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A Whorfian speed bump? Effects of Chinese color names on recognition across hemispheres

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ABSTRACT

Recent research has provided impressive new evidence of linguistic ("Whorfian") effects on cognition, much of it focused on categorical perception of colors, usually focusing on a single contrast (e.g., blue/green). This research has raised new questions about the location, timing, and robustness of such effects, some of which we addressed in two studies, one on color naming and one on color memory. In Experiment 1 we presented a wide array of colors in the right visual field (RVF) and left visual field (LVF), and found that easy-to-name colors were named more quickly than hard-to-name colors in the RVF, but not the LVF. In Experiment 2 participants studied easy-to-name and hard-to-name colors carefully, then were tested on a recognition memory task. Accuracy did not differ across conditions, but easy-to-name colors took longer to recognize than hard-to-name colors, and recognition was faster in the LVF than the RVF for both easy-to-name and hard-to-name colors. The results suggest that: (1) linguistic effects on color discrimination cannot be restricted to the left hemisphere, as is often assumed; (2) faster implicit naming of colors (i.e., lexical accessibility) does not yield faster color recognition, but slower; and (3) varying effects on timing are most likely a byproduct of the relative specialization of color discrimination to the right hemisphere and of linguistic discrimination to the left hemisphere. Overall, these results suggest that linguistic effects on color cognition are more robust, distributed, and diverse than previously acknowledged. Implications of this research for the distributed, dynamical, and ecological nature of language, color, and cognition are explored.

1. Introduction

Whorf (1956) linguistic relativity hypothesis holds that the language we speak can affect our ways of thinking and perceiving, concerning aspects of the world that are not linguistic, such as spatial relations (e.g., Majid et al., 2004), number (e.g., Frank et al., 2008), pitch (e.g., Dolscheid et al., 2011), and motion (e.g., Papafragou et al., 2008). A domain that has attracted particular attention over the years has been color perception and color memory, and research in this area has intensified considerably in recent years. Although some studies suggest that language may not affect color perception (Heider, 1972; Heider and Olivier, 1972; Franklin et al., 2005; Lindsey and Brown, 2002), a growing body of empirical work has emerged in support of linguistic relativity theory (e.g., Athanasopoulos et al., 2011; Roberson et al., 2008; Thierry et al., 2009;

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Winawer et al., 2007). Even researchers who have favored claims that there is a universal color structure, one that constrains how we perceive colors and mark them linguistically, have come to acknowledge "Whorfian effects" in color discrimination (e.g., Daoutis et al., 2006; Drivonikou et al., 2007), as well other perceptual domains (Gilbert et al., 2007). Thus, for these varying researchers it is an empirical question whether linguistic activity shapes non-linguistic aspects of cognition and action. Linguistic data alone is not definitive. We will provide a brief sketch of recent evidence regarding linguistic involvement in color perception to frame our experiments on color naming and color memory.

Perhaps the most compelling demonstrations of linguistic effects on color perception have come from studies of *categorical perception*, which refers to the observation of faster or more accurate discrimination of two items (i.e., colors) between categories than within a category. To be more precise, if three different colors, A, B, and C are equidistant from each other on a continuum of physical measurements (e.g., Munsell color system), but A and B are reliably discriminated in some perceptual task more accurately or more rapidly than is true for B and C, then it is assumed that B and C fall within the same category, while A and B are in different categories. In short, categorical perception is the claim that smooth physical continua are broken into more discrete units, at least for some purposes, such that within-category differences are discriminated less well than cross-category differences.

The question posed by linguistic relativity is, "Are these discriminative differences observed in perceptual tasks aligned with the way color terms are used in a particular language group, and if they are aligned, are the perceptual differences caused by the linguistic differences?" As a practical methodological matter, these studies often emerge from a comparison of two different linguistic communities, one of which habitually refers to two specific hues with two different basic color terms, compared to another community which routinely uses the same basic color term to refer to the same two hues. For example, in Russian there is no single word for *blue*; rather, there are two terms *goluboy* and *siniy*, that correspond to what English speakers might characterize as lighter blue and darker blue, respectively (Winawer et al., 2007). In a speeded discrimination task Russian speakers, but not English speakers, were faster to discriminate various pairs of blues (in terms of English) if one was *goluboy* and one was *siniy,* as opposed to both being in the same category. Winawer et al. further found that the categorical perception effect was stronger for pairs of colors that were physically close (i.e., hard to discriminate), and that the effect was eliminated if speakers were engaged in a secondary task that was verbal, but not if it was spatial. Thus, lexical categories appear to alter ongoing perceptual activity when semantic activities (that include color naming) are not engaged elsewhere.

Comparing Greek and English speakers, Thierry et al. (2009) found enhanced perceptual discrimination of colors that are distinguished in Greek but not in English, *ghalazio* and *ble*, including event-related potentials fast enough to suggest the effects were perceptual and unconscious. Roberson et al. (2008) used a visual search task and found faster cross-category than within-category color discrimination by Korean speakers, who observe a linguistic boundary that does not exist in most other languages, and thus is unlikely to be part of any universal set of color categories. These and similar studies suggest that color space is not perceived as uniformly distributed; rather it is structured, and one of the factors contributing to the structuring are color naming practices of particular linguistic communities. In addition, the interplay of linguistic and perceptual activity appears to be dynamic (or "online"), rather than a fixed effect or one that requires conscious reflection (Thierry et al., 2009; Winawer et al., 2007).

It is important to note that the studies showing linguistic influence in color perception do not mean that speakers whose language does not make a distinction, for example, between lighter blue and darker blue, cannot see the difference. Speakers with or without the linguistic distinction can see the difference, but speakers of a language that marks the difference in a particular (i.e., conventional) way, are encouraged, even obligated, to notice the difference in a way that others are not. This is despite the fact that the perceptual task does not require linguistic guidance or involvement. Finally, although the evidence from the three studies just cited suggests that linguistically marked differences sharpen and speed the perception of certain color differences, there is insufficient evidence to indicate whether the categorical effects are due to cross-category differences being enhanced in some way, or within-category differences being diminished, or some combination of both.

1.1. Neurological evidence

In addition to the behavioral evidence for relativity effects, there have been neurological studies that point to linguistic involvement in various perceptual tasks involving colors and action choices. For example, using functional magnetic resonance (fMRI), Tan et al. (2008) found evidence of neural activities related to linguistic actions (e.g., word finding and naming tasks) being involved in neural networks during a color task that required a speeded decision of whether two colors were the same or different. The crucial finding was that activity in these areas (i.e., left posterior superior temporal gyrus and inferior parietal lobule) was strongest when the colors were easy-to-name as opposed to hard-to-name. The significance of this distinction is that easy-to-name colors are those that are most clearly differentiated and marked in the language, and thus, the ones most likely to generate linguistic activity while making same/different decisions. Despite the neural activity difference, there was no difference in accuracy or speed with which decisions were made.

