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COLOR TERM COMPREHENSION AND THE
PERCEPTION OF FOCAL COLOR
IN YOUNG CHILDREN

A thesis presented
By
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Psychology
ABSTRACT

Thirty 2-year-old subjects participated in a color perception task designed to assess the influence of color term comprehension on the perception of "focal" color areas. The subject's task was to choose a color from an array of Munsell color chips consisting of one focal color chip with a series of non focal color chips. Each subject was given a color comprehension and color naming task. Results from the frequencies of choices of color chips revealed that subjects were essentially responding by chance over all color chips, which suggests that the two year olds employed in this study did not perceive focal colors as more salient than non focal colors, regardless of whether or not the subjects comprehended the color name for the focal area. These results are contrary to Heider's (1971) contention that focal colors are perceived as salient prior to the acquisition of color vocabulary.

An analysis of the color term comprehension data suggested that the development of color vocabulary in children does not follow the evolutionary development found by Berlin and Kay (1969). However, the results did suggest that color term comprehension develops quite rapidly in the second half of the second year.
The controversy over the "linguistic relativity" hypothesis (Whorf, 1956) was recently reopened and refreshed by Berlin and Kay's (1969) extensive research into the universality of basic color terms. They found that there exists certain "focal" areas of the color space which are universally salient to all adult members of differing ethnolinguistic cultures. Berlin and Kay asked informants from many different language groups to map the color space for each basic color term in their language and to choose the best examples of those color terms from an array of three hundred and twenty color chips representing the entire spectral range. Although the color spaces mapped on their color board differed considerably between the informants from different linguistic cultures, the chips chosen as best examples of each color term showed remarkable similarity among totally unrelated languages. For example, the spaces mapped for the color term red differed considerably between different languages. However, all informants unequivocally chose the same few chips as representing the best example of the red color term in their language. Berlin and Kay called these areas of agreement "focal areas" and suggested that these areas are universally salient to members of all ethnolinguistic cultures. This data implies that although linguistic terms for a certain area of the color solid differ in their extensive properties from culture to culture (i.e., what colors are subsumed under a term and what
colors are not), color terms have the same core meaning across languages. Berlin and Kay argued that previous cross cultural research into color categorization, which revealed major cultural differences in this process, derived the conclusion of "linguistic relativity" from observations of color space boundaries and not from focal areas. They also observed that basic color terms emerge in an invariant evolutionary order; that order being (a) black, (b) white, (c) red, (d) green-yellow, (e) blue, (f) brown, and (g) pink-orange-purple-grey.

Heider (1971) found these same focal areas to be salient for three and four year old American children. She presented her subjects with arrays of color chips and asked the children to choose a color. Her results demonstrated a high frequency of choices for focal chips as compared with choices for non focal chips. She suggested that these areas are points to which color names become attached, and that the growth of color concepts are generalizations from these focal areas.

The research presented here extends the previous investigation to an age at which the subjects do not know all eight basic color terms in the English language. Heider (1971) maintained that color language did not play a major role in her results. She based this assumption on Istonima's (1963) data which revealed a high degree of unreliability in Russian three year olds' use of color names. However, pilot data for the present research revealed most of the three year old children sampled used color names with nearly adult precision. This
pilot data was more in agreement with Frankenburg and Dodd's (1967) findings that at least seventy-five percent of their subjects accurately named the three colors in the Denver Developmental Screening test by age three and one half. Also, Heider (1971) did not consider the possible influence of color name comprehension. Language comprehension has been well documented to develop prior to language production (Fraser, Brown, and Bellugi, 1968). Therefore, the possibility remains that the perception of focal color may be contingent upon comprehension of the color names. For these reasons, a two year old population was employed in the present research.

Specifically, the present study asked the following three questions: (1) will the same focal areas found to be salient for both adults from differing ethnolinguistic cultures and three year old American children be salient for two year old children who cannot name all the color terms for those areas? (2) will the saliency strength of the focal areas be greater for children who do possess comprehension of a color term for a particular focal area than children who do not possess comprehension of that color term? (the assumption here is that the addition of the linguistic term may increase the saliency for that color by enhancing the color's codability as defined by Brown and Lenneberg [1954]); (3) does basic color term comprehension develop in young children in the same evolutionary order as found by Berlin and Kay's (1969) observation of the historical growth of color vocabulary across cultures?
Method

Subjects

The subjects were thirty, 2-year-old children of parents living in the vicinity of the University of Massachusetts, Amherst campus. The subjects' parents were contacted by letter and telephone and asked if they would like to participate in a series of research projects currently in progress at the University of Massachusetts' psychology department.

