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# Categorical Perception Beyond the Basic Level: The Case of Warm and Cool Colors

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**Abstract**

Categories can affect our perception of the world, rendering between-category differences more salient than within-category ones. Across many studies, such categorical perception (CP) has been observed for the basic-level categories of one's native language. Other research points to categorical distinctions beyond the basic level, but it does not demonstrate CP for such distinctions. Here we provide such a demonstration. Specifically, we show CP in English speakers for the non-basic distinction between "warm" and "cool" colors, claimed to represent the earliest stage of color lexicon evolution. Notably, the advantage for discriminating colors that straddle the warm–cool boundary was restricted to the right visual field—the same behavioral signature previously observed for basic-level categories. This pattern held in a replication experiment with increased power. Our findings show that categorical distinctions beyond the basic-level repertoire of one's native language are psychologically salient and may be spontaneously accessed during normal perceptual processing.

*Keywords:* Categorical perception; Color; Lateralization; Language and thought; Basic level

## 1. Introduction

Categories can affect our perception of the world, rendering between-category differences more salient than within-category ones (Goldstone & Hendrickson, 2010; Harnad, 1987). Across many studies, such categorical perception (CP)[1] has been observed for the basic-level categories of one's native language (e.g., Roberson, Pak, & Hanley, 2008; Thierry, Athanasopoulos, Wiggett, Dering, & Kuipers, 2009; Winawer et al., 2007; but see Wright, Davies, & Franklin, 2015). Other research points to categorical distinctions beyond the basic level (e.g., Berlin, Breedlove, & Raven, 1968; Boster, 1986; Heider,

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1972), but it does not demonstrate CP for such distinctions. Here we provide such a demonstration. Specifically, we show CP in English speakers for the non-basic distinction between "warm" and "cool" colors, claimed to represent the earliest stage of color lexicon evolution (Kay & McDaniel, 1978).

Previous research on CP in adults has focused almost exclusively on basic-level categories, showing that those of one's native language—but not of other languages—yield CP. For example, Winawer et al. (2007) found CP in Russian speakers—but not in English speakers—for light blue ("goluboy") and dark blue ("siniy") colors, a basic-level distinction in Russian but not in English. Several other cross-linguistic investigations of CP have yielded similar results for basic-level categories across a variety of languages (e.g., Davidoff, Davies, & Roberson, 1999; Goldstein & Davidoff, 2008; Holmes, Moty, & Regier, 2016; Kay & Kempton, 1984; Pilling & Davies, 2004; Roberson, Davies, & Davidoff, 2000; Thierry et al., 2009). There is some evidence that such cross-linguistic differences in CP are mirrored by corresponding differences in CP across the two hemispheres of the brain. Specifically, CP is often found to be lateralized, with stronger CP observed in the right visual field (RVF) than in the left (LVF) for basic-level categories in color and other domains—possibly reflecting the language dominance of the left hemisphere, to which the RVF projects (Drivonikou et al., 2007; Franklin et al., 2008; Gilbert, Regier, Kay, & Ivry, 2006; Gilbert et al., 2008; Holmes et al., 2016; Paluy, Gilbert, Baldo, Dronkers, & Ivry, 2011; Roberson et al., 2008 [for fast-responding participants]; Roberson & Pak, 2009; but see Brown, Lindsey, & Guckes, 2011; Witzel & Gegenfurtner, 2011 for failures to replicate this pattern). Lateralized CP has also been observed for newly learned categorical distinctions between items initially from the same basic-level category (Zhou et al., 2010; see also Holmes & Wolff, 2012), consistent with a downward shift in the basic level with training or expertise (cf. Tanaka & Taylor, 1991).

The emphasis on basic-level categories in these studies might give the impression that such categories are the only psychologically salient ones. However, much other work across the cognitive sciences suggests the existence of non-basic categorical distinctions that may also be psychologically active, even in the absence of overt linguistic marking (e.g., Burgess, Kempton, & MacLaury, 1983; Heider, 1972; cf. Malt et al., 2015). For example, Berlin et al. (1968) and Berlin, Breedlove, and Raven (1973) used the results from sorting and similarity judgment tasks to identify so-called covert categories that, though unnamed, represented culturally meaningful groupings within Tzeltal speakers' folk taxonomies of plants and animals. Similarly, Boster (1986) showed that native English speakers, when asked to successively sort colors, tended to honor distinctions at superordinate levels of the evolutionary hierarchy of color lexicons proposed by Kay and McDaniel (1978; see also Berlin & Kay, 1969; Kay & Maffi, 1999).

