Experimental Investigation into the Continuous Pattern of the Relationship Between Color Focality and Short-Term Memory Performance for Colors

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Abstract

Past studies reported that language-specific color focality has substantial influence on the short-term memory (STM) performance of colors of the speakers of the language, which we call the "focality effect." This study attempts to clarify the continuous pattern of this effect, that is, the manner in which correct recognition possibilities and misrecognition error distances of colors, which are two aspects of the STM performance for colors, change in a gradual fashion along the continuum of color focality. Our experiment, which tests the Japanese language, finds that a U-shaped relationship exists between the focality and the possibility of correct recognition, and that the misrecognition error distance increases as the focality decreases. We speculate that the subjects' frequent and conscious employment of the memorization strategy of coding colors using linguistic categories is one important cause of the detected effect patterns.

Keywords: color focality; short-term memory; continuous pattern; color discriminability; basic color terms

Introduction

While color sensation changes gradually along the perceptual dimensions of hue, lightness, and chroma (Munsell, 1919), in languages, this is conceptualized into a series of categories. Every language contains a set of basic color terms in its lexicon, such as *black*, *white*, *red*, *green*, *blue*, *yellow*, *brown*, *gray*, *orange*, *pink*, and *purple* in the English language (Berlin & Kay, 1991). The categories signified by the basic color terms (called "basic color categories" for short) are natural categories that have their inner structures formed around their prototypes. This means that within a basic color category, the member colors differ in their focality, namely their "closeness" to the prototype, or in other words, their goodness as a typical example of the category (Rosch, 1973).

In this case study, which tests the Japanese language, we aim to experimentally evaluate the universality of the phenomenon that language-specific color focality influences short-term memory (STM) for colors of the speakers of the language, which we call the "focality effect." More important, we attempt to clarify the continuous pattern of this effect if its existence turns out to be supported in our experiment.

The focality effect first appears in the English language in Heider (1972). In her experiment, Heider used a simplified version of the color array that Berlin and Kay (1991) used. The array was composed of 160 Munsell color chips, 24 of which were selected as test chips. Eight of these chips were focal colors, that is, the colors of the highest focality for each of the eight chromatic basic color categories that were shared by numerous languages but generally corresponded to the English categories *Red*, *Green*, *Yellow*, *Blue*, *Brown*, *Purple*, *Pink*, and *Orange* (Roberson, Davies, & Davidoff, 2000; Roberson, J. Davidoff, & Shapiro, 2005). The other 16 chips were of lower focality for these categories, and thus were classified as nonfocal colors. The selection and categorization of the test chips were based on the color-naming data gathered by Berlin and Kay (1991). In each trial in Heider's experiment, a subject was required to watch a color chip for 5 s and then search for it in the color array after a 30-s interval, where the chip was hidden from the subject. For either stimulus type, two indexes of STM performance were measured. The first index was the "memory accuracy score (MAS)," which was defined as the mean number of correct recognitions for this stimulus type across the subjects. The second index was the "error distance score (EDS)," which measured the mean error distance across the incorrect trials of this stimulus type. The English-speaking subjects showed superior performance for both measures of the focal colors relative to the nonfocal ones. Roberson et al. (2000) employed the same experimental paradigm and stimuli. Regarding the English-speaking subjects, a focality effect similar to that reported by Heider was detected in terms of MAS. However, no focality effect was found in terms of EDS. Roberson et al. (2005), which also used this experimental paradigm and stimuli, found that the mean *d'* score (a modified version of MAS) of the test chips that were focal only in Himba (a language mainly spoken in Southern Africa) were significantly higher than that of the test chips that were focal only in English. This effect was also detected in the language of Berinmo, which is mainly spoken in Papua New Guinea. The index of EDS was not used in this study.

