Color categorial perception and second language acquisition

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ABSTRACT

This paper illustrates results of perceptual and linguistic experiments conducted to verify *"categorial perception"*, naming, and comprehension of color terms in Italian as mother tongue and in English as a second language. I employed Franklin, Clifford, Williamson, and Davies' [2005] experimental procedure to see if young Italian children, 3- to 5-year-olds would confirm their results of categorial perception in 2- to 4-year-olds. I followed their procedure with the objective of being able to compare the results across the different language groups. Franklin et al. found that categorial perception emerges *"irrespective of naming and was not stronger in those children with more developed color term knowledge"*, and maintain that *"color term knowledge does not modify categorial perception, at least during the early stages of childhood"*. This research, differently than the original research, argues that linguistic categorization amplifies the category effect: those showing a correct linguist boundary and a between-category facilitation scored high in focal naming/comprehension, and in the 2-AFC naming score. The tested group demonstrated a good progressive general knowledge of color terms and color fluency, and an apparent interference from second language acquisition showing slightly different linguistic color categories (i.e. blue - blu, azzurro, celeste). This is in keeping with the perceptual reorganization model, which postulates an innate predisposition for category boundaries in the color space, and that language learning modifies the location and extent of categorial perception, and may reorganize the representation of perceptual color space.

KEYWORDS

Color Categorial Perception, Category Boundaries, Linguistic Color Perception, Second Language Acquisition

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1. INTRODUCTION

This paper illustrates results of perceptual and linguistic experiments conducted to verify *"categorial[a] perception"*, naming, and comprehension of color terms in Italian as mother tongue and in English as a second language. I employed Franklin, Clifford, Williamson, and Davies' [1] experimental procedure to see if young Italian children, 3- to 5-year-olds would confirm their results of categorial perception in 2- to 4-year-olds (the age range considered for the onset of color term establishment reliability acquired of the first focal colors by 3 years and brown and grey 6-9 months later [2]). I followed their procedure with the objective of being able to compare the results across the different language groups. Franklin et al. found that categorial perception emerges *"irrespective of naming and was not stronger in those children with more developed color term knowledge"*, and sustain that "*color term knowledge does not modify categorial perception, at least during the early stages of childhood"* [1]. The further objective was to verify if there is any variation or interference in categorial perception during the acquisition of a second language that has slightly different linguistic color categories (i.e. blue - blu, azzurro, celeste).

We understand the color *spectrum* as a continuum and identify colors through distinct categories. Basic or focal colors are easily identified and agreed upon, though the boundaries of these categories are difficult to agree on and tend to vary according to context —when blue is no longer blue and becomes green. A category contains those members that are similar. The more a single item is different from another the more likely it be identified as belonging to a separate category. Recognizing that two items belong to separate categories is known as *"categori(c)al perception"* [3], [4]. Categorial perception of color is understood to be activated when colors from the same category are discriminated less easily than colors that cross a category boundary. I tested categorial effect in groups of 3, 4, and 5-year-olds through: *'two-alternative forced-choice tasks'* (henceforth 2-AFCs), a naming test (for the stimuli of the three different 2-AFC sets), a comprehension and a naming test of the eleven focal colors. The 3 and 4-year-olds did the training and the tasks in Italian, and the 5-year-olds did the training and tasks in English as a second language and repeated the naming and comprehension tasks again in Italian.

The results of this series of tasks should support one of the three theories of the origins of categorial perception: 1) Categorial perception is *"hardwired"* into the visual system —the universal point of view; 2) Categories are constructed by language —the relativist stance; or, 3) Categorial perception is a matter of *"perceptual reorganization"*, somewhere in-between linguistic universalism and relativism. The third option *"postulates that there is an innate predisposition for category boundaries at certain points in the color space, but that language learning modifies the location and extent of categorical perception, reorganizing the representation of perceptual space"* [1]. The cognitive linguistic approach would explain perceptual reorganization as stemming from our embodied projection of the world, which becomes specialized according to the linguistic construal of the single language-culture-context and the cognitive models thereby developed (e.g. [5]). Hence, categorial perception may expand or recede if the category boundary is not specifically reconfirmed by the language(s) acquired or learned. This type of refining mechanism has been found in research on language acquisition [6] and in reference to universal grammar, i.e. principles and parameters [7].