Following up Tan et al.'s (2008) study, Siok et al. (2009) used event related fMRI measures to assess categorical perception in the discrimination of targets in the blue–green range, where the task required a speeded decision about whether the target (e.g., a blue among blues, or a blue among greens) occurred in the left or right visual field. They found that the discrimination of targets for cross-category colors were faster, with somewhat weaker evidence that these categorical differences were faster for right visual field (RVF) targets (which are first "processed" in the left hemisphere). The fMRI measures indicated that there was enhanced activity in both visual and linguistic areas (associated with lexical search and semantic retrieval) that was stronger for cross-category targets, primarily in the RVF. They interpreted these findings as supporting the claims made by Gilbert et al. (2006) that Whorfian effects are restricted to or are much stronger in the left hemisphere than in the right hemisphere. However, Drivonikou et al. (2007) reported that categorical perception effects occurred in the LVF (thus, the right hemisphere) as well as in the RVF (i.e., left hemisphere), a finding to which we will return later.

More recently, Holmes et al. (2009) used a visual "oddball" task, finding both enhanced accuracy and faster reaction times for cross-category compared to within-category color differences, where the differences between within-category and cross-category differences were equated in terms of Munsell hue. The evidence from event-related potentials suggested that early perceptual processes were involved, as well as later post-perceptual processes. Holmes et al. believe that linguistic effects occur in post-perceptual processes; thus, they propose that categorical perception effects that occur early must be due to non-linguistic constraints. This view may reflect the tendency of this group of researchers to favor the view that there are universal constraints on the structuring of color perception into focal colors.

Finally, using a same/different color discrimination task Liu et al. (2010) found evidence from event-related potentials that categorical effects occurred for RVF more than for LVF, which was primarily due to the suppression of within-category color differences. They note that this is consistent with linguistic influences (i.e., same name) on perceptual discriminations, but they did not observe clear evidence for greater left hemisphere activity in language-related areas for RVF differences. They discuss a number of methodological details that vary across studies that could account for varying results, but their study provides the clearest evidence to date suggesting that categorical perception effects may be due more to the difficulty of within-category discriminations than to the enhancement of cross-category discriminations.

Overall, these studies strengthen the case for linguistic relativity effects, but the details and patterns of how such effects occur are far from clear. Whether linguistic influences occur early or late, whether they function in both hemispheres or only one, and whether they are the primary cause of categorical perception effects or only one of many causes are all questions awaiting further research.

1.2. Surprises for everyone

Despite the impressive recent evidence offered in support of linguistic relativity effects, recent studies have provided no support for strong claims of linguistic determinism that are often attributed to Whorf (Wolff and Holmes, 2011). Rather, the picture that has emerged is of an array of effects, subtle and varied, that depend on learning, as well as developmental and cultural histories, and that are shaped and shifted by ongoing perception–action tasks, whether these are chosen by the speaker–thinkers (e.g., bilinguals' choice of which language to use) or by researchers (e.g., their choice of experimental tasks to assign). As one researcher has noted, the findings that have emerged do not fit neatly into traditional debates that have framed much of the research of the past half-century; there have been surprises for everyone (Kay and Regier, 2006; Regier, 2007).

One of the most interesting of these surprises is that entirely arbitrary color categories can be learned that then lead to a shift in categorical perception of color in the RVF (Özgen and Davies, 2002; Zhou et al., 2010). That is, colors which share a common name (within-category) before learning become cross-category after learning, resulting in their being perceptually discriminated more quickly. These categorical effects on reaction time involved violations of the larger scale patterns that ordinarily shape participants' discriminative activities (i.e., universal tendencies in color naming, and the categories of the participant's own language). That is, short-range learning can nurture categorical perception that overrides the boundaries of one's own language or those of many (or all) languages. Athanasopoulos et al. (2011) found that cognitive processing of bilinguals who spoke languages that did and did not segment semantically a certain portion of the color spectrum (e.g., light and dark blue) tended to follow the pattern of the language they had been speaking most frequently in the weeks prior to engaging in the experimental task.

Second, there has been a surprising array of variation in results across specific tasks and across specific measurements of influence (Liu et al., 2010). Experiments examining the possibility of linguistic influences include color discrimination (e.g., Drivonikou et al., 2007; Gilbert et al., 2006; Liu et al., 2010), color naming (e.g., Roux et al., 2006), forced-choice recognition (e.g., Roberson and Davidoff, 2000; Goldstein et al., 2009), Stroop interference (e.g., Wiggett and Davies, 2008), and various dual-task paradigms (e.g., Hermer-Vazquez et al., 1999; Trueswell and Papafragou, 2010). It is likely that different tasks vary significantly in the extent to which a person's linguistic practices (e.g., speaking French or Japanese daily) interact with various cognitive processes, but researchers are far from having a clear, coherent sense of those interactions. This diversity of tasks has generated many questions, such as whether linguistic effects are localized, are post-perceptual, and require longer time periods and lighter cognitive loads that are not typical of many cognitive tasks (e.g., Goldstein et al., 2009; Trueswell and Papafragou, 2010; Wolff and Holmes, 2011).

One question that continues to be unresolved is whether language plays a facilitating role in color perception (e.g., Goldstein et al., 2009; Kim et al., 2008; Pilling et al., 2003; Roberson and Davidoff, 2000; Winawer et al., 2007), or an inhibiting role (e.g., Liu et al., 2010). Some studies have suggested that both facilitating and inhibiting effects occur. For example, Drivonikou et al. (2007) found that RVF targets were detected more quickly than LVF targets for cross-category colors, but that the reverse was true for within-category colors.

A third surprise has been studies indicating that Whorf-like effects are lateralized to the left hemisphere (e.g., Gilbert et al., 2006; Siok et al., 2009), and others indicating that they occur in both hemispheres (e.g., Drivonikou et al., 2007; Roberson et al., 2008). It has been claimed that these categorical effects occur for different reasons and follow different developmental trajectories in the two hemispheres. Franklin et al. (2008) have presented evidence of categorical perception effects for color in pre-linguistic children, but only in the right hemisphere or LVF (Franklin et al., 2008). Infants (4–6 months) initiated eye movements to a color difference, if the difference crossed what adults would treat as different color categories, more quickly than if the difference was between colors that an adult would consider two shades of the same color category. These data showing categorical perception in infants do not sit comfortably with either strong relativist (Davidoff, 2001) or strong universalist (Kay and Regier, 2003) positions. The categorical effects do not fall neatly along the lines that a universalist theory would expect, but the very existence of such effects appears to indicate that categorical perception cannot be due to language alone, since the effects emerge prior to children learning color terms (Goldstein et al., 2009).