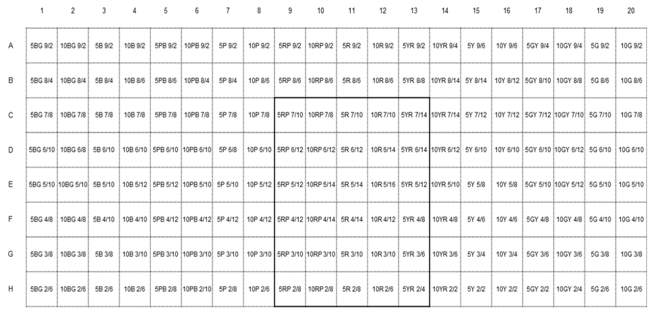
Overall, these studies have provided some evidence for the universal existence of the focality effect across languages in terms of MAS. On the other hand, no robust focality effect has been observed in terms of EDS. More empirical evidence is necessary to test whether the focality effect exists for these two STM performance measures. Because no Asian language has been studied in this field, we regard the Japanese language to be suitable as our target language. Furthermore, in these studies, color focality was treated as a categorical variable with only two values: "focal" and "nonfocal." This precluded any elaborate descriptions of the focality effect. Therefore, in this study, we quantified the concept of color focality in a continuous fashion and delved into the continuous pattern of the focality effect, that is, how STM performance for colors changes gradually along the continuum of color focality.

Experimental Settings

Participants, Materials and Environment

Twenty-two subjects (11 males and 11 females of ages M = 31.45 and SD = 14.34, all native Japanese speakers with no color-related art experience), who are either undergraduate or graduate students at Waseda University, took part in the experiment. They all passed the Ishihara Color Vision Test (38 plates, International Edition), and no one reported having color vision deficiencies. Hence, these subjects were considered to have normal color vision.

A color array of Heider (1972)'s design was used. Its layout is shown in Figure 1. This array was made of cardboard (58.5 cm * 28.5 cm), and had color chips embedded in its white surface. Thirty colors (called "test colors" for short) were tested in the formal trials of Session 1. These colors were mounted on the white surface of a 5.0 cm * 5.0 cm piece of cardboard when being presented to the subjects. Chips in the Munsell Book of Color (Glossy Edition) were used.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	5BG 9/2	10BG 9/2	5B 9/2	10B 9/2	5PB 9/2	10PB 9/2	5P 9/2	10P 9/2	5RP 9/2	10RP 9/2	5R 9/2	10R 9/2	5YR 9/2	10YR 9/4	5Y 9/6	10Y 9/6	5GY 9/4	10GY 9/4	5G 9/2	10G 9/2
B	5BG 8/4	10BG 8/4	5B 8/4	10B 8/6	5PB 8/6	10PB 8/4	5P 8/4	10P 8/6	5RP 8/6	10RP 8/6	5R 8/6	10R 8/6	5YR 8/8	10YR 8/14	5Y 8/14	10Y 8/12	5GY 8/10	10GY 8/8	5G 8/6	10G 8/6
C	5BG 7/8	10BG 7/8	5B 7/8	10B 7/8	5PB 7/8	10PB 7/8	5P 7/8	10P 7/8	5RP 7/10	10RP 7/8	5R 7/10	10R 7/10	5YR 7/14	10YR 7/14	5Y 7/12	10Y 7/12	5GY 7/12	10GY 7/10	5G 7/10	10G 7/8
D	5BG 6/10	10BG 6/8	5B 6/10	10B 6/10	5PB 6/10	10PB 6/10	5P 6/8	10P 6/10	5RP 6/12	10RP 6/12	5R 6/12	10R 6/14	5YR 6/14	10YR 6/12	5Y 6/10	10Y 6/10	5GY 6/10	10GY 6/12	5G 6/10	10G 6/10
E	5BG 5/10	10BG 5/10	5B 5/10	10B 5/12	5PB 5/12	10PB 5/10	5P 5/10	10P 5/12	5RP 5/12	10RP 5/14	5R 5/14	10R 5/16	5YR 5/12	10YR 5/10	5Y 5/8	10Y 5/8	5GY 5/10	10GY 5/12	5G 5/10	10G 5/10
F	5BG 4/8	10BG 4/8	5B 4/10	10B 4/10	5PB 4/12	10PB 4/12	5P 4/12	10P 4/12	5RP 4/12	10RP 4/14	5R 4/14	10R 4/12	5YR 4/8	10YR 4/8	5Y 4/6	10Y 4/6	5GY 4/8	10GY 4/8	5G 4/10	10G 4/10
G	5BG 3/8	10BG 3/8	5B 3/8	10B 3/10	5PB 3/10	10PB 3/10	5P 3/10	10P 3/10	5RP 3/10	10RP 3/10	5R 3/10	10R 3/10	5YR 3/6	10YR 3/6	5Y 3/4	10Y 3/4	5GY 3/6	10GY 3/6	5G 3/8	10G 3/8
H	5BG 2/6	10BG 2/6	5B 2/6	10B 2/6	5PB 2/8	10PB 2/10	5P 2/8	10P 2/6	5RP 2/8	10RP 2/8	5R 2/8	10R 2/6	5YR 2/4	10YR 2/2	5Y 2/2	10Y 2/2	5GY 2/2	10GY 2/4	5G 2/6	10G 2/6

Figure 1: Layout of color array.