The issues taken into consideration are: Will color categorial perception be found in young Italian children? What is the impact of language learning on the extent of categorial perception? Do children who linguistically mark the boundaries show categorial perception, or is categorial perception greater if children linguistically mark the boundaries [1]? Does knowledge of a second language alter accuracy in categorial perception?

2. EXPERIMENT OVERVIEW

To test for categorial perception, the first task involved the 2-AFCs, which is the same test used with adults, though adapted for young children. The methodology is explained in the next paragraph. As illustrated in Fig. 1., adapted from Franklin et al. [1], categorial perception tests stimuli grouped into a set of three: A1, A2, and B. They are equidistant in the color space. Two stimuli, A1 and A2 belong to the same linguistic category (e.g. green), and B belongs to a different linguistic category (e.g. blue) adjacent in the color space. Categorial perception is evinced when the participant identifies the stimulus pair A2-B more accurately than the stimulus pair A1-A2.

Researchers have verified categorial perception in same-different judgment, recognition memory, and 2-AFCs [1], [8], [9], [10], [11]. Both Franklin and Davies [12] and Franklin et al. [1] have shown that young children demonstrate categorial color perception across the green-blue, blue-purple hue boundaries, and across the red-pink lightness and saturation boundaries. This experiment calqued the previous studies using the same color boundary groups. I prepared three sets of stimuli, (1) Green:

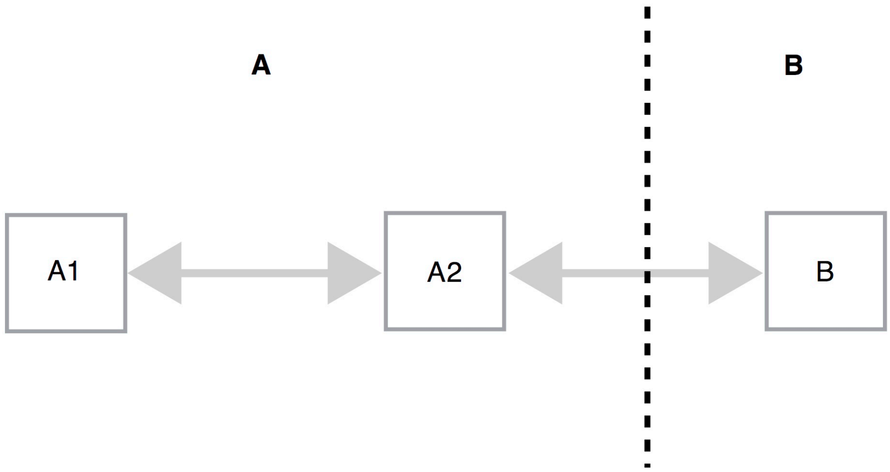


Figure 1 - Illustration of categorial perception between two categories: A and B. Each box represents a stimulus that is spaced equidistantly from the other. The dashed line represents the category boundary

green, blue-green, blue, (2) Blue: blue, purple-blue, purple, and (3) Red: red, pink-red, pink. I investigated the size and effect of each category by judging the accuracy of identification in the task between the foil and the target pairs.

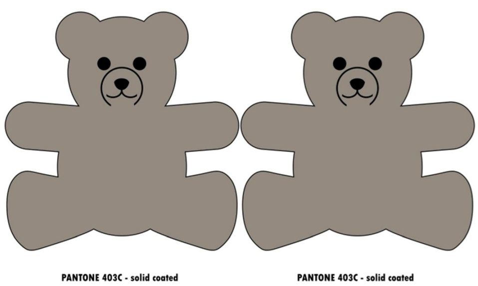
I used the naming tasks of the stimuli sets to reveal the presence of a linguistic category boundary. I grouped the naming patterns of the test stimuli as belonging to the group of: no linguistic boundary, a correct linguistic boundary, and a reversed linguistic boundary. As Franklin et al. [1] state: *"if the linguistic categorization creates the category effect (linguistic relativity model), then (a) those children with no linguistic boundary should show no category effect, (b) those children with a correct linguistic boundary should show between-category facilitation, and (c) those children with a reversed linguistic boundary should show within-category facilitation. If linguistic categorization amplifies the category effect (perceptual reorganization model), then (a) those children with no linguistic boundary should show weaker category effect than those children with a boundary, (b) those children with a correct linguist boundary should show between-category facilitation; and (c) those children with a reversed linguistic boundary should show within-category facilitation. If linguistic categorization has no impact on the category effect (universalistic model), then all children would respond categorially to the same extent, irrespective of their pattern of naming"* (p.122).

