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Color Language and Color Cognition: Brown and Lenneberg Revisited

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Introduction

The relation between language and non-linguistic behavior has a long history of empirical investigation and continues to engender lively debate (see Steels & Belpaeme, in press). In a seminal investigation of this relationship in the color domain, Brown and Lenneberg (1954) reported a positive correlation between a range of measures of codability for colors (speed of naming, consensus, communication accuracy) and the accuracy with which those colors were recognized A number of subsequent cross-cultural studies also found evidence of a relationship between codability and non-linguistic behavior, (e.g. recognition memory. Lantz & Stefflre, 1964).

These findings implied a tight link between language and thought, but Brown and Lenneberg (1954) also found positive correlations, independent of codability, between recognition accuracy and the discriminability of targets within a test array. Lucy (1992, p. 165) suggested that these factors interact, because codability is a property of a stimulus in isolation, while discriminability (how easy it is to distinguish a particular stimulus) is a property of a color stimulus “in the context of a particular array” (italics in original).

Rosch (Heider, 1972) suggested that, rather than either discriminability or codability determining categorization, the best (focal) examples of the putative Universal basic color categories were simply more salient in nature and thus likely to become the foci of evolving categories in any language. Recent investigations suggest that the relationship is more subtle and complex than previously proposed (Gentner & Goldin-Meadow, 2003). Guest and Van Laar (2002) suggested that identification of colors is enhanced when the exemplars are highly codable, but that this is attenuated by context. Where all items are red the term ‘red’ is less useful than an idiosyncratic description.

An early measure of codability that took context into account was communication accuracy: the efficacy with which a description, generated by one individual, allows another to identify a particular color (Brown & Lenneberg,1954; Lantz & Stefflre, 1964) , a task that allows participants “to tailor their descriptions to the particular array” Lucy (1992, p. 172). Thus, while naming in isolation may favor focal items, communication accuracy allows for idiosyncratic descriptions that may be equally effective for identifying non-focal items in any given context.

The present experiments return to these issues and compare the relationship between communication accuracy and recognition for both ordered and randomized arrays of highly colorful stimuli. If, “coding by basic names was in some sense optimal” (Guest & Van Laar, 2002, p.447), then the focal items should always be better communicated than traditionally ‘hard to name’ non-focal stimuli. If this advantage arises from some inherent salience of those focal points (Heider, 1972) then these items should also be better recognized, regardless of context. If, however, the advantage is tied to codability then it may be lessened when items must be located in a random array, where discriminability is equated and all items from the same category are not placed together for comparison.

We further investigated whether communicative behavior would be context sensitive and affected by knowledge of the array from which another individual would make their selection. We thus examined both communication accuracy and recognition memory, using an ordered and a randomized test array, to investigate whether focal colors are easier to communicate accurately and to remember than other colors, regardless of context.

Communication Accuracy

Experiment 1 extended Lantz and Stefflre’s (1964) experiment, exploring ease of communication for the identity of colors. In addition to a test array with stimuli laid out in Munsell order (hue horizontally, lightness vertically), a second, randomly ordered, display of the same stimuli was used. 30 pairs of native English speakers between the ages of 16 and 48 (mean age = 26.5) with normal color vision (City Colour Vision Test, Fletcher, 1998) sat on opposite sides of a table with a portable screen hiding the other person from view. Illumination was by D65 light source. After a briefing session the nominated ‘Encoder’ described each of 8 focal and 8 non-focal color stimuli, one at a time, for the ‘Decoder’, who then selected an appropriate match from either an ordered or a random array of 160 Munsell color chips. The screen prevented the Encoder from indicating a spatial location for the target within the array or from seeing the Decoder's choices (because they might modify their descriptions based on the Decoder's previous selections). Descriptions, latency to begin a description and latency to choose a target were measured using voice recognition software. Targets were shown in random order. 30 pairs of participants used the Ordered Array and 30 pairs used the Random Array.