The experiment was performed indoors with fluorescent lighting (type: National FHF 32EX-N-H, daylight color, color temperature: 5000 K). The experimenter and subject being tested sat opposite each other at a table. The distance between the stimuli and the subject's eyes was controlled at 50 cm. A cardboard separating the two persons was erected along the middle of the table, making the subject unable to see the experimenter's face when observing the stimuli, waiting during the 30-s interval, and filling out the answer sheets.

Procedure

The entire experiment, which was carried out in Japanese, consisted of two sessions.

Session 1, which used a procedure similar to that used by Heider (1972), aimed to measure the subjects' STM performance for the test colors. This consisted of 33 trials. In each trial, a test color was presented to the subject for 5 s and then retrieved by the experimenter. After a 30-s interval, the color array was presented to the subject, and the subject was asked to report which color in the array he/she thought was the previously presented one by writing the coordinates of the color on an answer sheet. There was no conversation between the experimenter and the subject. Each test color was tested at least once with each subject, and for each subject, the order of color testing was randomly determined. Thus, for each subject, there were three repeated trials, which were intended to prevent the subject from using a strategy of excluding the already tested colors. Before the formal experiment began, a two-trial training session using a different set of test colors was conducted. For each subject, the colors tested during the training were randomly selected.

After all 33 formal trials were completed, a questionnaire was given to the subject. This questionnaire asked the subject to report freely on the strategies that he/she adopted to memorize the test colors during this session.

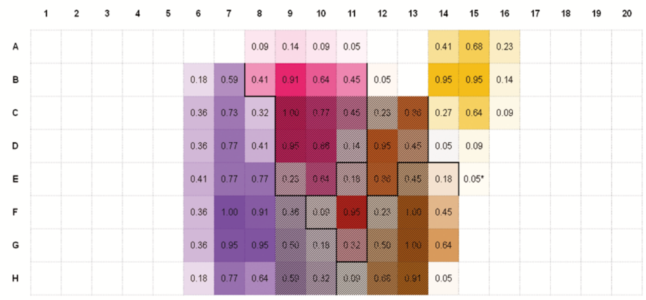
Session 2 was targeted to elicit the coverage of six basic color categories corresponding to the six Japanese basic color terms *akairo* (*red*), *pinkuiro* (*pink*), *kiiro* (*yellow*), *orenjiiro* (*orange*), *chairo* (*brown*), and *murasakiiro* (*purple*) (Uchikawa & Boynton, 1987). Then, the focality of each test color was quantified using a modified version of Berlin and Kay (1991)'s method. First, the subject was required to write on six answer sheets (one for each basic color term) all colors that he/she thought could be named by the term. The answer sheets were provided to each subject in random order. Next, the subject was asked to report the colors they thought were the best examples of each of the six basic color terms. This was accomplished by writing the coordinates of the colors on an answer sheet. Multiple answers were allowed for each term, but the subject was instructed to narrow his/her selections as much as possible.

Statistical Analysis and Results

Variable Definitions

Focality Score We used the data obtained from Session 2 to specify the coverages of the six basic color categories over the array, and quantified the focality of the test colors. We first computed the six attributes for each test color: Red Index, Pink Index, Yellow Index, Orange Index, Brown Index, and Purple Index. These attributes measured the intersubject naming consistency of the color in terms of each basic color term. The Red Index was defined as the percentage of subjects who named the color as *red*, and the other five indexes were similarly defined. Then, we designated the Overall Index (OI) of a color as the largest of the six single-term-based indexes of the color. We classified a color into the color category *Red* if its OI was its Red Index, the color category Pink if its OI was its Pink Index, and so forth. Figure 2 shows the distribution of the nonzero OIs and the partition of the six basic color categories.

