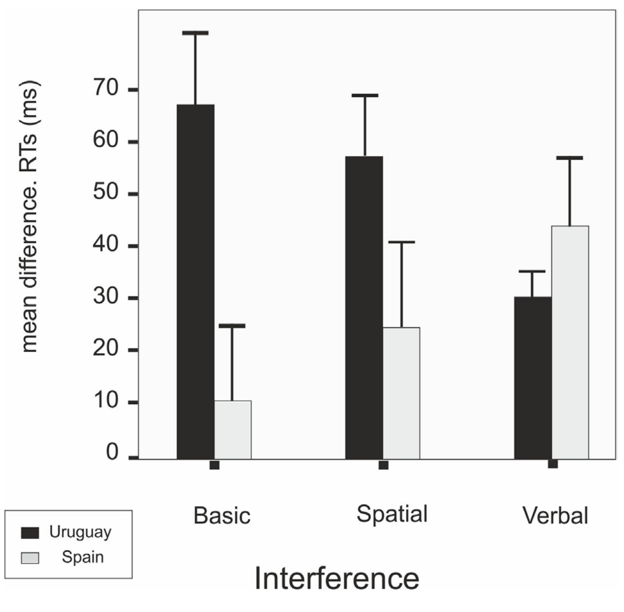


**FIGURE 7** | Category advantage (difference between cross-category and within category RT means) for the three interference conditions by group. Error bars represent SEM.

Interestingly, a non-significant difference was observed for categorical effects between countries in the different interference conditions (country by category by interference, $p = 0.059$). We calculated the differences between cross- and within-category trials to obtain a categorical effect score. Categorical effect size was greater for Uruguayans (68 ms) than Spaniards (10 ms) in the basic condition [pos hoc: $F(1,62) = 6.089$, $p = 0.016$, $e = 0.089$], more similar between groups in the spatial condition [56 vs. 24; $F(1,62) = 1.513$, $p = 0.223$, $e = 0.024$] and almost equal between groups in the verbal interference condition [30 vs. 43; $F(1,62) = 0.407$, $p = 0.526$, $e = 0.007$] (see **Figure 7**).

In sum, participants were faster and more accurate when discriminating between far stimuli than near stimuli and when stimuli pertained to different categories. Uruguayans were slower than Spaniards overall, less accurate and slower in the verbal interference condition, and slower in the no interference condition. Also, Uruguayans were less accurate than Spaniards at discriminating between near stimuli. The Uruguayan group showed more categorical effects in terms of accuracy, while both groups showed stronger categorical effects for near cases in terms of RT (with Uruguayans displaying significantly stronger effects). Finally, there was a non-significant trend for differences in the effects of verbal interference on categorical effects between groups for RT.

## DISCUSSION

The current study supports the Whorfian notion that language can influence color perception and is unique in that we were able to show differences in categorical effects in two groups of participants who speak the same language. Specifically, we found that Uruguayans, who have distinct color terms for light and dark blue, were more sensitive to color boundaries than Spaniards, who use a single color term for dark blue and two different compound terms for light blue. We also observed that a less frequent non-BCT—*azul celeste*—yielded some categorical facilitation. In this study, while both groups presented categorical effects in RT, the effect was strongest for Uruguayans on the more difficult "near" trials. Furthermore, only the Uruguayans were significantly more accurate at cross-category comparisons.

In contrast to previous studies where the color categories employed by the two populations clearly distinguished between dark and light blues (e.g., Russian and American participants in Winawer et al., 2007), one of the compound terms for light blue used by Spaniards (*azul celeste*) contains the monolexemic term (*celeste*) used by Uruguayans. From Lillo et al. (2016), we know that Spaniards do not consider "*celeste*" or "*azul celeste*" as a 12th BCT, as Uruguayans do, which may explain the weaker categorical effects observed among Spaniards relative to Uruguayans. Furthermore, as mentioned above, "*celeste*" is particularly salient in Uruguayan Spanish for cultural reasons, and may therefore appear more frequently for this population. According to several authors, the degree of exposure to color categories correlates with the strength of categorical effects in color discrimination tasks (Witthoft et al., 2003; Thierry et al., 2009; Athanasopoulos et al., 2011). An interesting future study would be to test category effects with a monolexemic color term whose frequency of use differs between two populations that speak the same language.

Importantly, several studies have shown that categorical effects on perception can be elicited by newly learned categories (Zhou et al., 2010; Clifford et al., 2012). In Zhou et al. (2010), participants who learned two new categories depicting light and dark shades of blue showed a categorical advantage compared with a control group, suggesting that the introduction of a novel verbal label can affect CP.

In Winawer et al. (2007), verbal interference disrupted CP for Russian but not for English speakers, suggesting a key role of language in CP (Roberson and Davidoff, 2000; Gilbert et al., 2006; Winawer et al., 2007). The results of the present study suggest that category saliency may also be affected by cultural factors.

Although the effect did not reach significance, we also observed that verbal interference diminished the categorical effect in Uruguayans and increased it in Spaniards (see **Figure 7**), which suggests CP effects are affected by linguistic input. Interestingly, Spaniards showed greater CP during the verbal interference block, suggesting the recruitment of the verbal label "*azul*" was inhibited. As shown by the *Stroop* effect (Stroop, 1935), automatic elicitation of a verbal label can interfere with color discrimination. Arguably, the discrimination between stimuli representing dark and light blues would benefit from the inhibition of the verbal label "*azul*" linked to the Spaniards' main blue category. Thus, further work is needed to clarify this issue. If replicated, it would be an unusual finding that has not been reported for English speakers in previous cross-cultural studies.