The further comprehension and naming tasks were administered to verify the general linguistic knowledge of the 3-5-year-olds (henceforth yos) of the 11 focal colors and to record the general fluency. I hypothesized that the children's general knowledge of color terms may be linked to categorial perception if a correlation between language knowledge and categorial perception emerges. I further hypothesized that language may affect the children's clarity of categorial perception when learning a second language, especially when the two languages mark the boundaries differently.

In this case the second language, English, may affect the boundaries of the tested categories, i.e. blue. English categorizes the macro area blue, including the Italian subordinate categories of *blu* and *azzurro*, and possibly *celeste* [12]. Furthermore, requiring the informants to identify half tones of blue-green, purple-blue, or pink-red as a different tone than the focal color could stimulate a linguistic accessing of something other than the terms green, blue, or red. This could give rise to naming frequent Italian terms that cross these color category boundaries.

2.1. METHODOLOGY

Participants: A total of 56 native Italian speakers (28 males and 28 females) between the ages of 3 and 5, agreed to participate in the experiments. *The Scuola dell'Infanzia "Lucina"* in Perugia was very cooperative in allowing Anna Testi to come to the school and work with the children in their own environment. The groups that were tested only in Italian were comprised of: 19 3yos (8 males and 11 females) and 18 4yos (10 males and 8



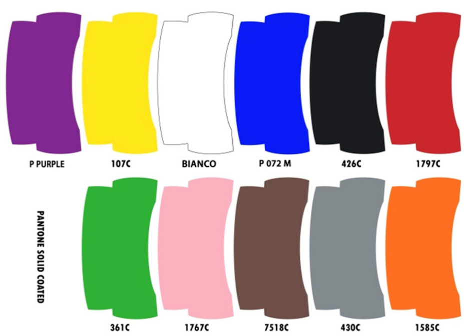


Figure 2 - Bear figures in medium grey Pantone color (left)

Figure 3 - Focal stimuli paper sweaters (right)

females). The group tested in Italian and English consisted of 19 5yos (10 males and 9 females). The 5yos had already participated in over 22 hours of English activities aimed at learning various English expressions (conventional greetings, holiday terminology, colors, family members, farm, forest, and jungle animals, and fruits and vegetables). The native English teacher conducted the matching and memory games using objects and flash cards, through one hour a week activities, working both on comprehension and performance.

Stimuli and design: For the 2-AFCs we made two bears on plasticized medium grey heavy paper, Pantone 403C, which had smiling faces drawn in black ink. The colored sweater stimuli were made of the same printed-paper and plasticized to withstand the practice and task usage of 56 children. Each paper sweater was the same size and shape. To allow for easy application to the bear, a Velcro strip was glued on the bears' tummy and on the back of the paper sweaters, so when the child had selected and applied the chosen sweater it would stay in place.

Focal stimuli: Different than the original test [1] we used Pantone coordinates to make sure that the colors were constant, measurable, and reproducible. The Pantone colors corresponded to the original Munsell colors as indicated in Franklin et al. [1], and were measured for compatibility by a typographer. The colors included: white (BIANCO), black (426C), red (1797C), green (361C), yellow (107C), blue (P072M), brown (7518C), pink (1767C), purple (PPURPLE), orange (1585C), and grey (430C). Two sweaters per color were made for the 11 focal colors, in keeping with the basic color terms in English [13].