For each basic color category, most of the colors having the largest OIs were also frequently selected as the best examples during the second part of Session 2. Thus, it is reasonable to deem the OI of a color as reflecting the appropriateness of the color as a typical example of the category to which the color belongs. In this manner, we defined the focality score (FS) of a color as its OI value.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A								0.09	0.14	0.09	0.05			0.41	0.68	0.23				
B						0.18	0.59	0.41	0.91	0.64	0.45	0.05		0.95	0.95	0.14				
C						0.36	0.73	0.32	1.00	0.77	0.45	0.23	0.36	0.27	0.64	0.09				
D						0.36	0.77	0.41	0.95	0.86	0.14	0.95	0.45	0.05	0.09					
E						0.41	0.77	0.77	0.23	0.64	0.18	0.36	0.45	0.18	0.05*					
F						0.36	1.00	0.91	0.36	0.09	0.95	0.23	1.00	0.45						
G						0.36	0.95	0.95	0.50	0.18	0.32	0.50	1.00	0.64						
H						0.18	0.77	0.64	0.59	0.32	0.09	0.68	0.91	0.05						

Figure 2: Distribution of Overall Indexes of test colors (colors within area covered by thin diagonal stripes) and other relevant colors, and partition of the six basic color categories. Color depth represents Overall Index magnitude. *[*: Orange Index = Brown Index]*

Discriminability Score We defined the discriminability score (DS) of a test color on the color array as the average of the color differences between the test color and its eight adjacent colors. In this study, a color difference was defined as a Euclidean distance in the CIE L*a*b* color space. Thus, before calculating color differences, we transformed the Munsell coordinates of all relevant colors into CIE xyY coordinates using the O.S.A.-developed conversion tables (Newhall, Nickerson, & Judd, 1943), then XYZ coordinates, and finally the L*a*b* coordinates. In the final transformation step, the parameter values of the CIE D50 standard illuminant, which resembled the light source used in this experiment, were used.

STM Performance Index 1: Memory Accuracy Score We adopted MAS as one index of STM performance. It measures the probability for which a color can be accurately recognized. Since FS is continuous in our study, it is necessary to take MAS also as continuous. We defined the MAS of a test color as the percentage of the trials where the subjects correctly recognized the color.

STM Performance Index 2: Error Distance Score The EDS is adopted as another index of STM performance. EDS measures the expected error extent in the case of misrecognition. As in Heider (1972)'s and Roberson et al. (2000)'s studies, the EDS for a test color is defined as the mean of the color differences between the test color and the colors mistaken for the test color in the incorrect recognition trials.

The Relationship Between FS and MAS

In order to determine the continuous pattern of the relationship between FS and MAS, we first conducted regression analyses on the FS data and the original MAS data of the test colors to obtain a general impression of the relationship pattern. No statistically significant linear relationship could be detected ($R^2 = 0.066$, $P = 0.171$ [$B_{FS} = 0.152$, $P = 0.171$]), but a significant quadratic relationship was found ($R^2 = 0.237$, $P = 0.026$ [$B_{FS} = -1.064$, $P = 0.045$; $B_{FS*FS} = 1.073$, $P = 0.021$]).

Brown and Lenneberg (1954) found that color discriminability could facilitate STM performance for colors, which we call the "discriminability effect." Later, Heider (1972) and Lucy and Shweder (1979) pointed out that because the colors in the color array were unequal in discriminability, it was possible that it was color discriminability, not color focality, that caused the detected variance in STM performance for colors. This possible source of distortion was checked by using the following procedure. First, we looked into the relationship between DS and MAS. A significant positive linear regression model could be established between these two variables ($R^2 = 0.353$, $P = 0.001$ [$B_{DS} = 0.024$, $P = 0.001$]). Then, regression analyses investigating the relationship between FS and DS were conducted. These analyses produced neither a significant linear model ($R^2 = 0.014$, $P = 0.534$ [$B_{FS} = 1.710$, $P = 0.534$]) nor a significant quadratic one ($R^2 = 0.029$, $P = 0.675$ [$B_{FS} = -7.032$, $P = 0.618$; $B_{FS*FS} = 7.712$, $P = 0.527$]). Nevertheless, we noticed that a slight U-shaped relationship could be recognized when we scrutinized the scatter plot. This means that the possibility that DS mediated the FS-to-MAS relationship could not be ruled out. Hence, we conducted partial linear and quadratic regressions on FS and MAS while excluding the influence of DS on MAS. No significant linear relationship was found ($R^2 = 0.054$, $P = 0.217$ [$B_{FS} = 0.111$, $P = 0.217$]), but a significant quadratic one was detected ($R^2 = 0.233$, $P = 0.028$ [$B_{FS} = -0.893$, $P = 0.037$; $B_{FS*FS} = 0.885$, $P = 0.018$]. This is plotted in Figure 3A). This is similar to the results of the initial regressions, and indicates that a significant quadratic relationship exits between FS and MAS even if DS has been treated as a control variable.