Although such evidence is suggestive, these and other studies of non-basic categories are limited by the explicit nature of the tasks used to reveal them. The conceptual groupings suggested by sorting preferences or similarity judgments may become salient only when one is tasked to find structure within a set of seemingly disparate stimuli, and hence may have no psychological reality beyond overt categorization contexts (for discussion, see Boster, 1986; Malt et al., 2015; Pinker, 1994; Winawer et al., 2007). Indeed, Boster

(1986, p. 71) stopped short of endorsing, on the basis of his findings from sorting tasks, the existence of "proto-color categories in [English speakers'] heads."

Stronger evidence for the psychological salience of non-basic categories would come from showing that these categories affect behavior in implicit tasks—especially those in which the categories are task-irrelevant and participants are unaware of being tested on them. Tasks used to assess CP meet these criteria. That is, such tasks typically require participants to make judgments about stimuli on the basis of appearance rather than categorical status, which the task structure renders non-obvious (Goldstone & Hendrickson, 2010; Harnad, 1987). If non-basic categories can be shown to yield CP in such an implicit task, this would suggest that they are—like basic-level categories—psychologically salient even when not explicitly invoked, and can modulate ongoing perceptual processing.

We investigated this possibility by testing for CP in English speakers for a non-basic categorical distinction between colors that is superordinate to the basic-level color categories of English. This distinction—claimed to be evolutionarily primary, reflecting the earliest stage of color lexicon evolution (Kay & McDaniel, 1978)—is captured by two-term color naming systems, as in the language Dani (Heider, 1972).[2] In the linguistic hierarchy of Kay and McDaniel (1978), proposed to represent the historical evolution of color categories across languages (see also Berlin & Kay, 1969; Kay & Maffi, 1999), two-term systems constitute the most coarse-grained division of colors—grouping white, red, orange, and yellow hues into one category, and blue, purple, green, and black hues into the other. In English, this distinction is marked by the non-basic, non-color-specific terms "warm" and "cool" (cf. Berry, 1961; Newhall, 1941).

Given evidence that CP is lateralized for basic-level categories (see Regier, Kay, Gilbert, & Ivry, 2010), we tested whether the non-basic warm–cool distinction would likewise yield lateralized CP. If lateralized CP is driven by the left hemisphere's dominance for language (e.g., Gilbert et al., 2006), one might expect not to find it in this case, as the terms "warm" and "cool" are much less frequently used to describe colors compared to basic-level terms. However, some studies have observed lateralized CP even for categories with no explicit labels (Holmes & Wolff, 2012, 2013), suggesting that lateralization may, at least in some cases, be driven by the left hemisphere's dominance for categorical processing more generally (see Kosslyn et al., 1989)—and hence might generalize to non-basic categories. To test for lateralized CP for the non-basic warm-cool distinction, we adapted the visual search task of Gilbert et al. (2006). To preview our results, we find faster discrimination of color pairs that straddle the warm–cool boundary compared to pairs that do not, but only when the stimuli appear in the RVF—the behavioral signature of lateralized CP.

## 2. Method

Our experimental method closely followed that of Gilbert et al. (2006). The general structure of the method was the same as theirs, but rather than testing for lateralized CP in English speakers for the basic-level green–blue distinction, we tested for lateralized CP in English speakers for the non-basic warm–cool distinction. Our method is described in full below.

### 2.1. Participants

Twenty-six University of California, Berkeley undergraduates participated for course credit. All were right-handed native English speakers and reported normal or corrected-to-normal vision, including normal color vision. One participant was excluded for a mean reaction time (RT) >2.5 *SD*s from the group mean RT.