Test stimuli: We used the Pantone coordinates that corresponded to the colors established in, and confirmed by, adult naming and similarity judgments [10]. The test stimuli were made according to these three sets and were broken down in the following manner according to the Pantone code that corresponded to the Munsell code. The Green set is: green (361C = 7.5G 5/10), blue-green (562C = 5BG 5/10), and blue (P072 = 2.5B 5/10) (with 7.5BG indicated as the boundary). The Blue set is: blue (P072 = 10B 3/10), purple-blue (Pviolet = 7.5PB 3/10), and purple (PPurple = 5P 3/10) (with 10PB indicated as the boundary). The Red set is: red (1797C = 5R6/10), pink-red (1787C = 5R5/12), pink (1767C = 5R4/14). Figure 4 shows the approximate hue of the color patches; some variation in color due to the phases of print or online versions should be kept in mind. The first two columns in Fig. 4 (*green* and *blue-green*, *blue* and *purple-blue*, and *red* and *pink-red*) comprised the "within category" couples and the middle and last columns (blue-green and blue, blue-purple and purple, pink-red and pink) comprised the "between category" couples. (See also Franklin et al [1] original diagram of within and between category differences in Appendix).

The procedure was conducted in a non-standardized lighting condition, though the situation was the same for all of the participants. We tested each child individually in the well-known environment of their school library with natural mid-day sunlight that penetrated on three sides of the room; in relation to the child's right, front, and left. No artificial light or shadow interfered with the representation of the experimental stimuli. We chose the place that the children were used to, with the precise aim of verifying how they would normally respond to linguistic identification of color in both performance and comprehension.

Procedure: All children completed the 2-AFC task, naming, and comprehension tasks after a training session. The training session consisted in familiarizing them with the task using the focal colors (Fig. 3). We showed them how when one bear wore a colored sweater, the other bear should wear the same color sweater, and that

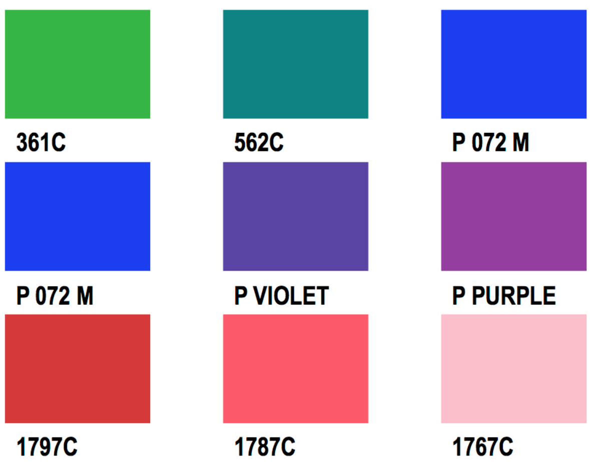


Figure 4 - Test stimuli color sets: green, blue, red

they could pick it out of the sweaters on the table and put it on the other bear. We placed the two bears and the two sets of sweaters on the table in front of the child, a color was randomly selected from set A and placed on Bear A, the child was asked to pick out the corresponding sweater for Bear B from set B. We went through this process three times with different colors, before proceeding with the more complex task. Bear B and its set of sweaters was covered with a white piece of paper while the test stimulus –Bear A and an A sweater– was uncovered for 5 second exposure. Then Bear A was covered for another 5 seconds, before uncovering Bear B and the B sweater set. After the child had made his/her selection and placed it on Bear B, we uncovered Bear A to allow the child to evaluate his/her choice. The child was praised with a matching choice and encouraged to modify it, if not. Each child carried out this task successfully three times before proceeding to the 2-AFC task experiment. Each child was tested on only one of the color sets.
In the 2-AFC task we used only the test stimuli (Fig.4), and the procedure was the same as the second part of the training. This randomized task limited the choice between two sweaters: the correct choice (the target) was the exact color of Bear A's sweater, and the incorrect choice (the foil) was either a *between* or *within* category color sweater. The categorial relationship –between and within– was poised twice to each child, for a total of four judgments. We then showed the stimuli sweaters to the child and asked what color they would call the sweater.
Comprehension and naming: After completing the 2-AFC tasks, we laid out the focal color sweaters and asked the child to put, for example, the *"red"* sweater on the Bear. Each color was tested and the child's response recorded. After this, the focal stimuli sweaters were put out on the table and the child was asked to name the colors.

