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Color Categorization in Bilingual Populations: Korean-English Bilinguals

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Honors Thesis, May 2015

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Abstract

Empirical research on the influence of language on cognition often focuses on the domain of color categorization. With a global increase in bilingualism, investigating how semantic information is cognitively processed by speakers of two languages is especially important. For example, it remains uncertain whether a bilingual's sensory representation of color appearance similarity is affected by their linguistic representations of color semantics. The literature on this topic has primarily examined the color naming of bilingual participants in non-English language modes. To address this gap in the literature, the present study compares color categorization and naming of bilinguals in both of their known languages. The study investigates Korean-English Bilinguals as the Korean color lexicon has interesting features that differentiate it from the English color lexicon. In particular, research suggests that Korean has two highly salient basic color terms for the region of color space that in English language would be described with the single color term "green" (Roberson, Hanley & Pak, 2008). We examine whether bilingual participant's categorization of colors vary across language of testing, especially in relation to categorization and naming observed for the green region of color space involving category differences across Korean and English.

1. Introduction

1.1 Linguistic Relativity

Leading up to the mid-1900s, linguists and anthropologists largely held a view of linguistic relativity, believing every language to be semantically arbitrary. The semantic differences between language systems were thought to result in nonlinguistic cognitive differences (Brown & Lenneberg, 1964). This view was first presented by Edward Sapir in the 1920s, and later popularized by Benjamin Lee Whorf. Empirical research aimed at addressing the Sapir-Whorf hypothesis has frequently centered on the domain of color cognition in cross-cultural investigations (Kay & Kempton, 1984).

1.2 Linguistic Universals

The dominant view of linguistic relativity was overturned with Brent Berlin and Paul Kay's (abbreviated B&K below) seminal study on basic color terms (1969). With the intuition that color terms are easily translatable, even among unrelated languages, B&K hypothesized that the segmentation of color space by a given language might not be wholly independent of color space lexicalization seen in other languages. To begin, B&K established a criterion for distinguishing the basic color terms of a language from the non-basic color terms; a criterion that is still integral to present research in the field. According to B&K, the basic color terms of a language are said to be monolexemic terms that are general, i.e. applying to a diverse class of objects, and salient, i.e. used consistently by speakers of a language with a good degree of consensus (Hardin & Maffi, 1997). B&K surveyed bilingual speakers of 20 different languages in their native languages, and accompanied their survey data with a literature search of 78 additional languages. Based on their study, B&K contributed two main ideas to the study of color cognition. First, they concluded that color naming systems across different cultures do have different numbers of basic color categories, but draw from a universal inventory of eleven colors corresponding to the English color terms *black, white, red, green, yellow, blue, brown, purple, pink, orange,* and *gray*. Second, B&K observed that there tended to be great amount of agreement on foci or "best examples" of basic color terms across languages, even when the category boundaries denoted by the basic color terms varied in the languages (Berlin & Kay, 1969). In a study with English speakers and speakers of the Dani language of Papua New Guinea, Rosch-Heider found that the memory accuracy of both groups for focal colors was higher than that of non-focal colors, even though Dani speakers consistently use only 2 basic color terms compared to the use of 11 basic color terms by English speakers (1972). Several such studies provided an alternative perspective to the linguistic relativity view, lending support instead to the existence of linguistic universals.

1.3 Continuing Debate: Linguistic Relativity vs. Linguistic Universals

Although linguistic universality was highly influential as an alternative perspective, recent research has raised new challenges for the universal color categories view. Several exceptions to B&K's first hypothesis on the existence of only 11 basic perceptual color categories across cultures have been brought forward. In a study of Russian color naming, Davies and Corbett (1994) demonstrated the existence of 12 color terms that satisfy B&K's criteria for basicness. The blue region of color space was shown to be consistently categorized by Russian speakers into two non-overlapping regions, a 'light blue' region and a 'dark blue' region, designated by the distinct terms *"goluboj"* and *"sinij"* respectively. Influences of this category distinction on color discrimination were investigated by Winawer et al. (2007), who found that Russian speakers were able to discriminate two colors faster when they fell into different ‘blue’ categories in Russian, and this advantage was not shown by English speakers who do not have a similarly lexicalized category distinction. Distinctions in the blue region of color space have similarly been shown for Greek (Androulaki et al., 2001), Japanese (Uchikawa and Boynton, 1987), and Turkish (Özgen & Davies, 1998) color lexicons.

A separate line of research raises further questions about B&K’s second hypothesis of cross-cultural agreement on focal colors. For example, while seeking to replicate Rosch-Heider’s (1972) results with groups of English speakers and speakers of Berinmo (i.e., another language of Papua New Guinea with a vocabulary of only 5 basic color terms), Roberson, Davies & Davidoff (2000) found no evidence of higher memory accuracy for English focal colors in Berinmo speakers, thereby raising a counter-example to the universalist claims of Rosch-Heider (1972). Further study with speakers of Himba (a language of Southern Africa that is geographically very distant from the Berinmo speakers, but also with a vocabulary of only 5 basic color terms), Roberson et al. (2005) once again found memory performance to be poor for English focal exemplars, but superior for the recognition of the focal color exemplars of their native language. These results showing the influences of different lexical categorization systems on the discrimination of color stimuli provided renewed attention for linguistic relativity ideas (Roberson, 2005).

However, contemporaneous analyses of World Color Survey (WCS) data (consisting of interviews with monolingual speakers of 110 diverse languages; Cook, Kay & Regier, 2005), showed statistically strong universal tendencies in color naming across languages (Kay and Regier 2003), as originally postulated by B&K (1969). With a flow of research steadily accumulating evidence for both relativist and universalist arguments, the current debate has come to rest on a middle ground between the two positions. For example, Jameson and colleagues presented a range of papers in which both relativist and universalist factors were explored (Jameson 2005a, Jameson & Alvarado 2005a, 2005b), while Kay and Regier synthesize the two viewpoints by suggesting that universal tendencies in color naming do exist, but differences in categorization across languages do cause differences in color cognition (2006).

1.4 Bilingualism and Color Cognition

Since the time of B&K’s 1969 study and collection of the WCS in the 1970s, the global linguistic environment has greatly changed. The spread of media and technological advances brings new linguistic influences to monolingual speakers of indigenous languages. As pure monolingual populations are less common in today’s world, an investigation of the impact of bilingualism on cognition is especially relevant. Even at the time of B&K’s study, the conclusions drawn from B&K’s data were constrained because their informant population was also bilingual in English (Cook, Kay & Regier, 2005), a factor which was not considered in their analyses.