### 2.2. Materials

We took warm colors to be exemplified by red and yellow, and cool colors by green and blue. In a pilot study, a separate group of 12 participants selected the best examples of "red" (R), "yellow" (Y), "green" (G), and "blue" (B) from a representative array of 144 colors presented on a computer screen. We used the modal choice for each of the four terms as our stimuli (see Fig. 1). As determined by a photometer, the Yxy values of the stimuli were as follows: R = (44.5, 0.63, 0.34); Y = (161.0, 0.42, 0.50); G = (31.2, 0.27, 0.55); B = (13.9, 0.15, 0.07). Stimuli were presented on a light gray background with Yxy values (84.2, 0.31, 0.33).

We computed the perceptual (dis)similarity of each of the six pairwise combinations of our four stimuli using two different metrics: CIELAB distance (assuming illuminant D65 and 2° observer; ASTM International, 2012; Wyszecki & Stiles, 1982), and a similarity metric that is a Gaussian function of CIELAB distance (Regier, Kay, & Khetarpal, 2007). As CIELAB distance is intended to capture relatively small color differences (Brainard, 2003), perceptual similarity for our stimuli may be better characterized by the latter metric. Table 1 displays both sets of values. If color pairs are discriminated based on perceptual similarity with no influence of categories, RTs should closely reflect CIELAB distance and the similarity metric—irrespective of whether the colors are from the same category or different categories. CP, in contrast, would be revealed by faster responses overall to between-category pairs than within-category pairs, over and above any influence of perceptual similarity. Lateralized CP would be revealed by a combination of

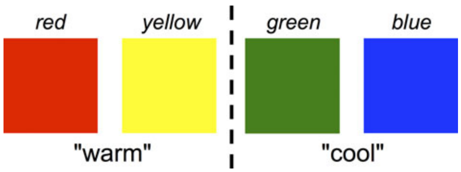

Fig. 1. Print-rendered versions of the four colors used. The dashed line represents the categorical partitioning of the colors into the two superordinate-level categories "warm" and "cool."

Table 1
Mean reaction times and standard deviations (in ms) to color pairs by visual field in the original experiment and replication, and measures of similarity/dissimilarity of color pairs

| | Original Experiment | | | | Replication | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | LVF | | RVF | | LVF | | RVF | | | | |
| Pair | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | CIELAB Distance | Similarity[a] | Lightness (L*) Difference |
| *Within-category* | | | | | | | | | | | |
| Red-yellow | 397.4 | 49.4 | 394.6 | 49.3 | 384.8 | 38.1 | 383.2 | 37.1 | 132.6 | $2.3 \times 10^{-8}$ | 47.4 |
| Green-blue | 404.4 | 43.5 | 406.0 | 43.7 | 395.2 | 42.1 | 394.2 | 43.5 | 218.8 | $1.7 \times 10^{-21}$ | 18.6 |
| Overall | 400.0 | 45.6 | 399.5 | 45.1 | 389.9 | 39.4 | 388.5 | 39.3 | 175.7 | $1.2 \times 10^{-8}$ | 33.0 |
| *Between-category* | | | | | | | | | | | |
| Red-green | 400.1 | 44.5 | 399.3 | 46.6 | 394.8 | 44.3 | 386.2 | 41.1 | 169.0 | $4.0 \times 10^{-13}$ | 9.9 |
| Red-blue | 406.3 | 54.3 | 390.3 | 33.6 | 390.4 | 39.6 | 383.5 | 35.9 | 207.1 | $2.3 \times 10^{-19}$ | 28.5 |
| Yellow-green | 402.7 | 48.6 | 393.6 | 41.6 | 384.3 | 39.2 | 383.8 | 38.2 | 94.4 | $1.4 \times 10^{-4}$ | 57.3 |
| Yellow-blue | 392.9 | 42.0 | 389.6 | 40.0 | 384.8 | 41.8 | 379.5 | 34.5 | 259.3 | $6.3 \times 10^{-30}$ | 75.9 |
| Overall | 399.9 | 46.1 | 393.1 | 39.3 | 388.5 | 39.8 | 383.2 | 36.1 | 182.4 | $3.4 \times 10^{-5}$ | 42.9 |

*Note*. LVF, left visual field; RVF, right visual field.
[a] Gaussian function of CIELAB distance (Regier et al., 2007).

these two patterns—that is, a between-category RT advantage should be observed in the RVF, but RTs should more closely reflect perceptual similarity in the LVF.[3]