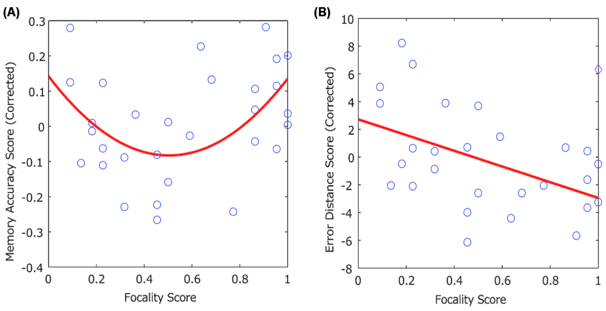


Figure 3: **(A)**Relationship between Focality Score and Memory Accuracy Score (corrected);**(B)**Relationship between Focality Score and Error Distance Score (corrected) in the general case, with a data point unexplained by the regression model depicted by a magenta-colored rhombus.

The Relationship Between FS and EDS

The continuous pattern of the relationship between FS and EDS was investigated in the following manner. First, to obtain a preliminary impression of what the relationship pattern looks like, we carried out linear and quadratic regression analyses on the FS data and the original EDS data. Only the quadratic model reached statistical significance (quadratic model: R^2 = 0.250, P = 0.027 [B_{FS} = -30.113, P = 0.019; B_{FS*FS} = 22.376, P = 0.041]; linear model: R^2 = 0.110, P = 0.084 [B_{FS} = -4.694, P = 0.084]). Then, a positive linear relationship was found between DS and EDS through a regression analysis (R^2 = 0.299, P = 0.003 [B_{DS} = 0.692, P = 0.003]). In order to remove the distorting influence of the discriminability effect (as in the case of MAS), the regressions on the FS and EDS data were repeated but with the impact of DS on EDS partialed out. A significant quadratic model appeared (R^2 = 0.221, P = 0.044 [B_{FS} = -22.166, P = 0.041; B_{FS*FS} = 15.895, P = 0.085]), but not a linear one (R^2 = 0.121, P = 0.070 [B_{FS} = -4.110, P = 0.070]). This resembles the results of the initial regressions.

Nevertheless, there exists a test color that appears to be isolated from the cluster of other high-FS test colors at the EDS coordinates. Owing to the employment of the least squares method, this data point could have exerted a disproportionately strong influence on the relationship pattern. In order to determine what pattern the relationship actually takes in the general case, we reran the regressions on the corrected dataset but did not include this data point. This time we obtained a linear relationship (R^2 = 0.236, P = 0.010 [B_{FS} = -5.669, P = 0.010], which is plotted in Figure 3B), instead of a quadratic one. (When adding FS*FS to the regression as a predictive variable, neither B_{FS} nor B_{FS*FS} achieved significance, although the model remained significant). The removed color is 5YR 4/8. It was mistaken as the color one-unit above it (5YR 5/12) in all its misrecognition cases. This misrecognition pattern is difficult to explain by the strategy of linguistic categorical color coding which will be discussed later. We thus conjecture that it might result from other memorization strategies, which needs further exploration.

Memorization Strategies

In the questionnaire conducted at the end of Session 1, the subjects reported a total of six memorization strategies. For each strategy, Table 1 offers a brief description and shows how many subjects reported it.

General Discussion

The Continuous Patterns of the Focality Effect

Our experimental results demonstrated that in the Japanese language, color focality can affect STM performance for colors in a statistically significant way in terms of both correct recognition possibility and misrecognition error distance. With regard to the continuous patterns of the focality effect, a significant U-shaped quadratic regression function can be established between FS and MAS, which implies that STM performance is best for colors at the two terminals of the focality continuum, and begins to decrease as the focality moves toward the intermediate level. In addition, a significant negative linear regression function can be established between FS and EDS under general circumstances. This suggests that the average error distance in the case of misrecognitions for a color decreases as its focality increases.

Table 1: Memorization Strategies Reported by Subjects in Questionnaire.