A bilingual’s access to color categories and semantics from two languages poses interesting possibilities for investigating whether the cognitive representation and similarity relations of color might vary depending upon which language mode a bilingual speaker is in. It remains unclear whether bilinguals “code-switch” between two distinct forms of representation based on their language, or whether there is a degree of drift or transfer of concepts between the two languages (Alvarado & Jameson 2002, Jameson & Alvarado 2003a & 2003b, Athanasopoulos & Aveledo

2013). The paradigm of such research has been to compare bilinguals color naming and categorization to that of monolingual speakers of the same languages. In an early comparison between Navajo-English bilinguals and monolinguals of both languages, the color categorization of the bilingual and monolingual groups was observed to differ systematically, with a semantic shift occurring in bilingual naming based on a verbal mediation effect by the language which presented the most rapid response-term for the stimuli being tested (Ervin, 1961). A more recent study with Vietnamese-English bilinguals came to a comparable conclusion, finding the color naming of the bilingual speakers to be modified by category distinctions present in English which are not present in Vietnamese, suggesting that bilinguals may be adapting the language system presenting them with the most color category information (Jameson & Alvarado, 2003). This characteristic of a semantic shift has been observed in several other studies. In a study comparing the color categorization of Japanese speaking children living in Japan with Japanese children living in Germany, Zollinger found that the children influenced by the Western language gradually replaced the Japanese color terms for “non-basic” colors like brown, orange and pink, with borrowed Western terms (1988). Another study with Greek-English bilinguals found that bilingual speakers shifted their representation of color categories towards that of monolingual English speakers, but varied in the degree of shift depending upon their level of fluency and acculturation in the two languages (Athanasopoulos, 2009).

1.5 The Current Study

Although these studies have resulted in much progress towards modeling the relational structure and interaction among bilingual speakers’ color concepts under varying categorization systems, a gap in the literature remains. Previous studies have examined the color cognition of bilinguals in only their non-English language modes, in comparison with monolingual speakers of both languages of the bilingual. While such comparisons are informative, we believe that a within-informant comparison of naming and categorization patterns could be a valuable path to understanding the dynamics of language influence. The present study addresses this gap by comparing the color categorization and naming behavior of bilinguals in both English and their non-English language.

The bilinguals examined in the current investigation are speakers of both Korean and English. The Korean color lexicon has interesting features that differentiate it from the English color lexicon. Much like the Russian, Greek, Japanese and Turkish languages which have two basic color terms for the blue region of color space, research has shown that Korean has two highly salient basic color terms for the green region of color space, *yeondu* (yellow–green/light-green) and *chorok* (green), which in English would be typically described with a single basic color term (Roberson, Pak & Hanley, 2008).

In the current study, the first objective was to examine whether participant’s categorization of the basic colors would be observed as consistent within language condition (Korean vs. English) across three different tasks involving methods of naming, focus selection, and category mapping. The second objective was to examine whether bilingual participant’s categorization of basic colors would vary across language conditions, especially in relation to categorization and naming observed for the green region of color space involving category differences across Korean and English.

2. Method

2.1 Participants

Twenty-five Korean-English bilingual informants (9 men and 16 women; ages 19-28 years) participated in the study. The informants had varying degrees of proficiency in the two languages; some were raised in native Korea, while others were raised in the United States. All informants were students of the University of California, Irvine. Most were recruited through the School of Social Sciences, Research Participation Pool and received 1 extra course credit point for every hour of their participation, while a few additional male informants (3) were recruited from outside the Research Participation Pool but within the student population, and received $12 for every hour of their participation. All informants reported having normal (corrected) vision, and all were color normal, as assessed using the Ishihara Pseudoisochromatic Plates test and the Farnsworth-Munsell 100 Hue Test.

Data on 11 additional informants, 9 who did not complete the procedures for one of the language conditions, and 2 who were unable to complete the procedures in the allotted testing period, have been eliminated from the dataset reported here. The results and conclusions presented are not affected by the exclusion of these informants.

2.2 Procedure

Informants participated in two sessions of approximately two hours each. One of the sessions was conducted in Korean by a native Korean-speaking experimenter, while the other was conducted in English. The order of these sessions by language was counterbalanced for informants. Both sessions involved the following three tasks.

Task 1: Naming Task

Informants were asked to name 330 loose color chips (see description of stimuli that follows), without the imposition of any term-usage or time constraints by the experimenter. The chips were presented in a fixed random order, which was the same order of chip presentation as in the WCS. For every chip, informants were also asked to provide a confidence rating of how sure they were about the term they used to name the color chip. This was given on a scale of 1 to 5, where 1 indicated lowest confidence, and 5 indicated highest confidence.

Task 2: Focus Selection

Informants were asked to select (point to) the best example, or “focus,” of each different basic color name elicited in Task 1, on a fixed array of the same chips (Figure 1). The basic color terms to be tested were determined by the researcher based upon the color lexicon elicited by each informant in Task 1, and were selected on the basis of a criteria similar to the one adopted in the WCS (Kay et al., 2011).

Task 3: Category Mapping

For the same basic color terms as in Task 2, informants were asked to place a grain of rice on every color of the fixed array that could be named with “X” basic color term. The rice mapping of each basic color term was wiped from the array before testing on the next basic color term.

Informants were asked to complete a questionnaire on family demographics and language information. This included questions aimed at assessing the informants proficiency and frequency of language use. For example, informants were inquired about their age of language acquisition, estimated percent time of verbal language use, self-rating of language abilities, for both Korean and English. At the end of each session, informants also responded to a debriefing questionnaire. In Session 1, participants were asked about their experience with color perception, such as whether they were particularly skilled in art or painting, or if they had ever noticed color discrimination differences between themselves and other people in daily life. In both sessions, participants were also asked about their level of comfort with the tasks of the experiment, and their strategy in approaching the tasks. The responses to these debriefing questions were collected in order to have a means of assessing unexpected variation in participant data during the analyses.

2.3 Stimuli

For all informants, the tasks were conducted in a controlled ambient lighting-booth environment. The booth and table at which the informant was seated was covered in black felt. No other chromatic stimuli appeared in the informants view. The viewing booth was illuminated by an approximated daylight illuminant conforming to spectral power distributions of the CIE daylight model (CIE 1976 chromaticity coordinates of u'=0.1979 and v'=0.4685). Ambient illuminant intensity averaged 100.23 cd/m^2, subjectively approximating indirect daylight illumination (measured at CIE (1931) chromaticity: x = .313, y = .329). Viewing booth lamps were warmed up for 15 minutes before every session.