3. RESULTS

Three category boundaries: On the whole category effect was manifested. We calculated the number of correct judgments for *between* category and *within* category for each participant. Accuracy resulted in 86.25% target-foil choices of the *between* category compared to a 76.34% target-foil choices of the within category. Considering each set separately, an unusual result emerged: the Green set accuracy was higher for *within* category 94.74% compared to 86.84% *between* category accuracy. In keeping with [1] the Blue set accuracy was higher for *between* 78.94% than *within* 52.63%. And the Red set accuracy was higher for *between* 94.44% than *within* 69.44%. Even though the *within* category was higher for Green, the *between* category accuracy for Green was higher than the Blue set *between* accuracy, and close to the Red set between accuracy. Our results, Sandford (S), were higher for overall accuracy per set than Franklin et al. (F) for Green 93.42% (S) 60.62% (F) and Red 80.55% (S) 56.87% (F), and slightly lower in the Blue 72.37% (S) 77.50% (F). The higher percentages of accuracy are most likely due to maturation, since we included the 5yos to test second language acquisition. The average of correct 2-AFC answers grew with age: 3-yo mean 3.1, 4-yo mean 3.2, and 5-yo mean 3.6, out of 4 possible. Categorial perception emerged according to accuracy for all three sets.
Naming accuracy and comprehension: The majority of the color names given for the three 2-AFC sets were accurate. The accuracy ranged in the Green set: green 100%, blue-green 74%, blue (*blu*) 95%; in the Blue set: blue 85% (+5% *celeste*), purple-blue 49% (+ 5% *azzurro*), purple 54% (+ 31% *fucsia*); and in the Red set: red 100%, pink-red 67% (+17% *fucsia*), pink 90%. Following are the names given in Italian, in order of high to low percentage, with an asterisk marking those considered erroneous. The Green set names were: green (*verde*), blue-green (*verde scuro, verde acqua, *blu, *azzurro*), and blue (*blu, viola*). The Blue set names were: blue (*blu, celeste, *bianco, *arancione*), purple-blue (*viola, viola scuro, *blu, *azzurro, *celeste, *rosa, *bianco*), purple (*viola, *rosa, *fucsia, *rosso*). The Red set names were: red (*red*), pink-red (*rosso, *rosa, *fucsia, *arancione*), pink (*rosa, *viola, *fucsia*).
The method used to calculate the linguistic boundaries followed [1], though our results showed no child without a boundary, and some children with three distinct boundaries. A total of the naming task results show a majority, 62.50%, manifested a correct between category linguistic boundary, by assigning two names to the three stimuli (3yos 23.21%; 4yos 17.86%; 5yos 21.43%). Another 17.86% gave three different color names for each set of three (3yos 7.14%; 4yos 7.14%; 5yos 3.57%), demonstrating an advanced linguistic awareness that each color tone may have a different label; though 12.5% gave accurate labels (e.g. *fucsia* for pink or purple; *azzurro* for blue halftones), the other 5.36% were more approximate (e.g. *celeste* for blue, blue-purple; *arancione* for pink-red). 3.57% gave wrong labels, but recognized a difference. Considering the 3-label children with the other between linguistic boundaries, 80.36% total demonstrated linguistic boundaries. The other 19.64% showed a reversed boundary. No children showed no linguistic boundary in Italian.
Color term comprehension and naming: All of the children scored mean 92.05% of comprehension of the focal color terms, and 91.07% named the focal color sweaters correctly. The mean accuracy score on comprehension and naming

respectively is: 3yos 84.21% and 78.94%; 4yos 97.50% and 98.00%; 5yos 93.79% and 96.16%. The 4yos did best in comprehension and naming. The 3yos did better on comprehension than naming, and both the 4yos and 5yos did slightly better on naming than comprehension, which [1] affirms as expected.
We calculated a general term fluency index, explained in [1], by averaging the mean number of colors named and the mean number of colors identified: a result of 20.14 out of 22 focal colors. A categorial effect index was calculated by subtracting the within-category score from the between-category score (on the 2-AFC task) for each child. A score higher than 0 indicates a categorial effect; that is, between-category accuracy is greater than within-category accuracy. A score of 0 indicates no categorial effect. A score lower than 0 indicates a reversed categorial effect, within-category being higher that between-category accuracy. The categorial effect was 0.71 indicating a general result of between-category boundary.