By contrast, adults engaged in the same visual task given to the infants in the Franklin et al. (2008) study show categorical perception effects in both hemispheres, but more strongly in the left hemisphere (or RVF). Franklin et al. (2008) consider these results puzzling since categorical perception effects occur in both hemispheres: Are the left hemisphere effects due to linguistic influence alone? Are the right hemisphere effects a "leftover" of the processes operative in infants, or are they influenced by the use of linguistic color terms as well, or even exclusively? The complex relation of color naming practices to hemispheric differences in the speed and accuracy of discrimination tasks has yielded as many questions as answers at this point.

On balance the safest position at present seems to be that there may be some broad ecological–biological biases (e.g., heightened attention to red) shared by children across language groups affecting color preferences and discrimination behavior (e.g., eye movements), but there are also clear, early effects of cultural exposure and patterns as well. These cultural influences increase with the learning of language and may lead to longer-term shifts, as well as online modulations, in how colors are perceived and remembered.

1.3. Motivations for the present studies

The experiments we will describe did not address, at least directly, categorical perception, nor did it tackle developmental or cross-cultural comparisons, or the theoretical debates usually surrounding them. Rather our purpose was to broaden our understanding of tasks that require the discrimination of colors, the effects that linguistic categories (i.e., color names) have on those discriminations, and the speed with which those discriminations were made. One of the factors that prompted our study was the tendency of many prior experiments to choose a very narrow range of colors (e.g., blues and greens) to use as stimuli. Given the focus on particular questions about categorical perception, this is understandable, but nevertheless, it limits more general conclusions about the speed and accuracy with which colors can be discriminated and named.

A second factor we wanted to address was the diversity of tasks that have been used in various studies, most of which have focused on close discriminations (e.g., shades of blue–green) that are perceptual in nature. More particularly, we wanted to compare a task that was linguistic with one that did not require linguistic involvement, except as it involved a choice, which could be characterized verbally ("yes/no").

Third, we wanted a task that was challenging in terms of the information load, yet one that could be done with a high degree of accuracy. We did this by adopting a recognition memory task, rather than a perception task, one that involved many colors, and thus could be characterized as "high information load," but which allowed for sufficient study time that high levels of accuracy were possible.

Fourth, we wanted to address whether there were lateralization effects in which linguistic influences might affect the speed with which colors could be perceived and remembered. To address linguistic effects on lateralization, we adopted the tactic of Tan et al. (2008) of using easy-to-name and hard-to-name colors. This allowed us to skirt issues of categorical perception, and the limits on color diversity it required, and the tendency to focus on perception as the "acid test" of such effects. It also allowed us to use a much more everyday task in which we measured how quickly and accurately people could remember specific colors that they had studied earlier. Of course, memory tasks might be somewhat more susceptible to linguistic influences than perceptual ones as well, but we wanted to give an ample chance for such effects to occur, so we could measure what effect they would have on the speed and accuracy with which decisions were made.

Finally, we were interested in the question, "Do linguistic effects, if they occur, help or hurt the speed (or accuracy) with which colors can be named or remembered?" No direct measures of facilitation or inhibition were made, but we thought differences in the speed with which decisions were accurately made might contribute to clarifying prior commentary on this issue, which we discussed briefly earlier.

To summarize, we adopted the approach of Tan et al. (2008) of using easy-to-name and hard-to-name colors in two different tasks, a naming task and a recognition memory task. Using accessibility of color names rather than manipulating distances in color space increases the possibility that there will be spontaneous naming of colors. The question we wanted to focus was: First, does the implicit, spontaneous naming of colors affect other color discrimination tasks—recognition memory, in our case—and are the effects of accessibility lateralized, as others (e.g., Tan et al., 2008) have argued, or do they occur across both hemispheres? Second, does the accessibility of color names affect the speed and accuracy with which colors are named or remembered?

2. Experiment 1

Our first study investigated the accuracy and speed of naming color targets that differed in their ease of accessibility across right and left visual fields. This task required the explicit retrieval of color terms. We expected that differences in accessibility of color terms would lead to faster response times for easy-to-name colors than for hard-to-name colors. Moreover, we expected that this difference would be strongest for colors presented in the RVF, since naming is an explicitly linguistic task. Furthermore, we expected that accuracy of naming would be very high for easy-to-name colors, and markedly less accurate (i.e., using consensus judgments as the criterion) for hard-to-name colors.

Results of this study were expected to confirm the validity of the accessibility manipulation, and to see if the findings of other researchers (e.g., Tan et al., 2008) who used other methods and materials to examine linguistic effects on color cognition could be replicated. Overall we expected to find that in a naming task, language (i.e., linguistic accessibility) would enhance the speed and accuracy with which the task was done, and that this effect would show a lateralization effect to the RVF.

2.1. Materials and procedure

2.1.1. Participants

Twenty-one right-handed undergraduate students from South China Normal University in China (mean age = 21.4 years, SD = 1.2 years; 12 males) participated in the experiment. All had normal or corrected-to-normal vision, normal color vision as assessed by the City University color vision test (Fletcher, 1980), and were native Chinese speakers. All participants declared that they had not participated in a psychological experiment previously and provided informed consent to participate.

2.1.2. Materials

Forty-two color patches were used in the experiment. Twelve of these were easy-to-name colors and 12 were hard-to-name colors, as shown in Fig. 1. These 24 colors served as targets, while the other 18 were fillers. Each color patch was 1.06×1.06 cm in size and subtended approximately 1.04° of visual angle (with the participants' eyes being 60 cm away from the monitor). The stimuli were displayed on a 17-in. Dell SVGA monitor which was set to a refresh rate of 150 Hz. The RGB (red, green, and blue) values of the 12 easy-to-name colors were as follows (see Fig. 1): 0, 102, 255; 51, 51, 255; 0, 0, 204; 0, 204, 0; 51, 153, 51; 0, 153, 0; 0, 102, 0; 255, 255, 0; 255, 204, 0; 255, 0, 0; 204, 0, 0; 128, 0, 128. The RGB values of the 12 hard-to-name colors were as follows: 204, 204, 255; 100, 158, 167; 0, 128, 128; 0, 102, 102; 204, 255, 204; 51, 153, 102; 102, 102, 51; 204, 255, 153; 255, 204, 102; 204, 102, 0; 255, 153, 102; 153, 51, 102. Mean luminance was matched between the two groups of colors.