Color samples were presented one at a time to the informants in a neutral viewing context, free of potential color contrast and stimulus-set effects. Stimuli where sampled from Munsell Book of Color sheets, and corresponded closely to those used in the WCS (Kay et al., 2011). Each color sample measured approximately 1-inch square. Ten samples were achromatic, with values from 1.5/ to 9.5/ in the notation of the Munsell color-order system. The remaining samples were the 40 equally spaced Munsell hues (2.5 R to 10 RP, in hue steps of 2.5) sampled at each of eight values from 2/ to 9/ (hence, 320 hue/value combinations). Each stimulus was centered on a 2-inch-square neutral gray background (closely approximating Munsell neutral gray 5), leaving on all sides an approximate .5-inch gray border serving as a neutral visual context. The estimated viewing distance was 17 inches, with the stimulus placed flat in the horizontal position, and with the illuminant directly overhead. Approximate viewing angle subtended by the color stimuli was 3.82 degrees or greater. Specular reflections were minimized by the viewing angle of the stimulus relative to the illuminant position.

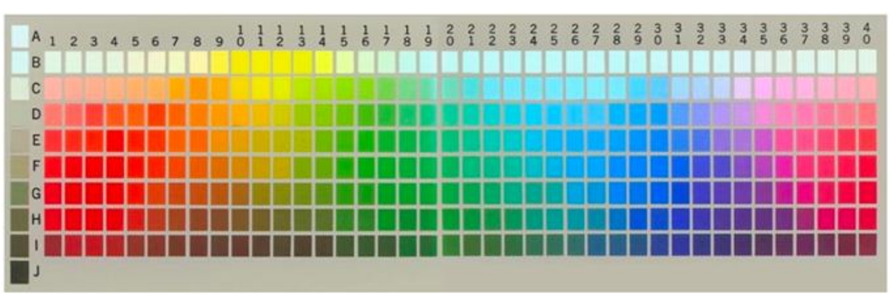


Figure 1: Color chart approximating the samples used in this study (Cook, Kay & Regier, 2005).

3. Results and Discussion

3.1 Color Categorization across Method of Testing

Consistency in color categorization is an important index for the analysis of color appearance salience. A standard measure of testing for consistency is to compare an informants naming of color stimuli on two separate occasions, as was done by Boynton & Olson (1987) and Sturges & Whitfield (1995). As the informants in the current study were already required to name the same 330 color stimuli on two separate occasions for the two language conditions, we instead tested for within-language categorization consistency by comparing across the three experimental tasks.

Although the naming of color stimuli in Task 1 was not limited to the use of only basic color terms, consistency of categorization was calculated by looking at instances of only the basic color terms elicited by a participant. This was because the samples for comparison in Task 2 (focus selection) and Task 3 (category mapping) were already limited by task design to only the basic color terms used by an informant.

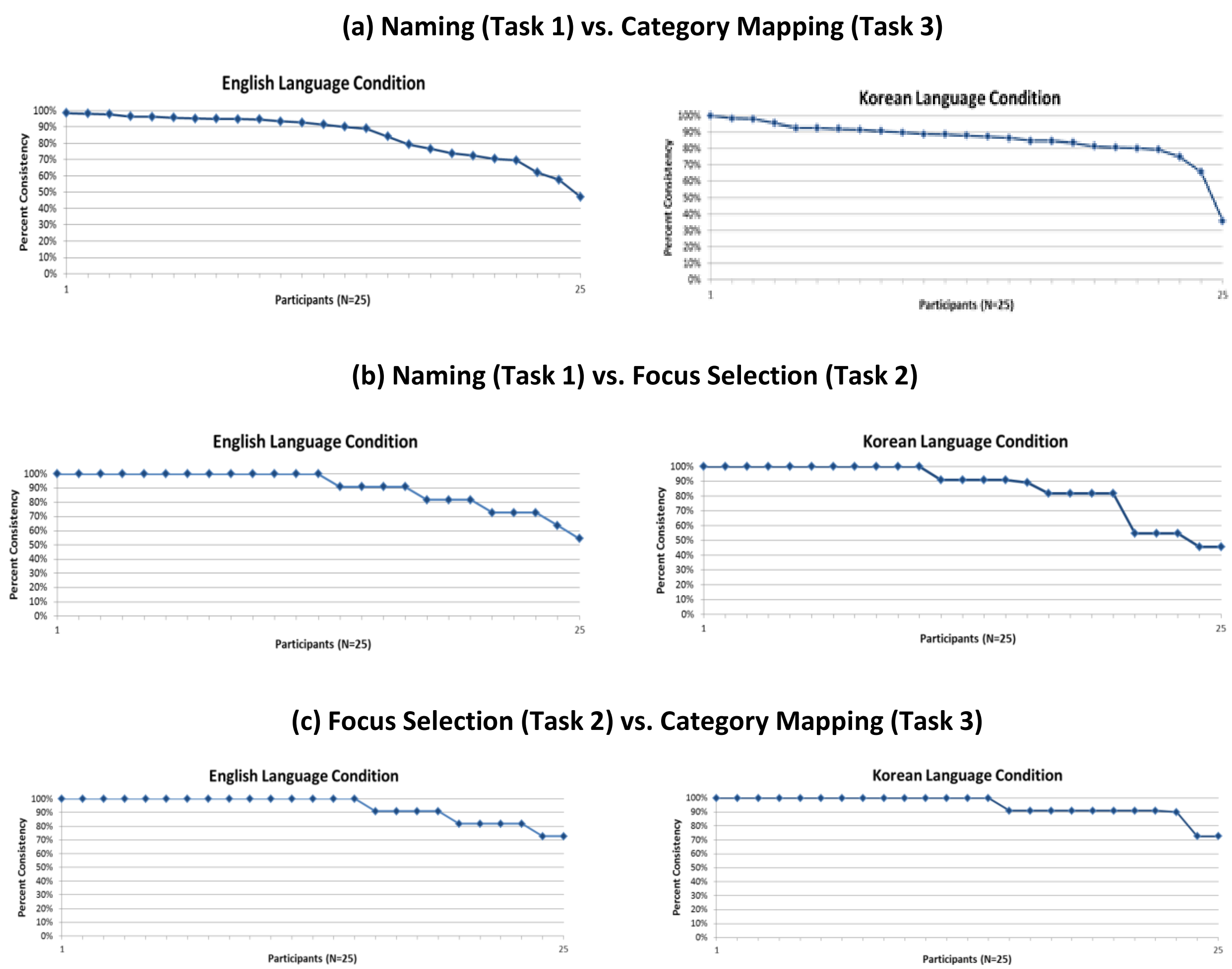


Figure 2: Percent consistency of informant responses in the English and Korean language conditions for three pair-wise comparisons of tasks shown (informants rank ordered by observed percent consistency on the horizontal axis).

Figure 2 above shows the percent consistency of informant responses in the English and Korean language conditions, over a pair-wise comparison of tasks, i.e., naming vs. category mapping, naming vs. focus selection, and focus selection vs. category mapping.