The subjects ranged from age twenty-four months to thirty-five months with $\bar{X}$ age = thirty-one months and S.D. = 4.4 months.

Materials

Color chip arrays. Colored chips of glossy finish provided by the Munsell Color Company's Book of Color served as stimuli and are referred to by Munsell notations. C.I.E. tristimulus values and chromaticity coordinates can be found in Nickerson, Tomaszewski, and Boyd (1953). Precise Munsell renotations are not required since all Munsell repaints from 1970 on were manufactured to conform with the recommendations of the O.S.A. subcommittee on the Spacing of Munsell Colors (1943).

The stimuli presented to each subject consisted of sixteen rows of color chips; two rows for each of the eight chromatic color terms. Each row contained one chip representing a focal color area, plus a series of seven to nine non focal chips. The focal chips selected for this purpose are those
chips found by both Berlin and Kay (1969) and Heider (1971, 1972) as the most salient areas of the color space. The focal color chips are the following eight chips: red, 5R 4/14; yellow, 2.5Y 8/16; green, 7.5G 5/10; blue, 2.5PB 5/12; pink, 5R 8/6; orange, 2.5YR 6/16; brown, 5YR 3/6; purple, 5P 3/10.

Non focal chips were selected from the same three hundred and twenty chip stimulus board used by both Brown and Lenneberg (1954) and Berlin and Kay (1969). This stimulus board contains color chips representing all hues and brightness values, each at maximum chroma. The method for selecting the non focal chips for each experimental array was as follows: (1) Each of the eight chromatic color terms in the English language was mapped on the stimulus board by drawing a fifteen chip rectangle (three x five) around the focal chip with the focal chip as the geometric center. Two more non focal chips were included in each color space by selecting two chips outside the rectangle on either the same brightness or hue dimension as the focal chip. Although this procedure should yield a focal chip plus sixteen non focal chips for each color, some adjustments to the mapped color spaces were necessary due to the overlapping of the color spaces on the high end of the wavelength continuum and also that this method yields a smaller space for those colors residing on the ends of the brightness scale. These adjustments were made by adjusting the space on certain colors in either the hue or brightness dimension such that there was no overlap between
color spaces and that the adjusted space did not include chips outside the appropriate color maps observed by Berlin and Kay (1969) for English speaking adults. (2) For the first array for each color, a random sample (without replacement) of eight non focal chips were selected from the same color space as the focal chip. The remaining eight non focal chips formed the second array for that color. This procedure was followed for all eight colors.

Although this procedure theoretically constructs two arrays of nine color chips for each color term, some rows only contain seven or eight chips due to the problem mentioned above that colors residing on the high end of the wavelength continuum (red, pink, orange, yellow, and brown) are clustered very close together. Therefore, there was only a limited space from which to sample non focal chips for the experimental arrays. Figure 1 shows the three hundred and twenty chip stimulus board with the eight adjusted color spaces and the position of the non focal chips selected for both arrays.

Insert Figure 1 here

Table 1 lists the Munsell notations for the focal and non focal chips in all sixteen arrays.

Insert Table 1 here
The focal chip with its appropriate non focal chips for each array were mounted on horizontal strips of white cardboard by inserting their tabs into slots. Each chip was easily removable from its slot.

**Color term naming and comprehension test.** For the color term naming and comprehension test, eleven 3 inch colored squares were pasted on a large sheet of heavy white construction paper. The colored paper employed for each of the eleven basic color terms (now including the achromatic color terms) was selected in an attempt to approximate the focal colors as nearly as possible.

For a quick check to be sure that the papers selected were good examples of the basic color terms, fifteen undergraduates attending the University of Massachusetts were asked to name the eleven colored papers. There was unanimous agreement on all eleven colored papers.

**Illumination.** Illumination during testing of the two year old subjects was provided by a Tensor high intensity lamp using a #1133 bulb and operated at the "lo" position. This light source is identical to that used by Berlin and Kay (1969).