The accessibility of the names of the 24 stimulus colors and the typicality of the color for particular color category were both assessed in a preliminary experiment in which 30 native Chinese speakers who did not take part in the formal experiments were required to first write out the name of the 24 color patches and rate each of them on two Likert scales ranging from 1 (very difficult to access the color name, or very atypical color of that particular color category) to 7 (very easy to access the color name, or very typical color of that color category). All participants gave the same name to each of the 12 easy-to-name colors: Colors 1–3 in Fig. 1 were *blue*, 4–7 were *green*, 8–9 were *yellow*, 10–11 were *red*, and 12 was *purple*. For the

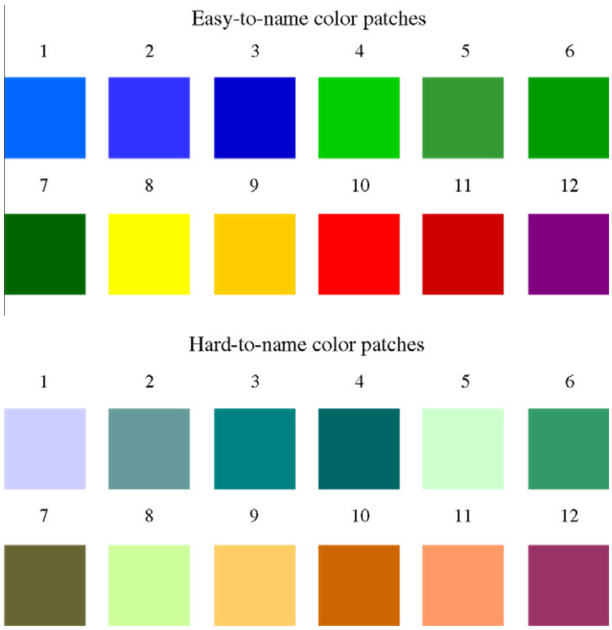

Fig. 1. Target colors used in Experiments 1 and 2.

hard-to-name colors, none of them was given a consistent name. For example, color 1 was *blue* or *purple*, color 2 was *blue* or *green*, etc. The 12 easy-to-name colors received high ratings for name accessibility ($M = 5.9 \pm 0.3$) and color typicality ($M = 5.6 \pm 0.4$), while the 12 hard-to-name colors received significantly lower ratings ($p < .001$) in naming accessibility ($M = 4.2 \pm 0.2$) and color typicality ($M = 3.8 \pm 0.2$).

2.1.3. Procedure

Participants were told that on each trial, the colors were to be presented one at a time against a white background (255, 255, 255), and the color names to be used were (the Chinese equivalents of) blue, green, yellow, red, purple, black, white, and gray. Instructions indicated that each name was to be given as quickly as possible, using these eight color terms. Participants were seated in a sound-attenuated room and viewed the display binocularly from a chin rest 60 cm away. Participants were instructed to fixate on a small black cross in the center of the monitor for the duration of each trial. After 500 ms a color patch appeared, ≈3.13 cm to the left or the right of the cross (within 3–5° of visual angle) with the cross remaining visible. After 50 ms both the color and cross disappeared. Participants named the color as soon as possible after the appearance of color patch. The program recorded their response time. The interval between trials was 500 ms. Participants were tested individually under the supervision of an experimenter, which allowed the experimenter to record the participant's responses.

There were two blocks of 42 trials. Each block contained the 12 hard-to-name colors, the 12 easy-to-name colors, and the 18 fillers, with equal numbers of colors in LVF and in RVF. Colors were presented in a fixed random order in each block of trials to ensure that no identical color name was used in any three successive trials. The order of presentation of the two blocks was approximately counterbalanced across participants. There were 5 practice trials before the test blocks and the first two trials of each test block were filler items.

2.2. Results

Responses latencies below 250 ms were not included in the analyses reported here (1.2% of the data were omitted). In addition, latencies longer than 2000 ms were excluded as outliers (0.2% of the observation). The mean correct response latencies and standard error of means for easy-to-name colors and hard-to-name colors are displayed in Table 1. These data were submitted to a 2 (accessibility of color name: easy-to-name colors vs. hard-to-name colors) × 2 (visual field: LVF vs. RVF) analyses of variance (ANOVAs) with repeated measurement by participants and by items. Not surprisingly, there was a significant main effect of accessibility of color name, F_1 (1,20) = 22.48, $p < .001$; F_2 (1,11) = 37.53, $p < .001$. Participants made faster responses to easy-to-name color patches ($M = 634$ ms) than to hard-to-name color patches ($M = 775$ ms). More importantly, there was a salient Accessibility × Visual field interaction (F_1 (1,20) = 5.74, $p < .05$; F_2 (1,11) = 5.5, $p < .05$), reflecting easy-to-name color RTs were faster when presented in RVF than in LVF, F_1 (1,20) = 10.6, $p = .004$; F_2 (1,11) = 10.38, $p = .008$, but the difference between two visual fields for hard-to-name color RTs was not significant, $Fs < 1$.

Participants made consistent responses to the easy-to-name colors within the specified exposure period. However, they very occasionally failed to make any response to hard-to-name colors (1.9% of cases). Responses to hard-to-name colors were inconsistent, with more than one color term assigned to each of them. We considered the most frequent response to be the correct answer for hard-to-name colors (see Table 1). The same two-way analysis of variance as for reaction time was conducted for accuracy. The results indicated a significant main effect for accessibility of color name on accuracy (F_1 (1,20) = 60, $p < .001$; F_2 (1,11) = 19.72, $p = .001$), but no main or interaction effects for visual field on accuracy were observed.

2.3. Discussion

Our results indicate that participants responded faster to easy-to-name colors than hard-to-name colors. Critically, there was a RVF advantage for easy-to-name colors, but not for hard-to-name colors. Since the RVF projects to the left hemisphere (LH), which serves speech and other linguistic functions, it is not surprising that naming responses were faster. Thus, the

Table 1
Mean latencies/standard deviations of correct responses (in ms) and accuracy scores (percent correct) in color naming task.

Accessibility of color name	Visual field	
	LVF	RVF
Easy-to-name color	659/72	609/50
Hard-to-name color	775/200	774/150
	Accuracy	Accuracy
Easy-to-name color	96%	95%
Hard-to-name color	72%	73%

faster responses to easy-to-name colors in the RVF than in the LVF makes sense if language enhances the processing of easy-to-name colors. However, there was no significant difference in time taken to say the name of hard-to-name colors between RVF and LVF, suggesting that ready accessibility of color names (i.e., implicit categorization) did not help the naming of hard-to-name colors. Thus, the results are mostly easily understood as showing a facilitation effect for easy to name colors.

First, the results of greater accuracy and faster naming of easy-to-name color validates the choice of easy-to-name and hard-to-name colors. Second, and more interesting, is that the increased speed of naming occurred only for colors presented in the RVF. The interaction effect showing that the shortest mean reaction time and the smallest variance occurred for easy-to-name colors in the RVF suggests that the linguistic nature of the task favored easy-to-name rather than slowing the attempt to name colors that were less typical (i.e., more ambiguous) about the correct category to which they should be assigned. Reaction times were equal for hard-to-name colors in both LVF and RVF, which provides further support for accessibility enhancing naming performance, since an inhibitory process would have likely led to hard-to-name targets in the LVF being particularly slow to be named.