The consistency of responses in each of the comparisons is calculated by counting the number of exact matches in an informants responses for the two tasks being compared, dividing this count by the maximum number of matches possible, and multiplying by 100. For example, in Figure 2a comparing consistency in naming (Task 1) vs. category mapping (Task 3), a match in the English language condition would be if an informant had selected a particular color chip as “Yellow” in the mapping of the boundary of that category in Task 3, and also had named that same color chip as “Yellow” in Task 1. If the participant had named that same chip as “Light-Yellow” or anything else in Task 1, this would count as a non-match. In the same Figure 2a, the maximum number of matches is limited to all of the colors mapped by an informant in Task 3. This is because all of the 330 color samples available to an informant are not necessarily mapped in Task 3, whereas all of the 330 color samples are named by all of the informants in Task 1. By a similar logic, the maximum number of matches in Figure 2b and 2c are limited to all of the colors selected as a focus by informants in Task 2. Importantly, the maximum number of matches in each case also differs for each of the informants, as the usage of basic color terms was variable.

To obtain a general understanding of the levels of consistency among informants, we examined the percent of informants falling within a cut-off criterion of atleast 80% consistency in responses. Comparing naming (Task 1) and category mapping (Task 3), 68% of informants in the English language condition, and 88% of informants in the Korean language condition meet this criterion (Figure 2a). Comparing naming (Task 1) and focus selection (Task 2), 80% of informants in both the English and Korean language condition meet this criterion (Figure 2b). The percent of informants was highest when comparing focus selection (Task 2) and category mapping (Task 3), with 92% of informants meeting the criterion (Figure 2c).

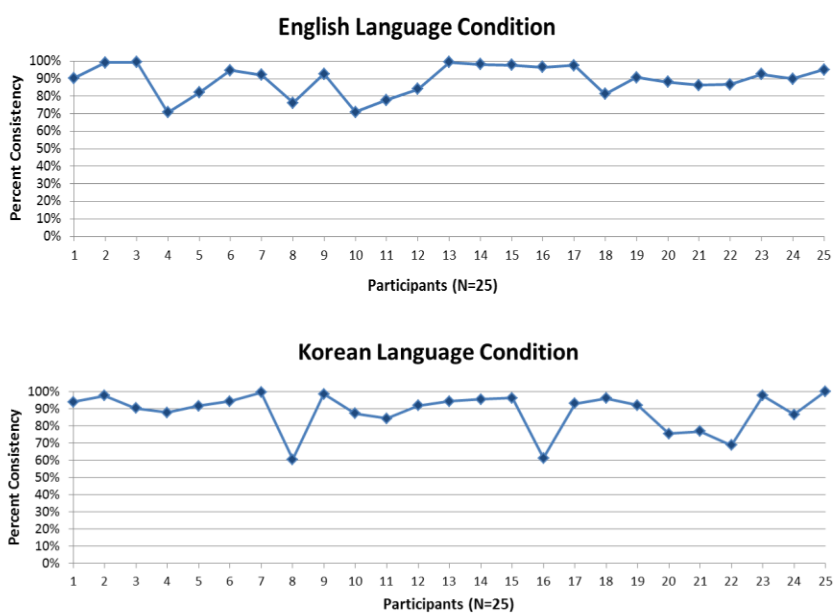


Figure 3: Average consistency of informants across all three experimental tasks.

In addition to comparing consistency across tasks, the average consistency of each informant across all three tasks was computed to obtain individual measures of overall consistency in each language condition, and is shown in Figure 3 above. The labels on the x-axis of both graphs correspond to particular informants. Almost all participants achieve within an overall consistency level of 70%, in both language conditions. Interestingly, informants ‘8’ and ‘16’, who exhibit relatively low levels of consistency (<70%) in the Korean language conditon, show much higher consistency in the English language condition. Such comparisions are easy to make for all informants from Figure 3, and reveal patterns that are likely to relate to the individual’s language proficiency.

3.2 Color Categorization across Language of Testing

In the sections that follow several descriptive comparisons of English and Korean language data are described.

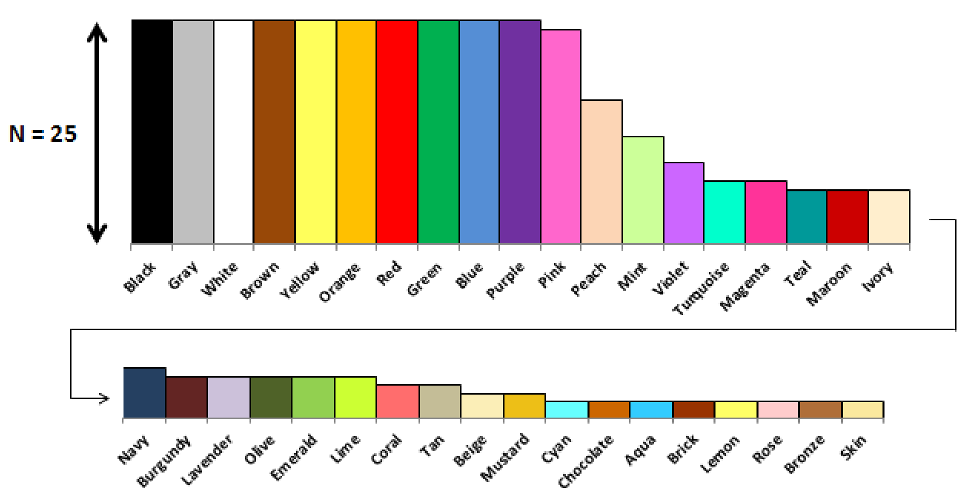
3.2.1 Color Naming

Every informant succeeded in naming each of the 330 color samples in Task 1. A group total of 56 monolexemic color terms were used in the English language condition, and a total of 104 monolexemic color terms were used in the Korean language condition. As naming was not restricted to monolexemic color terms, the total number of unique color terms used to name the 330 color samples in both language conditions was far greater. In English naming, informants used an average of 49.5 terms (*SD* = 29.64), and an average of 17 monolexemic terms (*SD* = 4.2). The minimum number of English terms used by a single informant was 12, and the maximum was 116, whereas the minimum number of monolexemic English terms used by a single informant was 11, and the maximum was 29. In Korean naming, informants used an average of 47.7 terms (*SD* = 38.62), and an average of 20.2 monolexemic terms (*SD* = 5.94). The minimum number of Korean terms used by a single informant was 9, and the maximum was 127, whereas the minimum number of monolexemic Korean terms used by a single informant was also 9, and the maximum was 32.

Figure 4a and 4b present the most commonly used basic and nonbasic color terms in English and Korean naming. In the English language condition (Figure 4a), all 25 informants used the first 11 basic color terms, except for one male informant who did not use the basic color term *pink* in naming. Among the nonbasic color terms, *peach* was used by the largest number of informants (16 out of 25). *Peach* was also observed to be the most frequently named nonbasic color term in a study by Lindsey & Brown (2014) with monolingual American-English informants. The only other nonbasic color term used by a sizeable proportion of informants (12 out of 25) was *mint*. This was a significant finding as the English color term *mint* is comparable to the additional Korean green category *yeondu* (yellow–green/light-green), and has not shown up in the color inventory of any previous research.