3.1. SECOND LANGUAGE RESULTS

There are several things to consider in the 5yo group: their accuracy scores were not as high as the 4yos, which I would argue has to do with interference from second language acquisition. Often there is a period during second language acquisition where there is a set back in linguistic performance, before a general advancement [6]. Naming and comprehension: The actual performance and competence in English was tested three times. Naming the 2-AFC stimuli: the mean accuracy was 1.47 out of 3 in English (2.68 in Italian). The linguistic boundary for the 5yos emerged as between category for 47.37%, no linguistic category for 26.32%, and reversed for 26.32% in English (between category for 68.42% and reversed for 31.58% in Italian). The between category children in both languages were the same, though fewer in English due to lack of color term production. Naming of the 11 focal colors averaged 6.21 in English, and 10.57 in Italian. Comprehension of the 11 focal colors averaged 8.1 in English, and 10.32 in Italian. The average of naming and comprehension was 65.09% in English, and 94.95% in Italian.

4 DISCUSSION

The group responded accurately to all three boundaries with an average of 86.25%. Though the category effect was evident for the Blue (0.68) and Red boundaries (0.55), the Green boundary showed a slight *within* category effect (-0.15). The distant boundary ratio A1-B was the most accurate of the between category tasks. Considering the effect of naming on the size of the category effect, it seems that the linguistic categorization amplified the category effect along with maturation of the individual. The three different age groups emerged each with gradually higher average scores on the 2-AFC task (17 errors for 3yos, 15 for 4yos, and 8 for 5yos; see §3). They also had progressively higher scores on naming 2-AFC stimuli accuracy: 3yos 2.37, 4yos 2.67, 5yos 2.68. The subordinate color terms that the children were stimulated to access in the 2-AFC naming task included *azzurro, celeste,* and *fucsia*. In a previous study by Sandford [14] *azzurro* [blue/light blue], *rosa* [pink/ rose], *celeste* [blue/sky blue], and *fucsia* [fuchsia/ magenta] ranked close to and above some of the 11 focal color terms in cognitive salience. Each subordinate term in Italian is translatable into more than one term in English and could result in the naming a half-tone: *azzurro* in blue, green, or purple; *celeste* in blue and possibly green; and *fucsia* in purple or pink. The focal color naming/ comprehension tasks showed a high degree of accuracy, with a slightly lower percentage for the 5yos. This most likely was due to the English interference in the training and task experience and the general process of second language acquisition. The 2-AFC halftone purple-blue and pink-red stimuli, and full tone purple naming accuracy were lowest. Difficulty in naming accuracy for the *"blues"* seems relevant to the restriction of linguistic category in English. Or as suggested by a referee of this paper, the discrimination capacity of minimal differences in color hue is highest in the colors around green and yellow, but decreases dramatically toward blue and red; which could be reflected in these results.

5. CONCLUSIONS

This research, differently than [1], argues that linguistic categorization amplifies the category effect: those showing a correct linguist boundary and a between-category facilitation scored mean 20.30 in focal naming/comprehension, and mean 3.48 on the 2-AFC naming score. Those few showing a reversed linguistic boundary and within-category facilitation scored mean 19.54 in focal naming/comprehension, and mean 3.4 on the 2-AFC. No children in this study showed no linguistic boundary in Italian, yet 23.32% of the 5yos did in English. The group demonstrates a good progressive general knowledge of color terms and color fluency, which is in keeping with the perceptual reorganization model. The model as described in [1] postulates an innate predisposition for category boundaries in the color space, and that language learning modifies the location and extent of categorial perception, and may reorganize the representation of perceptual color space. Athanasopoulos et al. [15] also confirmed this model with electrophysiological evidence. The increased error in color naming in Italian by the 5yos, who were in the process of acquiring a second language, would seem to further confirm this model and reflect language interference. Nonetheless, the high degree of accuracy makes it difficult to tease out the variation of perceptual category effect, and at the same time there was greater general accuracy in categorial perception than in linguistic ability to mark the boundary. This, and the higher mean number of 3yos in establishing a between boundary in naming, allows us to evince that categorial perception is independent of color naming. [1] states that *"infant color categorial perception has been found in British and American infants, but no such tests have been made on infants from other language groups"*, this research evinces that young Italian children also demonstrate categorial perception.