**Procedure**

Each subject was tested individually in a three part procedure.

**Color blindness test.** At the start of the experiment, every subject was first screened for color blindness by the last
three sections of the Ishihara tests for color blindness. Subjects were pretrained to trace a curved line with their finger prior to this test. In addition, parental reports were used. A total of forty-one subjects were initially run, of which five were questionable during the color blindness screening, and six either did not complete the experiment or perseverated on a particular position on the arrays.

**Color chip choices.** Each subject was shown sixteen arrays, one at a time. The arrays were presented in a random order for each subject. The position of the chips within each array was also randomized for every subject.

On presentation of each array, the subject was instructed to take one of the chips out of its slot and show it to the experimenter. This method was employed quite successfully by Heider (1971) with three and four year old children.

The instructions were as follows: "This is a game called 'show me a color.' Do you see the colors I have? See how they come out? [Experimenter pulls out the chips and allows the child to manipulate them.] Now, I want you to pick one out and show me."

The rationale for this procedure is that the children will choose the chip which captures their attention, i.e., is most salient to them.

A few practice trials using non experimental arrays were used until the subject understood the task. For many subjects, this allowed the experimenter the opportunity to train out
position perseveration.

Each subject made one choice for each array. Subjects were praised for every choice. After each choice, the experimenter recorded the notation of the chip chosen.

Color naming and comprehension test. After all sixteen arrays were exhausted, the experimenter showed the subject the color comprehension and naming board and pointed to each color successively asking the subject to name that color. After completing all eleven colors in this naming task, the experimenter then asked the subject, "Where's x," x being the name of one of the colors. This procedure was followed for all eleven color terms. The first part of this task was to assess color naming ability, and the second part was designed to assess color term comprehension.

Results and Discussion

Color naming and comprehension. The results from the color naming task were quite consistent. Only four subjects could reliably name more than one color, and only one subject named more than two colors. Therefore, we can eliminate color naming ability as a variable in the results presented below and focus our attention on possible differences in color term comprehension. For the color term comprehension results, a frequency distribution is presented in Table 2 which indicates the number of subjects with comprehension of each of the eleven basic color terms (including the achromatic color terms, black,
white, and grey). The eleven color terms are presented in Table 2 in the evolutionary order observed by Berlin and Kay (1969), reading from left to right.

Insert Table 2 here

With the exception of grey, the number of subjects comprehending all other color terms appears to be approximately equal. These results suggest an immediate answer to the third question posed in this study. If the order of acquisition were similar between children and cultures, we should have found a steadily decreasing number of subjects with comprehension of the color terms as we move through the historical order. Therefore, there is nothing in this data to support an hypothesis that children acquire color terms in a similar order as that of the historical development of cultures.

One interesting finding is the proportion of subjects with comprehension of the eleven basic color terms at various ages. Table 3 indicates the percentage of subjects divided into three age groups with comprehension of (a) none of the color terms, (b) the primary color terms, and (c) all eleven basic color terms.

Insert Table 3 here
The mean number of color terms comprehended and the standard deviations for each age group are given at the bottom of Table 3. The marked difference in the means of both groups below two years, seven months as compared with the mean of the group above this age suggests that the development of color word comprehension develops quite rapidly during the second half of the second year.

Color chip choices. To answer the first question of whether or not the two year old children in this sample perceived focal chips as more salient than non focal chips, the expected and observed frequencies of focal chip choices are shown in Table 4.

As may be seen, the actual observed frequency of focal chip choices pooled over all eight color terms is slightly less than that expected by chance, both for subjects with comprehension of the color terms and those without comprehension. Even within the individual colors, only yellow shows a higher observed frequency than expected.

However, this analysis loses much information since it does not describe whether or not any chips other than the designated focal chips were chosen significantly more than expected by chance. In other words, the focal areas found to be salient for adults may not be the same for children.
Therefore, to determine if the subjects' choices might be clustered around either chips other than the designated focal chips or centered on certain values of the three dimensions of color, separate $X^2$ goodness of fit tests were performed between the expected and observed frequency distributions for choices on the values of each dimension (hue, brightness, and chroma) for every color. Separate tests were executed for the two types of arrays, for all subjects, and then for the two groups of subjects based on whether or not they indicated comprehension of the color term. Of the one hundred and forty-four separate $X^2$ statistics (8 colors x 3 dimensions x 3 groups x 2 types of arrays) fifteen were significant ($p<.05$). Table 5 locates the fifteen significant $X^2$'s.