In the Korean language condition (Figure 4b), most informants used the first 11 basic color terms in naming, except for 2 informants who did not use a Korean color term for *gray*, 2 informants who did not use a Korean color term for *brown*, and 1 informant who did not use a Korean color term for *pink*. This result is most likely explained by the low Korean language proficiency of the three informants. The first panel of Figure 4b also illustrates the variability in basic color term usage in Korean naming. More than one color term was used to denote the *gray*, *white*, *pink*, *orange*, *brown* and *black* regions of color space. In each case, the informants naming patterns for all 330 color samples were carefully examined to determine the basic color term vocabulary of each informant. Among the nonbasic color terms, *Hanulsayk* (sky-blue/light-blue) was used by the largest number of informants (16 out of 25). As mentioned earlier, several other languages differentiate strongly between the light and dark regions of *blue* in the color space, and have a light-blue term in their lexicon of basic colors. Although the light/dark distinction of *green* in the Korean color lexicon has been discussed in the literature, this light/dark distinction of *blue* in Korean has not been examined to our knowledge, and may be warranted based on the present findings. On the other hand, *Yentwusayk* (yellow–green/light-green) was expected to be used with the frequency of a basic color term, but was used by only 14 out of 25 informants.

(a) English Language Condition



(b) Korean Language Condition

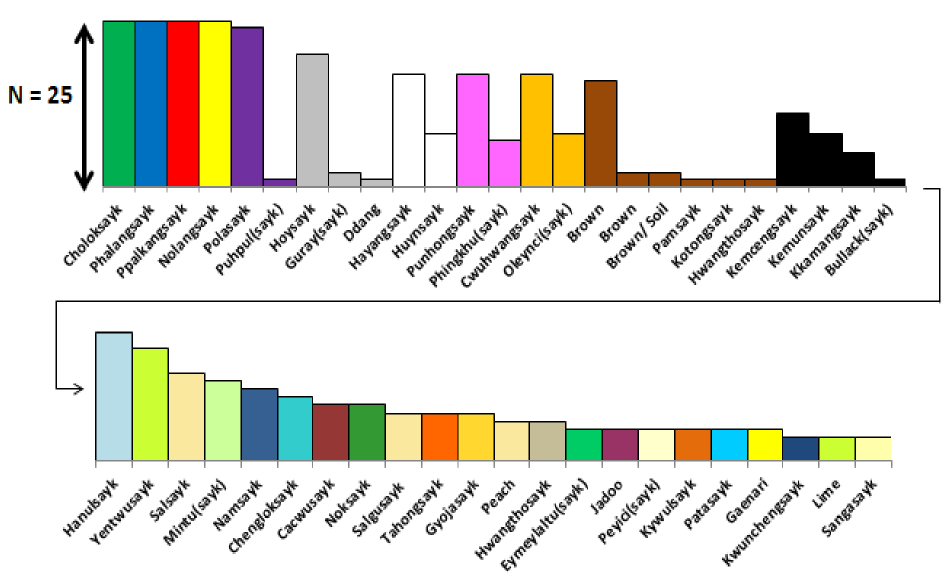


Figure 4: Most commonly used basic and nonbasic color terms in English and Korean naming.

To compare whether the same color samples were named with color terms with the same meanings across language condition, the modal response to name each color sample was identified. As in previous studies (Jameson & Alvarado, 2003), the modal response was defined as the single response free listed with the highest frequency to name each color appearance sample. All 330 modal Korean responses were translated to English on the basis of a pre-existing Korean color term dictionary (Tyson, 1994), and were also reviewed for correctness by a native Korean speaking experimenter. Figure 5 below depicts the modal color responses of the 330 chips in both languages. The percentage of agreement between the two languages was also calculated. Percentage of agreement was defined as the total number of matches between the modal names given in the two languages, divided by the total number of samples named (330), multiplied by 100. In order to be considered a match, the modal response given for a sample must have been exactly the same in both languages.

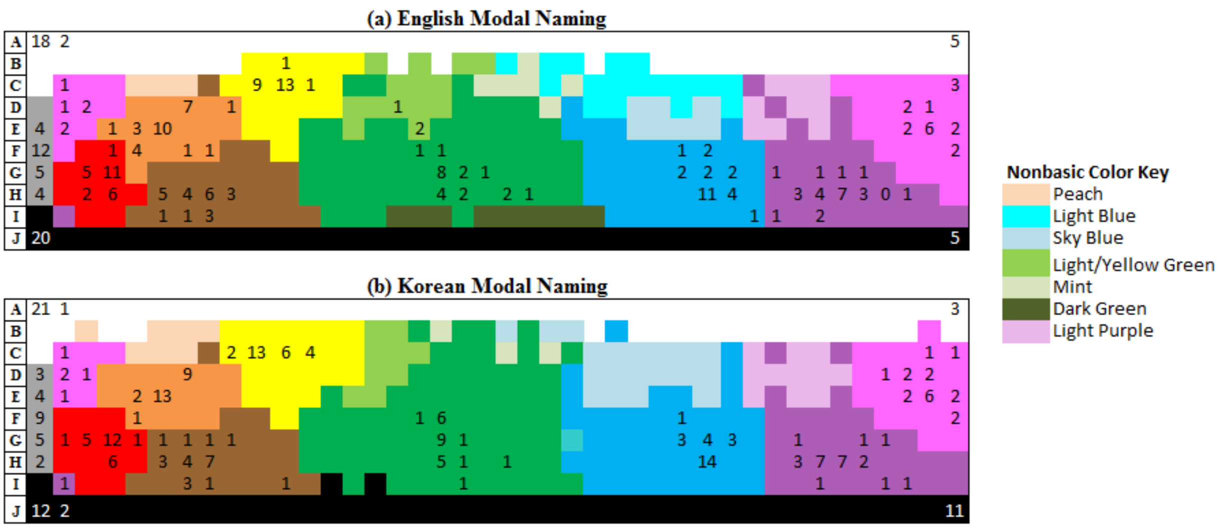


Figure 5: Modal naming and distribution of focal responses in English and Korean. The numbers indicate the number of individuals who chose a particular chip as the focus of the category.

The percentage of agreement between modal English and Korean names across all color samples was 76.6%. Under the hypothesis that bilingual informants employ two separate, language specific naming functions, this level of agreement between the modal naming responses of the two languages is suprisingly high considering the categorization difference hypothesized to exist in the green region of color space. This result is more easily explainable under the hypothesis that a bilingual speaker experiences some degree of shift in their conception of color categories of the two languages. For a better understanding of the factors contributing to this observation, the agreement percentage specific to the green category of color space was calculated. This was done by considering the number of matches in the color samples designated a *green* modal name, dividing by all of the color samples designated a *green* modal name in either English or Korean, and multiplying by 100. The agreement percentage for only the green samples was found to be 64%. A count of the number of non-matches in green modal names as a proportion of the total number of non-matches reveals that the green category accounts for 42.8% of the disagreement in the modal naming responses of the two langauges.