### 2.3. Procedure

Each participant sat in a darkened room with her head positioned in a chin rest such that the center of the computer screen was at eye level. On each trial, a central fixation marker appeared on the screen for 1,000 ms, followed by a stimulus display for 200 ms (an interval that discouraged eye movements). The display consisted of a ring of 12 colored squares surrounding the fixation marker (see Fig. 2). Eleven of the 12 colors in the display were the same (distractors) and the twelfth was different (target). The target and distractor colors were from either the same category (e.g., yellow and red; both warm) or different categories (e.g., yellow and blue; warm vs. cool). Participants were asked to indicate, as quickly as possible, the side containing the target ("odd one out") by pressing the left ("Q") or right ("P") computer key with the corresponding index finger. The next trial began 250 ms after participants made a response.

There were six target-distractor pairs (two within-category: RY, GB; four between-category: RG, RB, YG, YB). Across trials, each member of a pair served as both target and distractor, and the target occupied all 12 positions in the display, yielding 144 stimulus configurations. Participants completed 288 randomly ordered trials, with each configuration presented twice. Preceding the test trials was a 12-trial practice block, with only the colors black and white as stimuli.

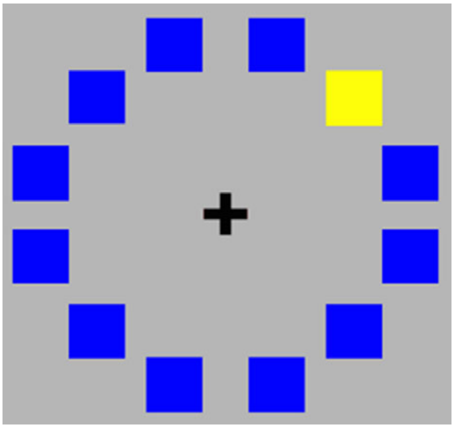

Fig. 2. Sample visual search display, here with a between-category pair ("warm" target: yellow, "cool" distractors: blue).

## 3. Results

Trials in which participants responded incorrectly (4.1% of trials) or in which RT was >2.5 *SD*s from individual means (2.3%) were excluded. A 2 (visual field: left vs. right) × 2 (categorical relationship: within- vs. between-category) repeated-measures ANOVA on the remaining RTs yielded a significant main effect of categorical relationship, $F(1, 24) = 5.55$, $p = .03$, $\eta^2 = .19$, with between-category pairs faster than within-category pairs. There was no main effect of visual field, $F(1, 24) = 1.83$, $p > .1$, but importantly, there was a significant interaction between visual field and categorical relationship, $F(1, 24) = 5.26$, $p = .03$, $\eta^2 = .18$, indicating lateralized CP. Participants responded faster to between-category pairs than to within-category pairs when the target appeared in the RVF, $t(24) = 2.95$, $p = .007$, $d = 0.69$, but responses were equally fast to the two pair types when the target appeared in the LVF, $t(24) = .06$, $p > .9$ (see Fig. 3). As is evident from Fig. 3, lateralized CP was driven by the between-category pairs, for which responses were faster when the target appeared in the RVF than in the LVF, $t(24) = 2.52$, $p = .02$, $d = 0.58$; no such difference between the two visual fields was observed for the within-category pairs, $t(24) = .15$, $p > .8$. An analogous ANOVA on the accuracy data yielded no significant effects (*p*s > .8), suggesting that there was no speed-accuracy tradeoff.

Inspection of mean RTs by pair suggests that lateralized CP was not limited to particular pairs: For all four between-category pairs (RG, RB, YG, and YB), responses were faster on average to RVF targets than to LVF targets (see Table 1); this difference reached significance for two of the pairs, RB ($t(24) = 3.21$, $p = .004$) and YG ($t(24) = 2.38$, $p = .03$). As discussed above, these results are unlikely to arise from uneven spacing of the stimuli in color space: CP was found in only one visual field, but the stimuli were the same across visual fields. Moreover, there was no clear relationship between RTs to RVF