Number of Reports	Brief Description
16	Use basic color concepts as reference points, and then fine-tune along the dimensions of lightness and/or saturation
14	Associate the test color with the color of a familiar object, e.g., the banner of Waseda University, a Bordeaux wine, or lipstick, and then fine-tune along the dimensions of lightness and/or saturation
3	Directly memorize the visual image of the test color
2	Use the degree of preference for the test color as a cue
1	Use the color of an object located in the experimental environment, e.g., an answer sheet, as a reference point, and then fine-tune along the dimensions of lightness and/or saturation
1	Use a previously presented test color as a reference point, and then fine-tune along the dimensions of lightness and/or saturation

One Cause of the Focality Effect Patterns

To determine what caused the continuous patterns, we examined the memorization strategies reported by the subjects (Table 1). We noticed that the strategy of encoding colors using linguistic color categories, which has the highest number of reports, might have played an important role in the formation of the detected focality effect patterns.

A detailed description of the procedure of this strategy in a single trial is as follows: The subjects consciously encoded the test color using the basic color terms while observing the test color. The basic color terms were used as reference points, which means that the subject anchored the test color to the central points of the basic color categories, namely, the most typical colors of these categories. The subject then retained this linguistic code in his/her STM during the waiting period. Finally, during the phase of color searching, the subject decoded the code to recover the test color.

For convenience of discussion, color focality is generally divided into the levels of "high," "medium," and "low," and their respective ways of being coded are described as follows: A high-focality color can be encoded using only one basic color term since it is, or is substantially close to, the central point of the basic color category. With regard to a medium-focality color, its coding needs some modifiers in hue and (or) lightness besides a basic color term, for example, *bright orange*, *dark brown*, and *purplish pink*. For a low-focality color, because it is situated at the border region between two basic color categories, the two basic color terms corresponding to the two categories are used to constitute the code for this color.

With the employment of this strategy, it is obvious that the correct recognition possibility for a color is mainly determined by 1) how easily the code for the color can be retained in STM during the waiting period, and 2) the semantic ambiguity of the code for the color, or in other words, how accurately the encoded color can be recovered from the code. Since codes for colors of all three types can be formed by just a few words, they will not cause a memory burden. This implies that the rate of successful retaining should be high for each color type. On the other hand, the variable of semantic ambiguity bears a much larger intertype variance, which indicates its chief role in mediating the impact of color focality on STM performance for colors. For a high-focality color, its code generally consists of a sole basic color term, which possesses a fairly plain meaning since any Japanese speaker is able to understand the definition of a basic color term. Thus, during the searching phase, the signifier of the code can be pinpointed in high precision. By contrast, the modifiers in the code for a medium-focality color have much vaguer meanings. Even if the subjects have carried the code into the decoding phase without mistakes, they will find themselves lost in numerous candidates, all of which more or less match the description. This will surely lower their chances of finding the one that they have actually coded. Following this logic, the code for a low-focality color, which involves basic color terms but no modifiers, should also be regarded as unequivocal in meaning. The central points of the basic color terms, as in the case of a high-focality color, can serve as reliable reference points for the localization of the encoded color. In brief, the semantic ambiguity of color codes, which negatively influences the likelihood of correct recognition for colors, is low for high- and low-focality colors and high for medium-focality colors. Thus, high- and low-focality colors tend to have higher rates of correct recognition than those of medium-focality ones. This is exactly what our experimental results have shown. In addition, owing to the fact that for any color the semantic ambiguity of its code is a language-inherent and thus subject-independent attribute, this continuous pattern can be expected to have a high degree of intralanguage consistency, or in other words, a high likelihood to be replicated if the experiment is repeated using the same language.