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CONFLICT OF INTEREST

To my knowledge no potential conflicts of interest exist, I have quoted Franklin, Clifford, Williamson, and Davies' [2005], and show the original category boundary indications of the color couples tested.

NOTES

a - Since the topic of discussion is "categorization", I opt to use "categorial" i.e. of or relating to a category, rather than *"categorical"* i.e. definite, uncompromising, unconditional, to thus disambiguate between the two lexemes, even though in this literature *"categorical"* tends to be used.

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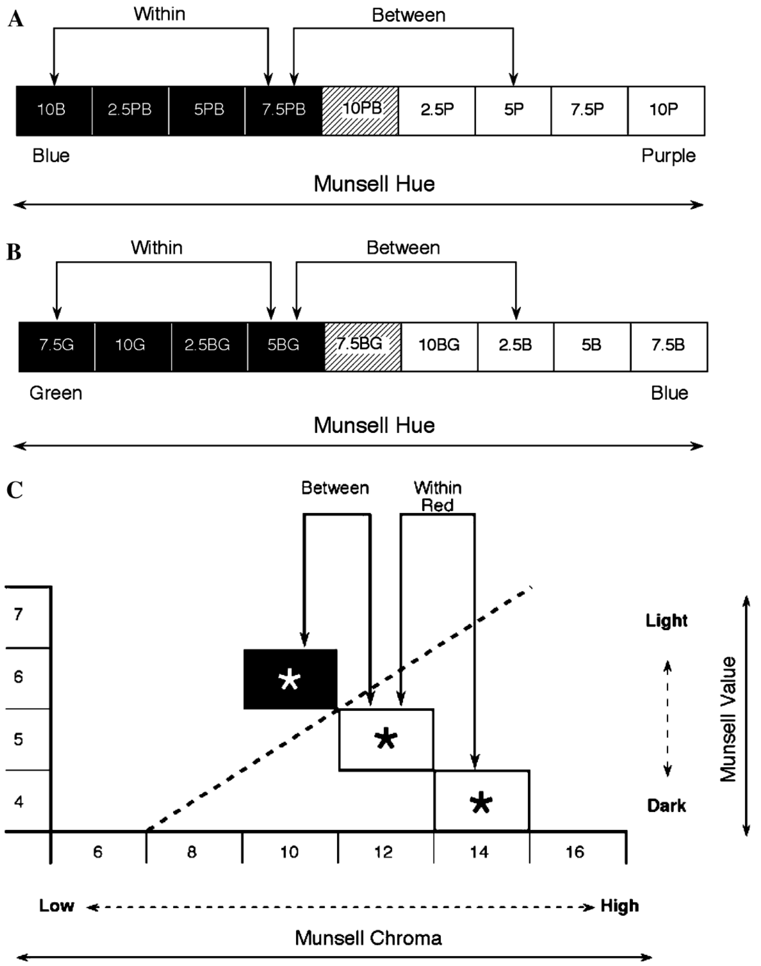
APPENDIX



Taken from Franklin et al. [1] page 124, their Figure 2 – Munsell codes, categorial status, and Munsell distances of the stimuli of the experimental pairs used. The categorial relationships (within or between) of the experimental pairs are shown for blue-purple (A), blue-green, and hue boundaries and a pink-red lightness saturation boundary (C). In panel A, Chroma = 3 and Value = 10. In panel B, Chroma = 5 and Value = 10. In panel C, Hue =5R.