Although we compared easy-to-name and hard-to-name colors like Tan et al. (2008), we observed differences in speed of naming for easy-to-name colors in the RVF, while they found no differences in accuracy or speed of color discrimination. Their task required a comparison of two color patches in order to make a same/different decision, while ours required saying the color of a single color patch. While naming might seem the easier task, a comparison of latencies across the two experiments indicates that the naming task we used took longer by more than 300 ms. The longer time to say the correct word we observed is probably due to the requirement that speech control processes be activated that are more complex than a left/right finger press. The perceptual discrimination task used by Tan et al. is sufficiently fast that it would not be likely to show timing differences, while our task gave time for such differences to emerge.

Having found evidence that explicit naming of colors was affected by the ease of accessibility of color terms, we turned to the more important question we wished to address: Would ease of accessibility affect the speed (or accuracy) with which colors could be remembered in a recognition memory task, when there had been ample time for the specific colors to be learned well enough to remember accurately?

3. Experiment 2

In Experiment 1 it appears that naming colors (i.e., assigning them to the consensually correct category) is fastest when colors are typical of their category (i.e., easy-to-name) and presented in the RVF. It is not surprising that easy-to-name colors are quick-to-name, and the particular speed with which this is done in the RVF fits the widespread assumption that linguistic functions such as naming are lateralized to the left hemisphere. In Experiment 2 we considered whether these biases for accessibility (and typicality) and for the RVF in speed of processing are sustained or altered in a color memory task. In particular, we wanted to choose a task that was not inherently linguistic like naming, and that required discriminating individual colors from an array of diverse colors rather than sampling a limited array (e.g., blue–green), as is often done in studies focused on categorical perception.

The task in Experiment 2 required participants to study 24 specific colors, 12 easy-to-name and 12 hard-to-name, until they felt confident they could remember them all. Recognition memory for target colors (relative to non-studied colors) was then tested and timed, with colors presented to participants in LVF and RVF. Given our assumption that easy-to-name colors were more likely to elicit a categorical name of a color than hard-to-name colors, we expected accessibility of naming to affect latencies of recognition decisions. One possibility is that implicitly generated color names would assist in remembering the colors, which might increase accuracy and reduce latencies of recognition decisions. A second possibility, one that we considered more likely, was that latencies would be slower for easy-to-name colors, since colors within a category (i.e., implicitly given the same name) would have their distinctiveness reduced. Thus, we predicted that reaction times would be faster for hard-to-name than easy-to-name colors.

Given that color naming is lateralized to the left hemisphere, and that we expected implicit naming of easy-to-name colors to affect latencies of recognition decisions, we predicted that effects of accessibility would occur primarily or exclusively in the RVF, as various other authors have suggested (e.g., Drivonikou et al., 2007; Gilbert et al., 2007). If this occurred, the pattern yielded would likely be the reverse of the pattern observed in Experiment 1. That is, latencies for easy-to-name colors in the RVF would be the slower than for all other conditions.

3.1. Method

3.1.1. Participants

A new group of 20 participants from the same subject population as in Experiment 1 were recruited in this experiment (mean age = 21.5 ± 1.2 years; 11 males).

3.1.2. Materials and procedure

The materials (e.g., target and filler colors) were identical to Experiment 1. There were two successive phases in Experiment 2, a learning phase during which participants studied the target colors to remember them, and a test phase during which their recognition memory of target colors was assessed relative to another group of colors, shown in

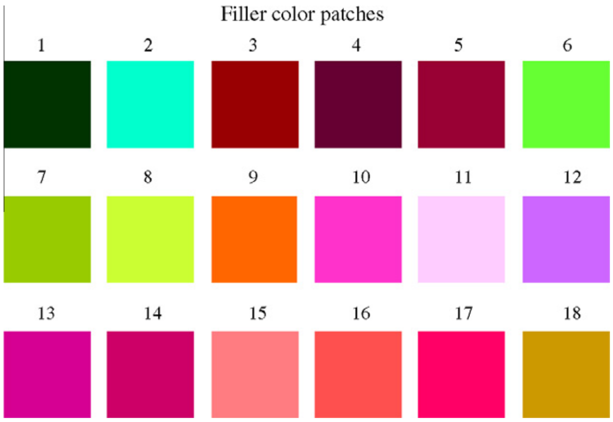

Fig. 2. Non-target colors used as fillers in Experiment 1 and recognition foils in Experiment 2.[1]

Fig. 2[1], which served as recognition foils. During the study phase, a trial sequence consisted of a black fixation cross on a white background for 500 ms indicating "get ready", followed by a color patch in the center of the monitor. Participants were required to memorize the onscreen color patch silently. Next trial began whenever they pressed the spacebar by the forefinger of their preferred hand. The interval of two trials was 500 ms. After the presentation of all the 24 test color patches, the program asked the participants whether they have surely memorized all the color patches, if not, they could press the key 'Q' to re-enter the study phase, if yes, they could press the key 'P' to go into the test phase. Therefore, the participants could keep on learning till they were sure that they have memorized all the target color patches. The presentation of the color patches was in random order.

During the test phase, each stimulus was preceded by the '+' signal (500 ms) in the center of the monitor. Then a color patch was presented at approximately 3.13 cm left or right away from the cross (within 3°-5°of visual angle) for 50 ms with the cross maintaining onscreen. Participants were asked to respond 'yes' if the color patch appeared previously in the study phase, and to respond 'no' if it did not while maintaining fixation on the black cross for the duration of each trial. Participants made their responses by using the index finger of each hand to press either 'yes' key or 'no' key designated by two keys on the left and right of the keyboard (the left/right position was alternated across participants). The instruction emphasized the importance of responding immediately after the appearance of color patch while maintaining high accuracy. The interval between trials was 500 ms.

Each stimulus was presented twice, one in the LVF and once in the RVF. Color stimuli were divided into two blocks. Each block contained 12 hard-to-name color patches, 12 easy-to-name color patches, and 18 fillers, with an equal numbers of colors in LVF and RVF. The color patches were presented in a fixed random order, with the restriction that no colors in any three successive trials belonged to the same color. The first two trials of each block were filler items. The order of the two blocks was counterbalanced across subjects. Before the test session, there was a practice session, using different color stimuli, in which there was a study phase and a test phase, which ensured that participants were familiar with the procedure.