With regard to the misrecognition error distance of a color, within the framework of linguistic categorical coding, this mainly depends on which parts of the code the subjects have forgotten, and how many times each of these parts have been forgotten. For a high-focality color, once a subject has forgotten the sole basic color term during the waiting period, in the searching phase he/she is unable to tell the basic color category to which the test color belongs. His/her selection will thus be random, although other memory clues, such as the visual image of the test color, can be of help. It is easy to imagine that under this circumstance, a large error will occur. The loss of the basic color term for a medium-focality color or both of the basic color terms for a low-focality color will lead to similar consequences. For a medium-focality color, when only the modifiers have been forgotten, given that the basic color term has become the only guide, the central point of this basic color category may pull the subjects' selections toward it. In this case, a misrecognition is expected to occur, but within a moderate error range that is approximately half the "category radius." Following the same logic, with regard to the code for a low-focality color, when one of its two basic color terms has been forgotten, the remaining one will tend to drag the subjects' selections toward the central point of the category it represents. On this occasion, because the test color is situated at the border region of the category, a selection with a error distance of approximately one category-radius long might take place. Note that owing to the small total number of memory losses suggested by the small memory burden imposed by the color codes, it is possible that some of these "forgetting types" did not occur in our experiment. Thus, one explanation for the focality effect pattern that we detected is that our subjects have never forgotten the basic color terms in the codes for the high- and medium-focality colors. In addition, the small sample size of memory losses means that the distribution of occurrence frequency across the forgetting types can hardly be consistent across experiments even when using the same language. In other words, if the experiment is repeated, a substantially different frequency distribution across the forgetting types will occur, which will lead to a very different focality effect pattern.

The Universality of the Focality Effect Patterns

Several past studies on STM performance for colors, which used English-speaking subjects, also recorded their subjects' memorization methods. Lucy and Shweder (1988) recorded the subjects' incidental remarks on memorization strategies during the course of their experiments, and they carried out a questionnaire on memorization strategies when the experiments were finished. They provided a quantitative report which showed that the strategy of linguistic categorical coding was the most frequently adopted, followed by the strategies of direct retention of visual image, present object association, and absent object association. This coincides well with the results of our questionnaire. Brown and Lenneberg

(1954), Lucy and Shweder (1979), and Garro (1986) also reported the use of linguistic categorical coding by their subjects, although they did not provide detailed statistics. The fact that linguistic categorical coding is employed as a chief memorization strategy by both Japanese speakers and English speakers suggests that its applicability is possibly universal across languages. Moreover, considering the hypothesized close ties of this strategy to the formation of the continuous patterns of the focality effect, this further implies that all languages may share a common language-based mechanism for focality-effect generation.

In terms of the focality effect pattern for the possibility of correct recognition, considering its presumed intralanguage consistency, it can be expected to be observed in other languages. This conjecture is supported by the agreement between the FS-to-MAS relationship detected in our experiment and the superiority of focal colors to nonfocal colors in correct recognition possibilities reported by Heider (1972), Roberson et al. (2000) and Roberson et al. (2005). On the other hand, even if the use of the strategy of linguistic categorical coding is universal across languages, because of the lack of intralanguage consistency, it is difficult to find a consistent focality effect pattern across languages in terms of the misrecognition error distance. A comparison of the results of Heider (1972)'s and Roberson et al. (2000)'s studies and our study demonstrated such interlanguage inconsistency.

A trivial case as it might be, reports show that there exit languages that possibly lack basic color terms, e.g., Piraha and Warlpiri (Everett, 2005; Wierzbicka, 2008; but see Regier, Kay, & Khetarpal, 2009). This means that the linguistic definition of color focality and the memorization strategy of linguistic categorical coding possibly cannot be applied to such languages. Thus, the discussions in this section may be unsuitable for these languages.

Conclusion and Implications for Future Work

This study is the first to probe into the continuous patterns of the focality effect. Our experiment confirmed the existence of the focality effect in the Japanese language, and clarified its continuous patterns in terms of correct recognition possibility and misrecognition error distance, which were two aspects of short-term memory performance. Correct recognition possibility is highest at the ends of the continuum of color focality, and decreases as color focality moves toward the medium region from either end. In addition, misrecognition error distance for colors, in the general case, decreases as color focality increases. We speculate that the subjects' frequent and conscious use of memorization strategies, especially the strategy of encoding colors using linguistic color categories, played an important role in the formation of focality effect patterns. The interstudy agreement on the recordings of memorization strategies suggests that the employment of linguistic categorical coding is possibly universal across languages. For this reason, and also owing to its likely high intralanguage consistency, we expect that the focality effect pattern for correct recognition possibility that we detected can also be found in other languages. Empirical evidence for more languages is needed to evaluate this hypothesis. In addition, it is also interesting to see whether this focality effect pattern can also be found in the categories of other domains. These domains can be simple perceptual categories such as shapes and phonemes, complicated multimodal concepts such as animals and tools, or even emotionally or socially meaningful signals such as human facial expressions.

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