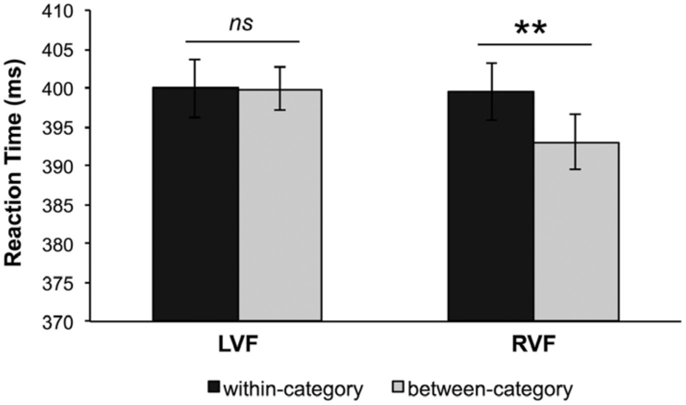

Fig. 3. Lateralized categorical perception for the non-basic warm–cool distinction. Responses were significantly faster to between-category than within-category pairs when the target appeared in the RVF, but no such difference was observed in the LVF. $^{**}p < .01$, $df = 24$; ns, nonsignificant. Error bars are 95% within-subjects confidence intervals. LVF, left visual field; RVF, right visual field.

targets and CIELAB distance ($r = -.02$), and there was, if anything, a negative relationship between RTs to RVF targets and Regier et al.'s (2007) similarity metric ($r = -.16$), inconsistent with discrimination based purely on perceptual similarity. The results are also not readily explained by differences in the intrinsic lightness of the colors, captured by the L* coordinate of CIELAB. The between-category pairs for which the largest RT differences were observed between visual fields (RB and YG) showed differences in lightness that were intermediate to those of the other pairs (see Table 1). Thus, we conclude that the non-basic warm–cool distinction yielded lateralized CP.

### 3.1. Replication

Given the relatively small sample size and effect size observed (a 6.4-ms between-category advantage in the RVF, or 1.6% change in RT), we conducted a direct replication to assess the reliability of the results. A power analysis on our data (RT difference scores, subtracting between- from within-category RTs, across visual fields), using G*Power (Faul, Erdfelder, Buchner, & Lang, 2009), indicated that a sample size of 40 would be needed to detect lateralized CP with 0.8 power. Therefore, 40 participants from the same population as in the original experiment were tested in the replication, using the same materials and procedure.

#### 3.1.1. Results

Trials in which participants responded incorrectly (5.2%) or in which RT was >2.5 *SD*s from individual means (3.0%) were excluded. A 2 (visual field) × 2 (categorical relationship) repeated-measures ANOVA on the remaining RTs replicated lateralized CP for the warm–cool distinction. There was a significant main effect of categorical relationship, with between-category pairs faster than within-category pairs, $F(1, 39) = 8.03$,

$p = .007$, $\eta^2 = .17$, no main effect of visual field, $F(1, 39) = 2.60$, $p > .1$, and a significant interaction between visual field and categorical relationship, $F(1, 39) = 4.15$, $p = .05$, $\eta^2 = .10$. Participants responded faster to between-category pairs than to within-category pairs when the target appeared in the RVF, $t(39) = 3.14$, $p = .003$, $d = 0.52$, but no such difference was observed when the target appeared in the LVF, $t(39) = 1.04$, $p > .3$ (see Fig. 4). As shown in Fig. 4, lateralized CP was again driven by the between-category pairs, for which responses were faster when the target appeared in the RVF than in the LVF, $t(39) = 2.91$, $p = .006$, $d = 0.49$; responses to the within-category pairs did not differ by visual field, $t(39) = .52$, $p > .6$. Interestingly, participants were roughly 11 ms faster overall compared to those in the original experiment, with this apparently driven by several participants in the original experiment who had considerably higher-than-average baseline RTs. An analogous ANOVA on the accuracy data yielded no main effect of visual field or categorical relationship (*p*s > .2), but unlike in the original experiment, there was a significant interaction between them, $F(1, 39) = 4.11$, $p = .05$, $\eta^2 = .10$. Consistent with the RT results, accuracy was significantly higher on between-category trials ($M = 95.6\%$, $SD = 4.1\%$) than within-category trials ($M = 94.2\%$, $SD = 4.6\%$) in the RVF, $t(39) = 2.72$, $p = .01$, $d = 0.44$, but not in the LVF (between-category: $M = 94.2\%$, $SD = 5.0\%$; within-category: $M = 94.7\%$, $SD = 6.6\%$), $t(39) = .84$, $p > .4$. Likewise, comparisons between visual fields showed that accuracy on between-category trials was significantly higher in the RVF than in the LVF, $t(39) = 2.34$, $p = .03$, $d = 0.38$, but that accuracy on within-category trials did not differ by visual field, $t(39) = .61$, $p > .5$.