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Insert Table 5 here

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Whenever a large number of significance tests are performed there is a certain probability that significance will be achieved in some small proportion of the tests merely by chance. However, on close inspection of the frequency distribution of all choices for all color chips presented in Table 6, a pattern emerges which suggests an explanation for many of the significant statistics.

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Insert Table 6 here
In the colors in which significant $X^2$'s were found on certain dimensions, a high frequency of choices can be observed for either one or two chips which lie on the outermost perimeter of that color space. For example, the significant statistics on the brightness and chroma dimensions from the color orange are all due to the high frequency of choices for the single chip, 2.5YR 8/6. It can be readily observed in Table 6 that there were eleven choices for this chip, which is the highest frequency in the orange color space. The fact that these few chips with a high frequency of choices lie on the perimeter of the color spaces suggests that the random sampling technique for selecting non focal chips within the adjusted color spaces yields a few chips which may appear markedly discriminable from the remaining colors in the same array. The exception to this rule is focal yellow which is chosen more frequently than any other yellow chip. However, focal yellow is probably more discriminable from its surrounding chips than any other yellow color chip. This is primarily due to the problem that Munsell colors are not all perceptually equispaced, and Munsell manufactures a highly saturated color chip at this hue and brightness value. Both Brown and Lenneberg (1954) and Heider (1971) observed this marked discriminability with focal yellow.

Consistent with this discriminability hypothesis in attempting to explain these results is the finding of no significant $X^2$'s for green, blue, or purple. These colors appear
at the low end of the wavelength continuum and possess larger non overlapping color spaces from which to sample chips to form the arrays. This would reduce the discriminability effects between color chips. At the high end of the wavelength continuum, the color spaces are considerably smaller and border each other. Therefore, in an attempt to keep the number of chips per array as equal as possible, it was necessary to sample non focal chips from the borders of an adjacent color space, yielding chips which may have a high discriminability when placed in the experimental arrays.

Therefore, it can be tentatively asserted that these two year old subjects did not perceive any colors as more salient than any others, except for the experimental artifact of a few discrimimniable chips.

Although there was an overall lack of significant differences between the expected and observed frequency distributions in the design, the possibility still remains that subjects possessing comprehension of the appropriate color terms were responding in an opposite direction from subjects without comprehension of color terms. To test for this possibility, separate tests for association were performed between these two groups on their respective frequency distributions for each color dimension within the eight colors. None of these tests approached significance. It appears that this linguistic variable had no significant effect on the subjects' choices.
Conclusions

The absence of any type of "focal" responding, either measured by frequency of choices to the designated focal chip, or by noting any consistent uni-modal distributions, lends itself to two possible explanations. The first is that individual subjects were differentially interpreting the instructions and therefore responding differentially. However, that we observed a higher frequency of choices on those few discriminable chips found lying on the perimeter of certain adjacent color areas suggests that the subjects were responding to some form of saliency. Why then should the subjects not respond more frequently to the focal chips, if we assume focal chips are salient areas of the color space? This interpretation is also difficult to understand considering that Heider (1971) observed a high frequency of focal responding employing the same instructions with three and four year old children. Although Heider presented each of three color dimensions separately to her subjects, and this study varied all three dimensions simultaneously, it is difficult to understand why these different methods should yield different results. Both methods employed the identical instructions of choosing a color from an array of one focal chip with a series of non focal chips. If focal chips are indeed the most salient areas of the color space, they should remain so, regardless of the type of array in which they are embedded.
The second interpretation of the results is that the two year old children in this sample indeed did not perceive focal colors as more salient than other non focal areas of the color space. This interpretation is consistent with the results and is the most plausible explanation.