3.2.2 Focus Selections

As with the naming responses, to compare whether the same color samples were chosen as the focal colors across language condition, the modal focal selection for each color category was identified. The modal focal choice was defined as the color sample response chosen with the highest frequency as the focus or best example or a color category. Figure 5 above indicates the distribution of focal selections for only the 11 basic color terms in both languages. Although focal selection responses were also collected for the nonbasic color terms (specified in Figure 5's Key) in the Korean language condition, the focal selection responses for those nonbasic color terms were not collected in the English language condition, as the terms (with the exception of *peach* and *mint*) did not meet the criterion (are not monolexemic English terms) for testing. The present comparison has therefore been limited to only the 11 basic colors common to both Korean and English.

(a)

Basic Color Term	English Language Condition	Korean Language Condition	Color Representation
Black	J0	J0	
White	A0	A0	
Gray	F0	F0	
Red	G3	G3	
Orange	E5	E5	
Yellow	C10	C9	
Brown	H7	H7	
Green	G17	G17	
Blue	H29	H29	
Purple	H35	H34/H35	
Pink	E39	E39	

(b)

English Language Condition	Frequency of Modal Choice	Korean Language Condition	Frequency of Modal Choice
Black	80%	**White**	84%
White	72%	**Black**	76%
Yellow	52%	**Blue**	56%
Gray	48%	**Yellow**	52%
Red	44%	**Orange**	52%
Blue	44%	**Red**	48%
Orange	40%	**Gray**	40%
Green	32%	**Green**	36%
Purple	28%	**Brown**	32%
Brown	24%	**Purple**	28%
Pink	24%	**Pink**	24%

Figure 6: (a) Modal focal choices for the 11 basic color terms in both English and Korean (colors shown only approximate), and (b) Percentage of informants contributing to the modal focal choices for the 11 basic color terms in English and Korean (color categories rank ordered by percent of observed informant agreement).

A comparison of the modal focal choices for the 11 basic color terms in English and Korean reveals many similarities (see Figure 6a). The same color sample was identified as the modal focal choice in both languages in all basic color categories except for with the color categories of *yellow*, where the modal focal choice was displaced by one sample in the two languages, and *purple*, where the modal focal choice in Korean was split between two adjacent color samples. This high degree of focal choice similarity is striking given that language conditions were separated by several days for all 25 informants. This strong agreement between modal focal choices of the two languages is however deceiving without a consideration of the frequency of modal choice within the informant group, or the percent of informants that contribute to each modal focal choice. As can be seen from Figure 6b, the frequency of the modal choice is consistently high in both languages only for the *black* and *white* categories, and decreases greatly down the rows of the table. An examination of the rank ordering of the sorted color categories by frequency of modal choice however reveals some similarities between the structuring of the two languages. Certain color categories (*yellow*, *red*, and *gray*), are at the higher end of the rank ordering of both languages, whereas other color categories (*purple*, *brown*, and *pink*) are at the lower end of both rank orders. The correlation coefficient, Kendall's Tau value for the rank ordering of the two languages was 0.748. This does imply significant and similar focal selection structure across language modes, but not identical.

The focal selections for nonbasic color terms were also compared. In the English language condition, focal selections for a total of 23 nonbasic color terms used by two or more informants were obtained. The frequency of modal choices for the nonbasic color terms never exceeded 20%, which indicates that more than 5 informants never made a common focal choice. This was even when the focal choices of commonly used synonyms for colors such as *beige*, *cream*, *ivory*, etc., were not differentiated. In the Korean language condition, focal selections for a total of 30 nonbasic color terms used by two or more informants were obtained. In only one case, the frequency of modal choice for the nonbasic Korean term *Salsayk* or *peach* (including a few of its synonyms) exceeded 20%, and reached a level of 28%. Notably, there was no agreement on the focal choice for the Korean term *Yentwusayk* (yellow–green/light-green), which was expected to produce greater agreement in focal choices as per the B&K model (1969), owing to its salience among Korean language speakers.

3.2.3 Naming and Category Mapping of the Green Region of Color Space

An important aim of this research for addressing bilingual color representation is to investigate the green region of color space in English and Korean. As stated earlier, the categories named for green color appearances differ across the two languages. In exploratory analyses presented below, we descriptively compare the naming and category mapping data for the green color appearances to determine whether any interesting patterns are immediately evident and suggest avenues for future detailed analyses.

Figures 7 through 9 are contour plots of aggregate frequency counts of naming (Task 1) and category mapping data (Task 3), for particular color terms used in the green region of color space. For example, Figure 7a is a plot of the aggregate naming frequency of the English monolexemic term *green*. In this plot, the frequency of color samples named as *green* in Task 1 has been aggregated across all 25 informants. The peak of the contour plot indicates the color sample that was most frequently named as *green*, and the maximum height of the peak is 25, indicating a color sample agreed upon by the whole informant group. The edges of the hill indicate the color samples that were named with lower frequency as *green*. Similarly, Figure 7b is a plot of the aggregate mapping frequency of the English monolexemic term *green*.

Visually comparing Figure 7a of the aggregate frequency of color samples named as *green* in English, and Figure 7b of the aggregate frequency of color samples names as *Choloksayk* in Korean, it is clear that the denotative range of the two terms covers a very similar region of the color space. The peaks of both contour plots coincide at the same point, and also match the modal focal choice for the English term *green* and the Korean term *Choloksayk*. Figure 7c of the aggregate frequency of color samples mapped as green in English, and Figure 7d of the aggregate frequency of color samples mapped as *Choloksayk* in Korean, are also visually very similar. The peaks of these plots coincide with each other, with the peaks of the naming plots, and also with the modal focal choices of the color terms in both languages. These observations are indicative as a measure of consistency and category robustness. A clear difference is however noticeable when comparing Figure 7a with 7c, and Figure 7b with 7d. In both the English and Korean language condition, the naming of the green term is more expansive, whereas the mapping of the green category in both languages is more centered.