Once again, lateralized CP was not limited to particular color pairs: For all four between-category pairs, responses were faster on average to RVF targets than to LVF targets (see Table 1); this difference reached significance for two of the pairs, RB ($t(39) = 2.59$, $p = .001$) and RG ($t(39) = 3.00$, $p = .005$). As in the original experiment,

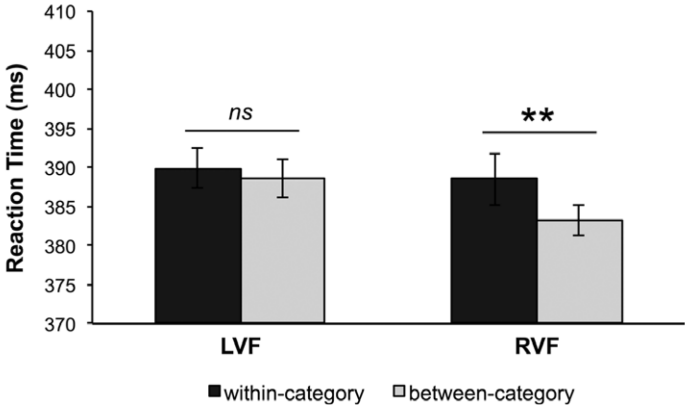

Fig. 4. Replication of lateralized categorical perception for the non-basic warm–cool distinction. Once again, responses were significantly faster to between-category than within-category pairs when the target appeared in the RVF, but no such difference was observed in the LVF. **$p < .01$, $df = 39$; ns, nonsignificant. Error bars are 95% within-subjects confidence intervals. LVF, left visual field; RVF, right visual field.

RTs to RVF targets were not reliably predicted by CIELAB distance ($r = .04$) or by Regier et al.'s (2007) similarity metric ($r = -.12$), and the between-category pairs for which the largest RT differences were observed between visual fields (in this case, RB and RG) showed relatively small differences in lightness. The results thus replicate lateralized CP for the warm–cool distinction.

## 4. Discussion

Previous research on CP and its lateralization has shown that for adult speakers of a language, CP reflects the basic-level categories of that language. This finding—that task-irrelevant categories affect simple perceptual decisions—is commonly interpreted as showing that the categories in question are psychologically salient and spontaneously accessed during the course of normal perceptual processing (e.g., Gilbert et al., 2006; Winawer et al., 2007). Here, across an experiment and its replication, we found that a *non-basic* English categorical distinction between warm and cool colors—previously revealed nonlinguistically only by more explicit measures in English speakers (e.g., Boster, 1986), and reflecting basic color terms in a *different* language (Heider, 1972)—yielded the same behavioral signature (lateralized CP) in English speakers as that shown for basic-level categories. We thus suggest that, at least in the case of the warm–cool distinction, non-basic categories are also psychologically salient and spontaneously accessed during perceptual discrimination.

It is arguable whether our results demonstrate that the warm–cool distinction rises to the level of "proto-color categories in [English speakers'] heads" (Boster, 1986, p. 71). While categories that are sufficiently salient to yield lateralized CP might be stably represented in long-term memory, it is also possible that the categories were rapidly generated by participants early in the experiment upon encountering the range of possible stimuli. However, even in the latter case, the fact that "warm" and "cool" were the categories generated suggests at least some preexisting sensitivity to the warm–cool distinction. Thus, regardless of the nature of the representation of the warm–cool distinction, our results suggest that at least in contexts in which a range of colors spanning the warm–cool boundary are available, this distinction may be mentally accessed and affect ongoing perceptual processing.