3.2. Results

In the learning phase of the experiment, the mean number of times participants studied the 24 target colors was 2.9 (SE = .7). Response latencies and accuracy rates of recognition memory trials were submitted to a 2 (accessibility of color name: easy-to-name color vs. hard-to-name color) $\times$ 2 (visual field: LVF vs. RVF) analysis of variance with repeated measurements on color patches, using both by-participant and by-item analyses. All reaction time analyses were performed on correct responses only. Responses shorter than 100 ms and longer than 1500 ms were omitted (this eliminated less than 2% of the data). The mean latencies, including standard errors, and accuracy rates are displayed in Table 2.

The analysis of variance revealed a main effect of Accessibility of color name, F_1 (1,19) = 5.42, $p < .05$; F_2 (1,11) = 5.95, $p < .05$, with longer response latencies for easy-to-name colors than hard-to-name colors (498 vs. 477 ms). There was also a main effect of Visual Field (F_1 (1,19) = 11.6, $p = .003$; F_2 (1,11) = 24.03, $p < .001$), with longer response times in RVF (M = 509 ms) than LVF (M = 466 ms). This pattern occurred for both easy-to-name colors (520 vs. 477 ms, $F(1,19) = 9.94$, $p = .005$) and hard-to-name colors (499 vs. 455 ms, F_1 (1,19) = 6.5, $p < .05$). There was no interaction of Accessibility and Visual Field ($F < 1$). Recognition accuracy for targets was uniformly high across all conditions, and there were no effects due to accessibility or visual field ($p > .05$).

3.3. Discussion

Using a relatively wide array of easy-to-name and hard-to-name colors in a recognition memory task, we found strong effects on response latencies for both accessibility of color names and visual hemi-field. Colors were recognized significantly

[1] The readers could contact the corresponding author for all the materials used in the current study.

Table 2
Mean latencies/standard errors of correct responses (in ms) and accuracy scores (percent correct) in color recognition task.

Accessibility of color name	Visual field	
	LVF	RVF
Easy-to-name color	477/163	520/181
Hard-to-name color	455/154	499/165
	Accuracy	Accuracy
Easy-to-name color	89%	87%
Hard-to-name color	88%	84%

more quickly if they were hard-to-name and if they were presented in the LVF. Accuracy, however, did not differ across conditions, and was relatively high (85–89%), especially for a speeded, high memory load task. These results are interesting for at least three reasons. First, the results overturn the common sense assumption that what is easy-to-name will be easy to recognize. Second, the results challenge the view that linguistic effects on color discrimination are restricted to the RVF (e.g., Drivonikou et al., 2007; Tan et al., 2008). Third, the results suggest that linguistic accessibility does not increase the speed with which a discriminative choice in a recognition memory task (i.e., target or non-target color) can be made; rather, it seems to slow it down.

These results lend support to both of the predictions we made: Latencies were longer for easy-to-name colors than hard-to-name colors, and the slowest latencies occurred when easy-to-name colors were in the RVF. While the results fit our expectations in some important ways, in other ways they led us to a broader, more careful examination of the literature. One of the most important things we discovered was there is considerable evidence indicating a LVF (right hemisphere) bias for color discrimination tasks, especially for memory tasks, and particularly for hard-to-name colors (e.g., Barnett, 2008; Clapp et al., 2007; Levy and Trevarthen, 1981; Sasaki et al., 2007; but see Danilova and Mollon, 2009). This would explain the shorter latencies for recognizing target colors in the LVF. These studies indicate that the LVF advantage for color discrimination is particularly apparent when colors are hard-to-name or when other task requirements (e.g., high memory load) make verbalizing ineffective.

A second important thing we discovered was a new appreciation for the flexibility and complexity of the relation between language and other forms of cognition–perception–action, and the multiple and differing ways in which these various activities interact. In particular, we came to realize that there are multiple ways in which our results might be approached, and multiple places in our experimental task in which language might be playing a role. We turn now to examining those possibilities and assessing the larger context of these studies.

4. General discussion

How do linguistic distinctions and relations affect the accuracy and speed of various cognitive tasks? While many recent experiments have examined the perception of color, we examined naming and recognition memory. Experiment 1 found that easy-to-name colors were named more accurately and more quickly than were hard-to-name colors for both left and right visual fields (LVF and RVF), but the speed of naming was most pronounced for easy-to-name colors in RVF. This suggests that spontaneous linguistic classification of colors speeded naming responses, and supports other recent studies (e.g., Drivonikou et al., 2007; Gilbert et al., 2007) showing such effects are lateralized to the RVF.

In Experiment 2 we tested for recognition memory of these same easy-to-name and hard-to-name colors in a paradigm that was challenging (i.e., high memory load), but which encouraged high accuracy (i.e., learning to criterion). Recognition accuracy was high across all conditions, but speed of processing was faster for hard-to-name colors and colors presented in LVF. These results suggest two things: (1) spontaneous linguistic classification of colors in easy-to-name conditions slows recognition memory decisions in both LVF and RVF; and (2) recognition memory of colors is lateralized to (i.e., processed faster in) the right hemisphere (LVF). The former finding, of inhibitory effects due to lexical categories, suggests language-cognition interactions are not restricted to the RVF, as some have suggested (e.g., Regier, 2007; Tan et al., 2008). Together the findings support the view that linguistic effects are flexible, varying with cognitive tasks, and these effects enhance or inhibit speed of processing. Tan et al. (2008), for example, did not observe differences in the speed of perceptual (same/different) color decisions, but we did observe them in our recognition memory task, and across both hemispheres.

4.1. Hemispheric effects, color and linguistic relativity

We predicted and found that when color names are highly accessible, accurate RVF responding in a color-naming task is faster than in other conditions, but in a recognition memory task accurate RVF responding is slower than other conditions. But how, exactly, is it that these effects occur? More generally, why are hard-to-name colors recognized more quickly than easy-to-name colors, why do these effects occur in both visual fields rather than only in one, and why does recognition occur more quickly in the LVF than the RVF? We will briefly consider each of these questions, considering as we go several possible ways of accounting for our results and those of others.

First, perhaps the most crucial assumption made in our studies is that easy-to-name colors are more likely to activate linguistic categories for focal colors, as structured, partly at least, by the participants' own language. Tan et al. (2008) has provided neurological evidence of linguistic involvement with perception–action choices (e.g., same/different color) with easy-to-name colors that does not occur for hard-to-name colors, thus providing direct support for our assumption. Other studies have found neurological (Liu et al., 2010; Siok et al., 2009) and behavioral (e.g., Drivonikou et al., 2007; Gilbert et al., 2007) evidence for linguistic category effects on color discrimination tasks. These studies have suggested that linguistic effects occur most prominently in the left hemisphere and either ''sharpen'' (Tan et al., 2008) color discrimination across linguistic category boundaries, making reaction times faster, or make within-category differences more difficult to discriminate, thereby slowing reaction times.