These results leave the question of the development of focal color perception and its relationship to color naming ability still unexplained. From Heider's (1971) results, we can infer that three year old children do perceive focal color as opposed to the two year old children employed in the present study. However, the exact controlling processes for this development are still unclear. Heider (1971) presumed that color naming ability was not the influencing variable in her results. Yet, from her own data, it can readily be observed that the vast majority of her subjects were correctly naming the eight color terms used in her study. Heider did not analyze her data for differences between subjects with and without the appropriate verbal production of the color names. Therefore, the relevant question for future research is the influence of color naming ability on the perception of focal color. This question is currently under investigation by this author with three year old children.

The results from the analysis of the color term comprehension task imply that comprehension of color vocabulary develops quite rapidly in the second half of the second year. However, these results do not lend support to the hypothesis
that the ontogenetic development of color vocabulary recapitulates that of universal cultural development. It should be noted, however, that this data is based on color term comprehension and not color naming ability. Heider (1971) tested this same order relationship with color naming ability with three and four year old subjects and found only minimal support for the hypothesis. It seems more likely that the specific order for color term acquisition may be more dependent upon environmental socialization and familiarity.
References


Figure 1. The eight adjusted color spaces with the locations of focal chips and non focal chips for both types of arrays.

- □ indicates the position of focal chips.
- □ indicates non focal chips in type one arrays.
- □ indicates non focal chips in type two arrays.
### Table 1

Munsell Notations of Chips Selected for Sixteen Arrays

<table>
<thead>
<tr>
<th>Color</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red:</td>
<td>1. 5R 4/14, 1R 2/8, 7.5R 4/14, 2.5R 3/10, 5R 3/10, 7.5R 2/6, 2.5R 5/14, 7.5R 3/12.</td>
<td>2. 5R 4/14, 5R 5/14, 2.5R 4/14, 10RP 3/10, 2.5R 2/8, 7.5RP 4/12, 10RP 2/8, 10RP 4/14.</td>
</tr>
<tr>
<td>Pink:</td>
<td>1. 5R 8/6, 7.5R 9/2, 7.5R 7/10, 2.5R 6/12, 10RP 8/6, 2.5R 8/6, 2.5R 7/8.</td>
<td>2. 5R 8/6, 5R 6/12, 7.5R 8/6, 2.5R 9/2, 5R 9/2, 10RP 7/8, 10RP 6/12, 7.5RP 8/6.</td>
</tr>
<tr>
<td>Brown:</td>
<td>1. 5YR 3/6, 10YR 4/6, 2.5YR 3/8, 7.5YR 2/4, 7.5YR 4/8, 5YR 2/4, 5YR 5/10, 10YR 3/6.</td>
<td>2. 5YR 3/6, 7.5YR 3/6, 10YR 5/10, 5YR 4/10, 2.5YR 4/8, 5YR 5/12, 7.5YR 5/10.</td>
</tr>
<tr>
<td>Yellow:</td>
<td>1. 2.5Y 8/16, 2.5Y 9/4, 10YR 8/14, 5Y 7/12, 2.5Y 6/10, 2.5Y 3/12, 5Y 6/10, 10YR 9/2.</td>
<td>2. 2.5Y 8/16, 7.5YR 6/14, 7.5Y 8/12, 5Y 8/14, 10YR 9/2, 7.5YR 8/8, 5Y 9/6, 10YR 7/14.</td>
</tr>
<tr>
<td>Orange:</td>
<td>1. 2.5YR 6/16, 5YR 7/14, 10R 6/14, 7.5R 6/12, 2.5YR 7/10, 5YR 5/12, 5YR 6/12.</td>
<td>2. 2.5YR 6/16, 5R 7/8, 10R 7/10, 2.5YR 4/10, 2.5YR 8/6, 10R 5/16, 2.5YR 5/14.</td>
</tr>
<tr>
<td>Green:</td>
<td>1. 7.5G 5/10, 7.5G 3/8, 2.5BG 5/10, 5G 4/10, 7.5G 3/8, 5G 5/10, 5G 6/10, 2.5G 4/10.</td>
<td>2. 7.5G 5/10, 2.5G 5/12, 2.5BG 6/8, 10G 5/10, 7.5G 6/10, 10G 6/10, 7.5G 4/10, 10G 4/10, 2.5BG 4/8.</td>
</tr>
<tr>
<td>Blue:</td>
<td>1. 2.5PB 5/12, 10B 6/10, 5PB 6/10, 5PB 4/12, 10B 4/10, 7.5B 6/8, 2.5PB 4/10, 5PB 5/12, 7.5PB 4/12.</td>
<td>2. 2.5PB 5/12, 10B 5/12, 2.5PB 6/10, 2.5PB 7/8, 2.5PB 3/10, 7.5B 4/8, 7.5PB 6/8, 7.5B 5/8, 7.5B 5/10.</td>
</tr>
<tr>
<td>Purple:</td>
<td>1. 5P 3/10, 2.5P 3/10, 10P 3/10, 7.5P 3/10, 2.5P 4/10, 10PB 4/10, 7.5P 2/6, 5P 4/10, 10P 2/8.</td>
<td>2. 5P 3/10, 2.5P 2/8, 10PB 2/8, 5P 5/10, 10PB 3/10, 5P 2/8, 7.5P 4/10, 10P 4/12.</td>
</tr>
</tbody>
</table>