Results

Communication..Table 1 shows mean latencies to begin descriptions and the mean number of words used for each type of array and target. Both were analyzed in 2 (Array type: ordered vs. random) x 2 (Target type: focal vs. non-focal) ANOVAs, with repeated measures over the second factor. In both analyses the only significant effects were for target type [latency: $F(1, 28) = 27.91$, $MSE = .14$, $p < .001$; words used: $F(1, 28) = 18.97$, $MSE = 29.61$, $p < .01$] Encoders were faster to begin describing focal stimuli in both types of array and used fewer words to describe focal targets for both arrays.

Table 1: Mean latency (ms) to begin descriptions and number of words used

Target type	Latency	Total words
Ordered focal	2720	17.32
Ordered non-focal	3075	22.24
Random focal	2839	19.54
Random non-focal	3534	24.78

Identification. Table 2 shows mean accuracy of target identification by decoders, and mean latency to select targets. These were also examined in a series of 2 (Array type: ordered vs. random) by 2 (Target type: focal vs. non-focal) ANOVAs, with repeated measures over the second factor. Again, the only significant effect was of target type [identification accuracy: $F(1, 28) = 18.19$, $MSE = .07$, $p < .01$; mean RT to select a target: $F(1, 28) = 30.86$, $MSE = 28.82$, $p < .01$]. In both types of array, Decoders accurately identified significantly more focal than non-focal targets. Decoders were also faster to select focal targets in both type of array

Following Roberson et al. (2000) two further measures were considered, namely, the compound distance (along the three CIE L*a*b* coordinates) between each target and all of the chips that had been selected in response to its description and the number of times that another target stimulus was chosen instead of a target stimulus. For the error distance a 2 (Array type: ordered vs. random) x 2 (Target type: focal vs. non-focal) ANOVA, with repeated measures over the second factor, revealed that the error distance between selected stimuli and focal targets was less than that from non-focal targets [$F(1, 28) = 21.69$, $MSE = .02$, $p <.01$]. There was no significant effect of array type and no interaction. As the Decoders were 'guessing' the designated target, there might have been a bias towards guessing the focal stimuli as 'best examples' of the basic terms. An examination of guessing rates revealed that these were rare but focal targets were selected in error more often (.063) than non-focal targets (.052).

Table 2: Mean correct selections of Focal and Non-focal items, mean RT to select target by Decoders in Experiment 1.

Target type	Mean correct	Mean Latency (ms)
Ordered focal	3.08	1804
Ordered non-focal	1.47	2592
Random focal	2.87	2050
Random non-focal	1.47	2803

Discussion

The link between communication accuracy and focality was found in every measure used. Encoders began descriptions earlier and used fewer words to describe focal than non-focal targets, in both arrays, so the link is not context dependent. Basic terms are also used more often to describe all types of target, regardless of the array. This finding is of particular importance where participants were not constrained either to length or type of description, or time allowed.

Effectiveness of communication also showed a strong link with focality. Focal stimuli were selected more accurately and faster than non-focal stimuli in both types of array. This cannot be accounted for by the position of focal stimuli within the ordered array, or the number of close perceptual competitors for each target, because performance for focal targets was still superior in the random array. Overall there was little indication that Encoders gave different descriptions when Decoders had to select from a random array. Since Encoders generally found the task difficult, they may have been unable to further elaborate their descriptions There was a strong tendency to use basic terms, in combination with modifiers and /or secondary terms, to describe all the stimuli, although these terms were seldom used alone. Given this preponderance of basic terms, the superior efficacy of communications for the focal stimuli (which are the best examples of basic categories) may be unsurprising. Given the consensus and consistency with which different individuals use these terms, they may indeed be optimal for communication (Guest and Van Laar, 2002) but the results of Experiment 1 cannot distinguish whether the focal items have inherent perceptual distinctiveness (because they are more salient in the natural environment) or merely more easily codable and communicable within a culturally relative framework. Experiment 2 returned to the question raised by Brown and

Lenneberg (1954) of the extent to which efficient linguistic description is linked to accurate recognition memory.