Second, we believe that the evidence from a variety of studies showing categorical linguistic effects on reaction time (e.g., Drivonikou et al., 2007; Liu et al., 2010) is most compatible with the view that these effects occur primarily because reaction time is slowed for within-category discriminations. Although our experiments do not employ cross- and within-category judgments, easy-to-name colors are those that tend to be focal, that is, typical of the category and thus perceived as similar to each other. If this is so, then activation of the category is likely to make those typical, similar colors more difficult to discriminate, at least in a memory context, compared to less typical (e.g., hard-to-name) colors, yielding slower reaction times.

More general arguments about the effect of conceptual structure on the speed with which particular exemplars of a conceptual category can be recognized lend further support to the view that linguistic categories can increase the time needed to distinguish two exemplars of the same category. Although the categories they used in their experiments were not colors, Lupyan et al. (2010) provide evidence that if a category is strongly evoked by a typical exemplar (e.g., a prototypical dog), this biases subsequent perceptual discrimination. Applying their argument to color discrimination, any highly typical exemplar of a color category presented visually is likely to invoke the conceptual category (e.g., blue), which tends to increase the similarity between exemplars, which increases the time to differentiate them. By contrast, a less typical color (e.g., hard-to-name colors) tends to elicit the conceptual (in this case, linguistic) category much less strongly, and thus the delay in distinguishing a particular color from some comparison color is reduced (Lupyan et al., 2010).

The third critical fact that helps to explain our findings is the evidence, cited in our earlier discussion of Experiment 2, showing that color discrimination, particularly in memory tasks, occurs preferentially in the right hemisphere. Such lateralization would yield quicker discriminative responses in color memory tasks in the LVF. The one recent paper that questions the LVF (right hemisphere) bias (Danilova and Mollon, 2009) used a perceptual threshold paradigm for color detection, which differs from most other tasks described in the literature, including ours. Their study does remind us, however, of a crucial point: Color can be discriminated minimally in either visual field. With color differences that are well above thresholds, though, the evidence suggests that color discriminations are accomplished more quickly in the right hemisphere (LVF).

In addition to the studies showing a LVF advantage for color discrimination, it is important to note that, even researchers who have emphasized the left hemisphere lateralization of linguistic relativity effects, such as Drivonikou et al. (2007), have also reported effects for the right hemisphere. Furthermore, Roberson et al. (2008) found equally strong linguistic effects in categorical perception (of two different blues marked in Korean) in both visual fields. Thus, they found, as we did, evidence for rapid differentiation of colors in the LVF, where the color differences are categorically differentiated in the language of the participants.

With these facts and assumptions clarified, we return to the questions posed earlier to see if they will illumine the pattern of results we observed. In Experiment 2 the most likely reason that hard-to-name colors are recognized more quickly is that they engender little or no implicit naming of color categories which tends to slow the process of deciding whether a given color is a target color learned earlier, or not. If spontaneous naming of colors reduces the distinctiveness of individual colors relative to other colors that share the same name, it would make their recognition in a memory task slower. Given the expected LVF advantage in recognition memory for colors, and the lower likelihood of spontaneous naming effects for hard-to-name colors, one would expect reaction times to be shortest for LVF and for hard-to-name colors. This was precisely what we found (i.e., a main effect for each variable). The fastest reaction time was for hard-to-name colors in the LVF; the slowest was for easy-to-name colors in the RVF. If this explanation is correct, hard-to-name colors are not recognized more quickly; rather, easy-to-name colors are recognized more slowly.

There are at least two alternative possibilities for explaining the difference in speed of recognition memory responses for hard-to-name and easy-to-name colors. One possibility is that the recognition time differences are generated by differences occurring during the study phase rather than memory phase of the experiment. It might be proposed that hard-to-name colors were studied longer than easy-to-name colors, and thus they are processed more quickly during the memory phase. This is unlikely, we think, because the recognition accuracy scores were unaffected by accessibility. The criterion for the learning procedure (i.e., know all the colors) was designed to minimize differences in accuracy. Participants were generally successful in realizing their intention to be able to recognize the target colors with high accuracy. Whatever effects accessibility of color names (or focal vs. non-focal colors) had, it does not appear that it alters perceptual discriminations of color per se. What was altered was the speed with which the decision to identify a color as a target color studied earlier. However, it is difficult to see how more effort during the study phase would increase speed of response without affecting accuracy.

Another possible way of trying to account for the difference in speed of recognizing hard-to-name and easy-to-name colors would be to claim that there was something unusual about the non-target colors (i.e., foils in the recognition paradigm) relative to the target colors that made faster recognition of hard-to-name colors possible, or made the easy-to-name colors more difficult to differentiate, slowing recognition. While this is possible, we cannot see any obvious difference in the relationship of easy-to-name and hard-to-name colors relative to the non-target foils. If anything, it appears that easy-to-name colors, overall at least, were more distinctive relative to the non-target foils than were hard-to-name colors.

One could criticize our experimental designs for not including secondary tasks designed to interfere with verbal processing, but there is evidence that effects of spontaneous color naming can survive such interference (Pilling et al., 2003), so inclusion of such secondary tasks is no panacea for ruling out alternative explanations. However, since Experiment 2 did not demand color naming or categorization, our explanation for the pattern of reaction times across conditions remains open to correction or refutation by further research.

Finally, we return to the last question about our results, posed earlier, regarding why easy-to-name colors were slower to be recognized than hard-to-name colors in the LVF, as well as in the RVF. If the effect of linguistic categories occurs during the recognition phase primarily, as we argued above, it does not seem difficult to explain linguistic effects (i.e., slowing) for RVF targets. What seems to require more explanation is the increase in reaction times found for easy-to-name colors when presented in the LVF. Although we can offer no direct evidence, a plausible explanation is that LVF colors initiate right hemisphere color discrimination functions, simultaneously projecting across the corpus callosum to left hemisphere identification functions. If the color is hard-to-name (i.e., not easily identifiable), the discrimination functions of the right hemisphere will control the yes/no memory decision enacted in the key press. On the other hand, if the color is easy-to-name, the categorical identification processes in the left hemisphere may compete for control of action functions related to keystroke choice, or at least generate a cautionary signal, that slightly delays the right hemisphere discriminative functions from selecting the correct answer. Evidence for or against such multiple constraint satisfaction of action choices in color recognition remains to be tested, but such accounts are emerging across cognitive science as a major contender for explaining the dynamics of choice and coordination (e.g., Lupyan et al., 2010). Overall, the pattern of reaction times in Experiment 2 could be largely explained by the neural state-space dynamics with a right hemisphere bias for color discrimination and a left hemisphere bias for linguistic categorization (i.e., implicit naming in our experiments), with color discrimination being weighted more heavily than linguistic categorization.