Our conclusions might appear to be challenged by a recent proposal suggesting that lateralized CP is an artifact of task demands (Suegami, Aminihajibashi, & Laeng, 2014) —specifically, the categorical left–right judgment used in the present study and in other work on lateralized CP. Because such categorical spatial judgments have been shown to be faster when stimuli are displayed in the RVF and initially processed by the left hemisphere (e.g., Kosslyn et al., 1989; Suegami & Laeng, 2013), the argument is that this hemispheric specialization could itself produce CP-like effects in the RVF. Yet a left-hemisphere specialization for categorical spatial judgments would predict faster responses to *all* RVF targets, not just those from a different category than the surrounding stimuli, as found here and in many other studies (e.g., Drivonikou et al., 2007; Gilbert et al., 2006, 2008; Holmes & Wolff, 2012; Zhou et al., 2010). Moreover, this proposal does not appear to account for findings of lateralized CP for which no spatial judgment is used

(Holmes & Wolff, 2013), nor for why lateralized CP for basic-level categories differs across languages (Holmes et al., 2016; Roberson & Pak, 2009; Roberson et al., 2008).

More consistent with our findings is the idea that the left hemisphere's specialization for categorical processing yields sensitivity to existing categorical relations—not necessarily linguistic ones (Holmes & Wolff, 2012)—among RVF stimuli. Holmes and Wolff (2012) found lateralized CP for categories learned with names as well as for those learned without names, suggesting that lateralized CP need not be driven by names per se (see also Holmes & Wolff, 2013). Although the non-basic distinction investigated here is marked by the terms "warm" and "cool," none of the participants reported covertly naming the stimuli using these or other superordinate terms (though several reported using basic English color terms such as "red" and "blue"—a strategy that would not yield CP for the warm–cool distinction). Thus, lateralized CP may have arisen from categorical representations of a nonlinguistic nature. However, we cannot rule out the possibility that the terms "warm" and "cool," though surely not the most dominant names for our stimuli, were nonetheless accessed during the task, and that lateralized CP was driven by these names. Further research is needed to discriminate between these linguistic and nonlinguistic accounts.

Although the present study is, to our knowledge, the first to explicitly investigate CP for non-basic categories, it is not the first to report results that bear on that issue. In cross-linguistic CP work, the basic-level categories of one language are often non-basic in another language (e.g., Russian "goluboy"/"siniy" vs. English "light blue"/"dark blue"; Winawer et al., 2007)—and these do *not* yield CP when non-basic. Why do we find CP for a non-basic distinction when other studies have not? We cannot be certain, but it is possible that the superordinate-level warm–cool distinction—proposed to be evolutionarily primary (Kay & Maffi, 1999; Kay & McDaniel, 1978)—is more psychologically salient than subordinate-level distinctions such as light blue versus dark blue in English. Analogous to classic categorization research using linguistic stimuli (e.g., Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976; Tanaka & Taylor, 1991), this idea could be tested by comparing CP across multiple levels of taxonomic organization beyond the basic level.

## Acknowledgments

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## Notes

1. Following the general convention of the language-and-thought literature, we use the term "categorical perception" in a broad sense. Whether CP reflects the

influence of categories on perception itself, or merely on post-perceptual decision processes, is the subject of ongoing debate (for discussion, see Firestone & Scholl, 2015; Gilbert, Regier, Kay, & Ivry, 2008; Goldstone & Hendrickson, 2010).

2. Whether Dani's color naming system consists of only two terms is arguable: Heider (1972, p. 451) found that two terms ("mola" and "mili") were used reliably "by all informants," but that others were used by "about half the informants . . . with some consistency" and that these additional terms were "roughly equivalent to the English terms 'red,' 'yellow,' and 'blue'."
3. Assessment of within-category versus between-category similarities averaged across stimulus pairs yielded different results depending on metric. CIELAB distances were slightly larger, on average, for the between-category pairs (182.4) than for the within-category pairs (175.7), but the alternative similarity metric yielded greater mean similarity for the between-category pairs ($3.4 \times 10^{-5}$) than for the within-category pairs ($1.2 \times 10^{-8}$). Thus, the two metrics make different predictions about the relative speed of responses to within-category versus between-category pairs across the two visual fields—but importantly, neither metric predicts stronger CP in one visual field than in the other. Thus, lateralized CP, if observed, would not be attributable solely to differences in perceptual similarity (see Gilbert et al., 2006, 2008; Holmes & Wolff, 2012).

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