Recognition Memory

Brown and Lenneberg (1954) proposed that recognition memory is tightly linked to codability, because encoding a stimulus for memory equates to describing it to oneself across time. Although they acknowledged that perceptual distinctiveness also affected recognition memory, they argued that the importance of codability, relative to the perceptual distinctiveness of a stimulus, would increase with increased task demands. In their original experiment, the test array used was large (and the interval between presentation of target and test long (30 seconds) so effects of codability relative to perceptual distinctiveness should have been maximized.

In the Ordered array, the focal stimuli are easier to discriminate than non-focal targets, when the target and test array are both visible (Roberson, et al., 2000). Discriminability may interact with codability to produce better recognition memory for focal targets. While superior recognition of focal targets has frequently been observed using an Ordered array (Brown & Lenneberg, 1954; Heider, 1972; Roberson et al., 2000), when the array was randomized to equate discriminability of targets, Garro, (1986) found an advantage for focal stimuli, but Lucy & Shweder (1979) and Roberson et al. (2000) did not. In the present experiment the delay between target and test was reduced to 5000ms and both test arrays contained only 16 stimuli, to reduce task demands that might encourage reliance on naming. Silence was maintained during the short retention interval. Discriminability was held constant across the two test arrays, while the context was varied, by using the same set of test stimuli, in either an ordered or a random array.

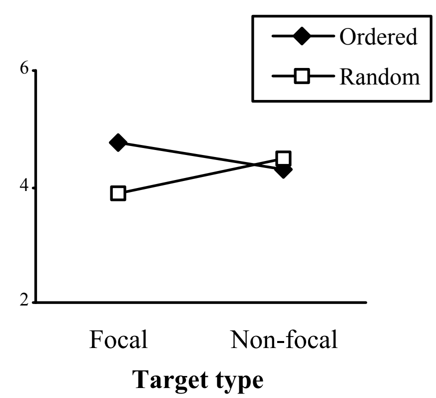
If focal stimuli are inherently more salient, regardless of context, there should be superior recognition for these stimuli in both arrays. If, however, the superiority for these items relies on their codability, then the advantage should be context dependent (Lucy, 1992; Guest & Van Laar, 2002), because a description such as 'best red' is maximally useful when all red examples appear together for comparison. Thus the advantage should be found in the ordered, but not in the randomized array.

24 native English speakers between the ages 16 and 32, (mean age 22.4) with normal color vision (City Colour Vision Test, Fletcher, 1998) were paid for their participation. Target and test stimuli were displayed on a Sony Trinitron 18 inch monitor, using E-Prime software, in a darkened room. Each of the 16 test stimuli appeared in the centre of the screen on a gray background, subtending a visual angle of 2.10° x 2.10°. Target stimuli were the same eight focal and eight non-focal colors used in Experiment 1, (matched on CIE L*a*b* coordinates). Co-ordinates were measured using a Minolta CR-100 Chroma Meter. Two versions of the same 16-color test array (one Ordered and one Random) were used for each target color. Test array patches were arranged in a 4 x 4 grid with a distance of 23 pixels horizontally and 26 pixels vertically between stimuli. In the Ordered Array patches were arranged in their Munsell order: hue horizontally, values (lightness) vertically. In the Random Array the same colors were laid out in a random pattern. All test arrays were matched for overall perceptual variation (ΔE^*ab). Each stimulus appeared once as a target for the ordered array and once as a target for the random array. Order of presentation of the 32 trials was pseudo-randomized so that the same target did not appear on two consecutive trials.

Results

Figure 1 shows the mean number of correctly recognized stimuli for each array type. Mean response times are shown in table 3. Accuracy, RT and error distance for erroneous choices were examined in three separate two (Array: ordered vs. random) by two (Target: focal vs. non-focal) within-subjects ANOVAs. For recognition accuracy, there was no significant effect of Array [F (1,23) = 1.05, $p > .1$] and no significant effect of Target [F (1,23) < 1], but a significant interaction [F (1,23)= 4.82, MSE = 1.14, $p < .05$]. Inspection of the simple main effects revealed that more focal targets were correctly recognized in the ordered than in the random Array ($p < .05$). There were no other significant simple effects. In recognition memory, there was an effect of context for focal, but not for non-focal targets.