1 The notations underlined indicate a focal color chip for that array.
Table 2. Number of subjects comprehending each of the eleven color terms*.

<table>
<thead>
<tr>
<th>BLACK</th>
<th>WHITE</th>
<th>RED</th>
<th>GREEN</th>
<th>YELLOW</th>
<th>BLUE</th>
<th>ORANGE</th>
<th>PURPLE</th>
<th>PINK</th>
<th>BROWN</th>
<th>GREY</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>12</td>
<td>16</td>
<td>16</td>
<td>17</td>
<td>19</td>
<td>19</td>
<td>15</td>
<td>12</td>
<td>13</td>
<td>9</td>
</tr>
</tbody>
</table>

* The evolutionary order observed by Berlin and Kay (1969) reads from left to right.
Table 3. Percentage of subjects with comprehension of color terms.

<table>
<thead>
<tr>
<th></th>
<th>2-0 to 2-3</th>
<th>2-4 to 2-7</th>
<th>2-8 to 2-11</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO COLOR TERMS</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>ALL COLOR TERMS (11)</td>
<td>0</td>
<td>0</td>
<td>55.5</td>
</tr>
<tr>
<td>ALL PRIMARY COLOR TERMS*</td>
<td>0</td>
<td>6</td>
<td>87</td>
</tr>
<tr>
<td>X NUMBER OF COLOR TERMS AND S.D.</td>
<td>0.6</td>
<td>2.33, 1.1</td>
<td>9.1, 1.4</td>
</tr>
</tbody>
</table>

* N= 12 3 15

* the three primary color terms are red, yellow, and blue.
Table 4. Expected and observed frequencies for focal chips.

<table>
<thead>
<tr>
<th></th>
<th>RED exp</th>
<th>RED obs</th>
<th>GREEN exp</th>
<th>GREEN obs</th>
<th>YELLOW exp</th>
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<th>ORANGE obs</th>
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<th>PINK exp</th>
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<th>BROWN obs</th>
<th>TOTALS exp</th>
<th>TOTALS obs</th>
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<td>3.33</td>
<td>3</td>
<td>3.33</td>
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<td>WITH COLOR</td>
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Table 5. Location of significant tests for goodness of fit (p < 0.05).

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<th>RED</th>
<th>PINK</th>
<th>YELLOW</th>
<th>BROWN</th>
<th>ORANGE</th>
<th>GREEN</th>
<th>BLUE</th>
<th>PURPLE</th>
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<td>H B C</td>
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</tbody>
</table>

**ALL S's**

| A R R A Y | WITH COLOR TERM | X | X | X |

| A R R A Y | WITHOUT COLOR TERM |

| A R R A Y | ALL S's | X | X | X | X | X | X |

| A R R A Y | WITH COLOR TERM | X | X | X |

| A R R A Y | WITHOUT COLOR TERM | X |

*The order of the cols from left to right represents high to low on the wavelength continuum.
H = hue, B = brightness, C = chroma.
Table 6. Total frequency of choices for all color chips*

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<th>Position</th>
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<th>Brown</th>
<th>Yellow</th>
<th>White</th>
<th>Green</th>
<th>Purple</th>
<th>Blue</th>
<th>Pink</th>
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</tr>
</tbody>
</table>

* indicates the position of focal chips.

* Since there is a focal chip for each of the two arrays, the frequency presented here is for both focal chips. Separate frequencies for each type of array are listed in Table 1.