It should be noted that because part of our study was conducted in Barcelona, some of our Spanish participants also spoke Catalan, which uses "*blau cel*" as a term for light blue. We have not studied "*blau cel*" or Catalan speakers specifically, so we cannot say whether this term is more similar to any of the terms used by Spaniards in Spanish or by Uruguayans. In order to exclude this variable as a possible confound, we conducted an additional ANOVA comparing the subset of Catalan-speaking Spaniards ($n = 18$) to the non-Catalan-speaking Spaniards ($n = 15$) and found that groups did not differ on any of the variables or interactions of interest.

A recent interpretation of Whorfian effects (proposed more than 100 years ago by William James; James, 1890) is called the *Label feedback hypothesis* (Lupyan, 2008, 2012), which proposes that labels (i.e., words) are automatically recovered to solve difficult discrimination cases and are recruited unconsciously when an object is perceived in order to highlight characteristic features and thus assist in the categorization process.

Furthermore, recent studies have revealed that neural networks of color perception show strong connections between basic visual areas V1 and V4 and inferotemporal and nearby regions associated with categorization (Walsh, 1999; Roe et al., 2012; Gilbert and Li, 2013; Simanova et al., 2015; Winawer and Witthoft, 2015). Moreover, an fMRI study showed activation of language regions during color perception, supporting the notion of an interaction between higher level cognition and perceptual processes (Siok et al., 2009; Brouwer and Heeger, 2013).

In the present study, perceptual processes seemed to benefit from the words' referential attributes, but the effect differed between Spanish-speaking groups. This suggests that the interplay between categorization and perception only partially depends on a particular language's structure (Ozgen and Davies, 2002; Harnad, 2005; Lupyan et al., 2007; Collins and Olson, 2014).

An alternative interpretation is that perception could be driven by cultural—and not just linguistic—influences. In fact, cultural differences in speakers of the same language may even be the driving force behind the creation of different linguistic terms. The Emergence Hypothesis for BCTs (Kay and Maffi, 1999) proposes an explanation for how BCTs have evolved in different cultures. Kay and McDaniel (1978) suggest that derived categories are a fuzzy set of intersections among primary terms. According to this view, the emergence of a new category denoting a light shade of blue would be the result of the intersection between the blue and white categories, as Androulaki et al. (2006) proposed for Greek. Exactly why a language would add a new BCT is not clear. Casson (1997) proposed that a society's technological development will increase the importance of color as a distinguishing property of objects. Paramei (2005) and Steels and Belpaeme (2005) agree that cultural and social factors are key in the development of color lexicons. Such constraints imply that color names map onto color appearances in a culturally modal pattern (Frumkina, 1999; Jameson, 2005) and, in certain languages, could emerge as culturally basic.

Probably the main debate in linguistic relativity is whether CP occurs early on (during stimulus perception; Notman et al., 2005; Lupyan, 2012) or at the time a response is given (affecting post-perceptual processes; e.g., Pinker, 1995; Li and Gleitman, 2002). This question has been investigated using ERP, with studies showing early (Fonteneau and Davidoff, 2007; Thierry et al., 2009; Clifford et al., 2010; Mo et al., 2011; Forder et al., 2017), post perceptual (Clifford et al., 2012; He et al., 2014; Witzel and Gegenfurtner, 2016) and both effects (Holmes et al., 2009). This suggests that a strictly linguistic theory of CP is at best incomplete.

One unexpected result in the current study was that Uruguayans were both most accurate and fastest at the spatial interference block, relative to the other two blocks. One possible interpretation for this is that unlike verbal interference, spatial interference had a minimal effect on performance on a task where verbal aspects were critical, and that the added challenge resulted in higher accuracy. This would not, however, explain why that interference block would result in better accuracy than the block with no interference. We do not have enough data to answer this question at the moment but will investigate it in future studies.

Another interesting but not totally unexpected finding was that overall, Uruguayans gave slower responses than Spaniards. As observed by previous investigators, this may reflect differences in groups' experience as study participants (Witthoft et al., 2003; Winawer et al., 2007; Witzel and Gegenfurtner, 2015). In the present study, while both groups were recruited within university psychology departments, the Spanish group was generally more familiar with psychophysical experiments than the Uruguayan group. In order to ensure that categorical effects across groups were not related to overall RT, additional analyses were performed on the subset (50%) of Uruguayans with the fastest responses. Results confirmed the trends observed for the whole group.

To conclude, color terms (both monolexemic and compound) carry different degrees of enhanced frequency and saliency within a linguistic community, which in turn depend on social, cultural, and historical factors (see Berlin and Kay, 1969; Casson, 1997; Kay and Maffi, 1999; Paramei, 2005, but also see Saunders, 2000). The present work shows that these differences can lead to different CP effects across groups that speak the same language.

## ETHICS STATEMENT

This study was carried out in accordance with the recommendations of University of the Republic and Autonomous University of Barcelona ethics committees with written informed consent from all subjects. All subjects gave written informed consent in accordance with the Declaration of Helsinki. The protocol was approved by the University of the Republic ethics committee.

## AUTHOR CONTRIBUTIONS

AA and FG-P conceived the study which was designed with the collaboration of IR and AM. IR and FG-P carried out the experiments and the analyses were conducted by AA, IR, and FG-P. All the authors contributed to the writing of the article.

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