Figure 1: Mean number of correctly recognized Focal and Non-focal targets in the Ordered or the Random Array in Experiment 2



For reaction times there was no significant effect of Array [F (1,23) = 2.27, MSE = 6311438, $p > .1$], and no significant effect of Target [F (1,23) = 2.14, MSE = 4088614, $p > .1$]. and no significant interaction [F (1,23) = 1.54, $p > .1$]. There was no difference in latencies for either type of target in either type of array..

For distance (ΔE^*ab) of erroneous choices, there was no significant effect of Array [$F(1,23) < 1$], or Target [$F(1,23) < 1$] and no significant interaction [$F(1,23) < 1$]. For both types of array, when the wrong selection was made there was no difference in the distance of errors for focal and non-focal stimuli.

Table 3: Mean Latency to select target in Experiment 2.

Target type	Mean Latency (ms)
Ordered focal	4602.4
Ordered non-focal	4608.2
Random focal	4780.7
Random non-focal	4792.3

A second error measure was also considered: the tendency of participants to select a focal target in error. Although such errors were few there were more to focal targets (.034) than to non –focal targets (.01).

Discussion

Roberson et al. (2000) found a memory advantage for focal stimuli, in an Ordered, but not in a Random array). In the present experiment, using a computerized display, where component stimuli were held constant between the two types of display and varied only in arrangement, there was a recognition memory advantage for focal stimuli only in the Ordered array.

Cognitive load might be increased in the Random array, because all sixteen stimuli need to be searched, whereas in the Ordered array, only one part of the array need be considered. However, if that were case, performance should be worse overall in the Random array condition and it is not. Performance for focal stimuli drops in the Random compared to the Ordered array, but performance on the non-focal stimuli is slightly better in the Random array.

General Discussion

The results of these experiments confirm the advantage in codability of the items central to basic categories compared to poor category exemplars. Focal items can be communicated faster and with fewer words, regardless of context. For English speakers, the best examples of basic categories do seem to have privileged status in any descriptive task and the basic terms may be optimal for communicative efficacy (Guest & Van Laar, 2002), perhaps because they are used with the greatest consistency and consensus across individuals. In recognition memory, however, participants only show superior recognition for focal colors in the Ordered array.

If focal points gain privileged status in the cognitive organization of color because they are inherently more salient than peripheral stimuli, they should always be better recognized, regardless of context. If, instead, this advantage is linked to labeling, then changing the context in which a color appears should affect the advantage gained (Lucy, 1992; Guest & Van Laar, 2002). In experiment 2, with a small set of distracter items and a short retention interval, to minimize reliance on verbal coding, superior recognition of focal stimuli occurred only in the Ordered array, where all items within a category are placed together for comparison. In such a context activation of 'category feature detector nodes' (through naming) might bias perceptual judgments towards the best example of the activated category (Pilling et al., 2003). Consistent with this explanation, we found more incorrect selections of focal targets (13) than non-focal targets (2).

Such effects may be particularly strong in the color domain, where naming and categorization converge, because to be called 'red' an item must have the property of 'redness'. For other domains there is a demonstrable distinction between the features that are necessary for the naming of objects and those that are central to the object's conceptual representation (Marques, 2002). Color is thus one area where links between naming and cognition might be strongest. In the Random array these effects may be attenuated because stimuli are not arranged systematically, with the best example at the centre of the category. In such circumstances, which more closely resemble naturalistic surroundings, participants may be less influenced by categorical labeling.

The present results indicate a strong and coherent cognitive and linguistic organization of basic color categories around best examples that are optimally communicated between speakers of English, using a limited set of basic color terms. The results also support the findings of Brown and Lenneberg (1954), Roberson et al., (2000) and Özgen and Davies (2002) that color perception is flexible and interacts with cognitive processes, when circumstances favor the activation of categorical information. However, the advantages found for coding and recognition of (focal) best examples of English color categories result from the tight links between linguistic and cognitive organization of categories, not from any inherent natural 'goodness' of these colors over others. When task demands are limited and well controlled, so that recognition need not be dependent on name retention, the Focal points of basic categories are *no* easier to recognize than other colors.