4.2. Distributed language and ecological color

Given that this research is being presented in the context of a special issue on "caring and conversing," what are the implications for distributed, dynamical, and ecological approaches to language? First, the *dynamics* of ways of speaking on ways of recognizing aspects of the world that have been conceptualized in many languages as "color" (including the ones within which scientists work) has yielded two clear patterns. One pattern suggests that semantic distinctions, including those that have been organized into a color domain, are *not* arbitrary conventions of particular languages. The second pattern indicates that variations in semantic practices over various time scales *do* alter perceptual and cognitive actions relative to colors. Put differently, linguistic relativity effects occur, but they do so against a backdrop of constraints that appear to be very broad and non-local. This has led some former combatants in the "Whorf wars" (e.g., Regier et al., 2010) to argue that a two-sides approach to language and thought questions (i.e., universalism vs. relativity) should be abandoned. Neither the non-local patterns of color recognition nor the more localized effects of particular ways of talking about color appear to be superficial (Roberson and Hanley, 2010).

Second, there has been increasing evidence of the *distributed* nature of language and color. Effects of specific linguistic practices occur across many domains (e.g., time, pitch), not just color, and these effects seem to be distributed across many time scales. Furthermore, these relativity effects are distributed across neural hemispheres, as our findings and those of others suggest. We believe that many factors besides hemispheric biases would be needed to account for variability across items and individuals we observed. Among those factors would be specific relations between targets and distractors (non-target colors), noted earlier, as well as factors such as faster and slower responders (Roberson et al., 2008), the diversity of the range of targets or boundaries to be distinguished (Liu et al., 2010), and historical (Rączaszek-Leonardi, 2010) and developmental usage patterns (Athanasopoulos et al., 2011). Neither language nor color can be confined to specific spatial–temporal scales. This distributed approach argues against claims of "a separate color-processing system that is completely independent of linguistic influence" (Roberson and Hanley, 2010), and against a simple hemispheric difference of right-side color specialization and left-side language specialization. Hard-to-name colors, such as those we used, are not part of some separate color system that is independent of easy-to-name colors.

The dynamical, distributed character of language and color point to the possibility that both are far more diverse than even linguistic relativity theorists have supposed, and far more integrated and systemic than even universalist theorists have assumed. It appears that the more we learn about languages and colors, the more complex they become; we increasingly realize both how insightful and how naïve our lexicons and our conceptual carvings of the world are relative to our actual, situated experiences and actions in the world.

Third, an *ecological* insight into language and color, is provided by a growing body of literature in cognitive science that is usually described as showing "interference effects" of one physical dimension (e.g., size) on another physical dimension (e.g., speed), where it is assumed that the first dimension is "irrelevant" to the second dimension. For example, heavier weights (real or imagined) are perceived as lasting longer than lighter weights (Lu et al., 2009, 2011). Overall, the evidence suggests that people perceive affordances (i.e., integrated opportunities for interaction) rather than a set of separate dimensions that must be related to each other after the fact (Lu et al., 2011). It appears that psychologists may have the same lesson to learn that physicists did in an earlier era when another relativity theory (Einstein's) indicated that space, time, and gravity were "of a piece" rather than separable dimensions of the world. A good question, rarely asked (but see Casasanto, 2008), is what is the relation between these "interference effects" and relativity effects in color recognition, and the metaphorical character of cognition (Lakoff and Johnson, 1980) more generally.

More specifically, though, what are implications of our studies on naming and color for *ecological* approaches to psychology and language (e.g., Fowler and Hodges, 2011; Hodges and Fowler, 2010)? It is possible that the hemispheric patterns we observed—speeded naming of well-known, easily referenced colors, and slowed recognition of easily named colors, compared to equally well-known colors that were difficult to name—speak to a larger pattern relating action, perception, and thought. Perhaps, the bump up in speed for naming comes at the ecological price of slowed recognition, such that implicit color naming (i.e., spontaneous anticipation of talking about colors that we perceive or remember) creates a speed bump that slows the neural vehicles of color differentiation and recognition. Just as the evolution of a lowered larynx allowed for the development of phonological differentiation in humans, but opened the door to food not going to the right place (Lieberman, 1984), perhaps the evolution of a shared system of color reference (for coordinating ways of differentiating colors socially, over time and space), may have come with a tradeoff in recognition.[2] More generally, coordinating socially with others requires anticipatory actions that may impact the speed or even the accuracy with which a particular dimension of our surroundings can be differentiated and identified. Stable social coordination patterns (e.g., linguistic color reference) provide an "extended ecology" (Steffensen, 2011) in which humans may act, and these expanded affordances allow for the "going on" and "caring" (Hodges, 2007) that make human conversation and culture possible. Among other things, language has made possible scientific research on color perception, leading eventually to debates about color and language. But that consequence alone hardly justifies color talk. What could?

Thus, a fourth point, framed as a question: Why should we *care* about language and color? One dimension that seems missing from our experiments, as well as most others, is a larger sense of color and its role in perception and action. Our study and the studies we have referenced suggest that researchers have an abstract fascination with color, with linguistic differences, and with various measurement techniques for assessing their relation. The larger ecological and social context of why color matters, and why it matters if language helps to define the meaning and value of color for humans needs renewed attention.[3] After all, Whorf's original interest in such matters was motivated by his concerns about establishing valid truth claims and about the threats to truth entailed in the ethnocentrism of linguists treating their own ways of speaking as privileged (Lakoff, 1987, Chap. 18). Whorf thought that any one language was not sufficiently comprehensive to capture the truth of the world. Each language was marked by tradeoffs, and for certain pragmatic purposes (e.g., scientific description, literal translations of religious texts) some languages were better suited to a particular task than others. He was angered by the ethnocentrism of linguists who took their own ways of speaking—without argument—as the most comprehensive and precise way of articulating the world. Whorf's argument was less about relativism (i.e., each language defines its own reality) than it was about the need for humility and for the need for argument across languages, if linguists wanted to be careful and truthful in their own activities and descriptions.

Color—like conversation—is fundamentally dialogical. Conversations across languages, as well as within them, extend our ecology. It allows us to notice tradeoffs such as those noted earlier between speed and social stability (i.e., consensus). However, it may be that these are not so much tradeoffs as they are values-realizing tensions that need to be explored and appreciated (Hodges, 2007). Perhaps, this was the real reason Whorf was trying to get English-speaking linguists to notice Hopi possibilities. He was arguing against linguists' assumptions that their own particular way of speaking could comprehend all possible ways of speaking. Instead he argued for a relativity that put alternative ways of speaking in honest, unpretentious dialogue, such that integrity would increase for all who participated. It is, after all, the point of dialogue—for all who participate to grow and learn in ways that add color to everyone's experience and everyone's words.

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[2] We thank Sune Steffensen for suggesting this idea to us.

[3] Anthropologists such as Wierzbicka (2008), seem to be moving in the right direction in this regard.

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