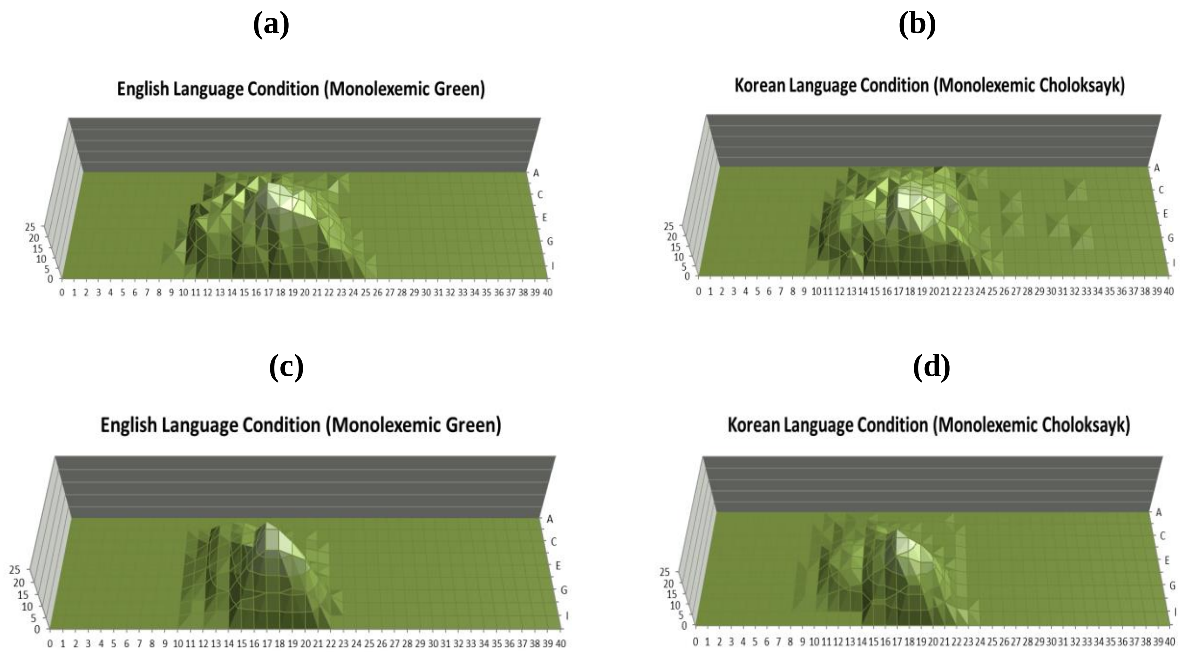


Figure 7: Contour plots of the aggregate frequency of (a) naming of monolexemic English *green* (b) naming of monolexemic Korean *Choloksayk* (basic green) (c) category mapping of monolexemic English *green*, and (d) category mapping of monolexemic Korean *Choloksayk.*

The same comparisons were conducted with the contour plots of the aggregate frequency of naming of monolexemic Korean *Yentwusayk* (yellow–green/light-green) in Figure 8a, and the mapping of monolexemic Korean *Yentwusayk* in Figure 8b. The maximum peak frequency in these two figures is 14, as only 14 informants used the color term. As with Figure 7, the area covered in both the naming and category mapping of the Korean term *Yentwusayk* is comparable, and is much more closely clustered in the category mapping method.

As in Korean, both the terms *Choloksayk* and *Yentwusayk* are believed to together denote the green region of color space, in the next set of figures, the combined expanse of these two terms are compared against the single English term for the green region of color space. Figure 9a is a plot of the aggregate frequency of color samples named as *green* in English, and Figure 9b is a plot of the aggregate frequency of color samples named as *Choloksayk* and color samples named as *Yentwusayk* in Korean. In the case of Figure 9b, overlap in the naming of these two terms did not contribute to the frequency count twice. Although Figures 9a and 9b look similar, a smaller second peak appears in Figure 9b in the region of color space denoted by the Korean term *Yentwusayk.* The difference in the English and Korean languages on the overall category of basic green is more evident when comparing Figure 9c, plotting the aggregate frequency of color samples mapped as *green* in English, and Figure 9d, plotting the aggregate frequency of color samples mapped as *Choloksayk* and color samples mapped as *Yentwusayk* in Korean.

(a) **(b)**

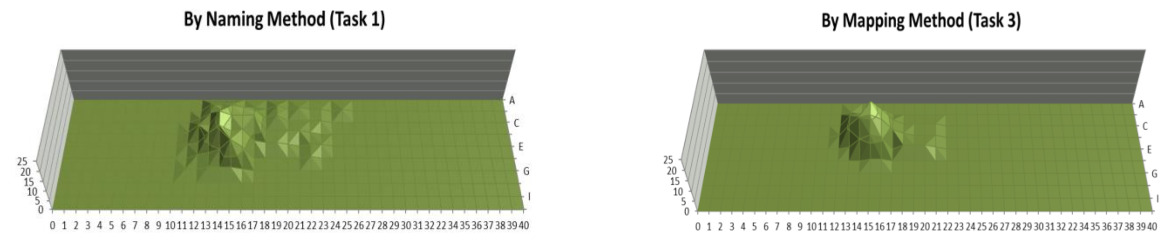


Figure 8: Contour plots of the aggregate frequency of (a) naming of monolexemic Korean *Yentwusayk* (yellow–green/light-green), and (b) category mapping of monolexemic Korean *Yentwusayk.*

An important feature of the frequency data is the noticeable task-dependent asymmetry in color categorization, where the naming of color samples is more variable than the category mapping of the same color. Such an asymmetry has also been observed in studies with other language groups (Jameson & Alvarado, 2003).

(a) **(b)**

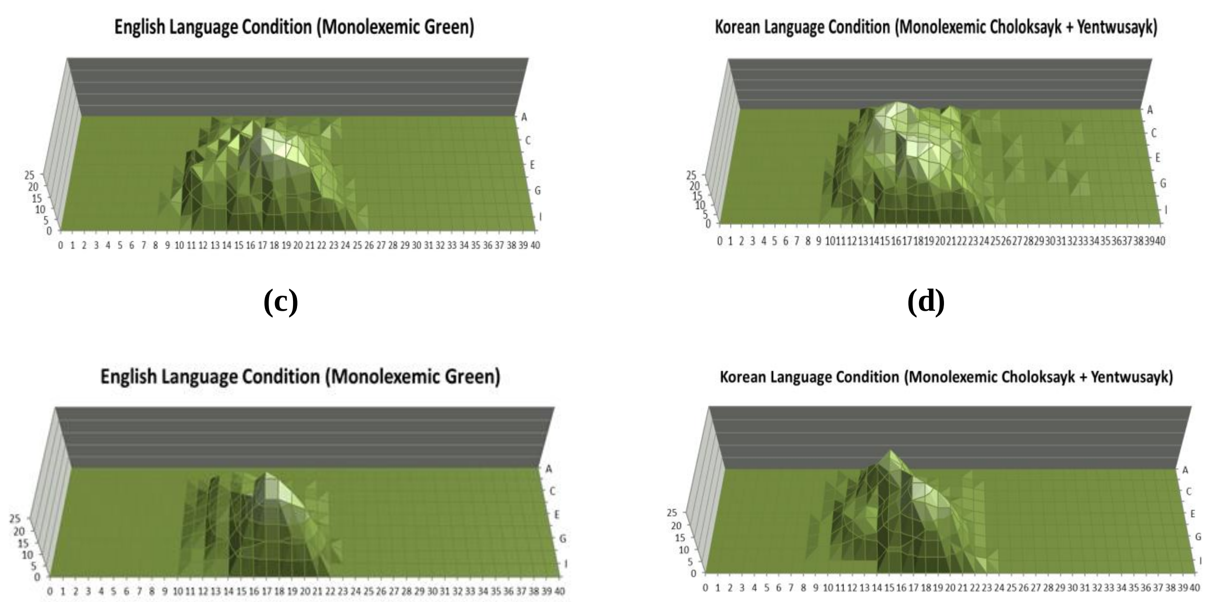


Figure 9: Contour plots of the aggregate frequency of (a) naming of English *green* (b) naming of Korean *Choloksayk* (basic green) and *Yentwusayk* (yellow–green/light-green) (c) category mapping of English *green*, and (d) category mapping of Korean *Choloksayk* and *Yentwusayk*.

The task-dependent asymmetry in color categorization is also hypothesized to relate to an observed pattern in consistency measures calculated across tasks, as presented in Section 3.1 above. Among the comparisons made, consistency was highest between tasks that involved the making of color choices (Figure 2c, focus selection and category mapping), and lowest when the tasks involved two different sorts of response behaviors (Figure 2a, naming and category mapping, and Figure 2b, naming and focus selection). This characteristic of consistency measures examined across different task formats, along with findings from the aggregate frequency contour plots, suggests that methods involving focus selection and category mapping can, in part, overcome the attenuation of consistency that may come with task variation. This may be an indicator that focal colors are more cognitively salient than non-focal colors as examples of category denotata. This feature perhaps can be enlisted to create a more objective definition of color category foci, and is a possible avenue for future study.

4. General Discussion

The current study is the first to obtain WCS type color categorization responses in both the English and non-English language modes of bilingual informants. The descriptive analyses presented here are a valuable first-step towards understanding the phenomena inherent in the data, and further analyses using statistical and mathematical modeling methods are planned. Here we examined the naming, focus selection, and category mapping data of the two language conditions using a variety of traditionally employed descriptive measures that enable comparisons with results from the area's vast literature.

As the informants were tested on the same color stimuli in their two languages, our first analyses sought to test for consistency of responses across the three tasks within a language condition. Our findings demonstrate a good degree of consistency in all three paired task comparisons – this is a new and important result that lends confidence to subsequent statistical comparisons planned between language conditions. Beyond observing consistency of response results, several findings are noteworthy.

First, we found an expected pattern of results for inter-task consistency, namely: the consistency of responses was attenuated when the underlying tasks compared differed (Figure 2a results), was maximal when the underlying tasks compared were the same (Figure 2c results), and was intermediate (presumably due to an underlying basic color salience) for the case of focus selection and category mapping even when the tasks compared differed (Figure 2b results). This is an important finding that establishes that our tasks are tracking the expected differences in naming that arise purely from task variation and from variation in stimulus salience.

Second, we found trends suggesting that the effects of language proficiency were isolated in bilingual individual's task performance. Maximal task consistency was observed in the language condition where high proficiency existed, while low language proficiency in the other language condition resulted in attenuated consistency in task performance (Figure 3). This is an important demonstration that even for bilingual participants, these tasks are capable of systematically distinguishing categorization and naming performance across language conditions in ways that potentially reflect the robustness of each language's distinct cognitive representation.

Third, we found the lists and distributions of participants most commonly used color terms in both language conditions agreed with what has been observed previously for monolingual assessments of English and Korean (Figure 4 results). Figure 4's results additionally isolated new findings suggesting emergent categories in both languages that heretofore were not identified in the existing literature. Future analyses aim to explore and clarify these trends further.

Fourth, modal focal choices compared across the two language conditions were found to closely agree on focal exemplar selections (Figure 6a) although not uniformly agree for all color categories (Figure 6b) suggesting that further analyses can be done to define a more objective quantitative notion of "basicness", which is a future analysis goal. Despite the good agreement across languages for focal selections, results showed the denotative ranges of category mappings to be specific in predictable ways to each language mode, and in ways that seem consistent with trends observed in previous research (Figure 5 results). Quantitatively indexing the denotative ranges of categories across languages is planned to extend the analyses of these data.

And, finally, results from contour plots of aggregate frequency of naming and mapping found, as expected, important consistent differences in naming and mapping agreement across language conditions which reflected specific features of each language's known color lexicon differences (Figure 7, 8 & 9 results). While these contour plots are preliminary visualizations of patterns of shared responses in the data, their results lend confidence to continued use of the present methods for investigating bilingual language interactions and dependencies in the naming and categorization of shared perceptual concepts. This is an important validation of the present approach as a procedure for differentiating systematic patterns of individual's responses that relate to underlying differences in shared cognitive models for color.

Beyond establishing that the present approach can be used to evaluate differences due to bilingual language processing, the methods of the present study replicate that of the WCS and the Mesoamerican/Multinational Color Survey (MCS) (MacLaury, 1997), additionally allowing for direct comparisons with hundreds of languages surveyed in these two archives. In particular, existing data on monolingual American English informants at the George Washington University (MacLaury, 1994), and data on both monolingual and bilingual Korean language informants (Tyson, 1994) surveyed in native Korea on the same three tasks are planned as the next important comparisons to correctly interpret the color categorization behavior of the current bilingual informants. If in such a comparison we were to find that the monolingual English informants name and provide denotative range mappings similar to the current bilingual informants in the English language condition, and that the monolingual Korean informants name and provide denotative range mappings similar to the current bilingual informants in the Korean language condition, then our results suggest that bilingual informants separately employ the naming functions of two languages to represent color categories. However, if in such a comparison we were to find that the naming and denotative range mappings of monolingual informants of English and Korean do not duplicate the bilingual responses in each of these language conditions, then our results suggest that the cognitive naming functions for color in bilinguals differ from that of monolinguals. Such a comparison will provide important insights for refining the current theories on variations in the color naming patterns of bilingual speakers.

Acknowledgements

I would like to thank my mentors Dr. Kimberly A. Jameson and Professor Louis Narens for their support and guidance throughout this project. I would also like to thank Helen Haan and Jacey Song for their assistance with data collection, and for sharing their valuable expertise with the Korean language over several discussions. This research was supported by an award to the author from the Undergraduate Research Opportunities Program, at the University of California, Irvine. Additional support was provided by The University of California Pacific Rim Research Program, 2010-2015 (K.A. Jameson, PI) and The National Science Foundation 2014-2017 (#SMA-1416907, K.A. Jameson, PI). IRB Approval for Human Subjects Research: HS#2014-1644.

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