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Research Regarding the Colour Naming

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Abstract

The paper presents some of the findings revealed after performing an experiment aimed to verify some aspects regarding colour naming. The experiment was designed to test the idea that focal colours are named better and, also, to test their features: their name consists of a single word and they can be used easily in constructing the name of a shade. The experiment confirmed that the concept of focal colour is true. The extended set of focal colours is composed of yellow, black, red, white, blue, green, azure, orange, violet, brown, pink and grey. The colours green, red, pink, yellow and blue were used rather well in the construction of shade names.

Rezumat

Lucrarea prezintă unele dintre rezultatele obţinute după efectuarea unui experiment destinat verificării unor aspecte referitoare la denumirea culorilor. Experimentul a fost conceput pentru a verifica ideea ca aşa-numitele culori focale sunt identificate prin denumire mai uşor şi, de asemenea, a testa caracteristici lor: numele lor constă dintr-un singur cuvânt și pot fi folosite cu ușurință în construirea denumirea nuanţelor. Experimentul a confirmat că noțiunea de culoare focală este veridic. Setul extins de culori focale este compus din galben, negru, roşu, alb, albastru, verde, azur, portocaliu, violet, maro, roz și gri. Culorile verde, roşu, roz, galben și albastru au fost folosite eficient în construcția denumirilor de nuanţe.

Keywords: colour naming, colour coding systems, colour identification

1. Introduction

The colour naming is of particular interest when the architect or the designer is performing the initial discussion with a client natural person and the project is just a mental draft. If the client is a legal entity, the colours are defined precisely according to a standard colour system and the errors are improbable. But the natural person does not know the subtleties of standard colour systems and relies mostly on the natural language. Also, some tasks performed by an operator require colour naming. The operator has to put a colour name to a region in a so-called scene (a region that possesses a certain chromatic homogeneity) and afterwards based on the colour association with significance performs a certain action [1].

The colour identification is important because some code systems are based on it. For example, the

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electronic colour code is used to indicate the values or ratings of electronic components, very commonly for resistors, but also for capacitors, inductors, and others. In this code, the colour red means digit *2* and, also, multiplier 10^2. A separate code, the 25-pair colour code, is utilised to identify wires in telecommunications cables.

Utility location code is used for identifying and labelling public utility mains which are located underground. These mains may include lines for telephones, electricity distribution, natural gas, television cable, fibre optics, traffic lights, street lights, storm drains, water mains, and waste water pipes. For example, blue means drinking water, green – waste water, yellow – natural gas, etc.
Another important use of colour is in robotics. Colour is one of the ways in which robots interact with the world, because digital optical systems have achieved high technological developments. Manufacturing of robots requires calibration of their optical systems and the inspiration from the natural perception of colours and especially colour categorisation proves to be extremely useful [2].
The correct colour naming is important when commercial contracts are signed. The right colour of products should be delivered and not another shade. In this case, it is recommended that the colour should be indicated using a standard colour system (like Munsell) and not using the natural language.

In order to identify the colour, the observer should know the colour names and, also, a colour classification system. It is important that colour names should not be relative; otherwise the observer will have problems communicating with other people in terms of precision and efficiency.
But the natural language presents an obvious imprecision, and confusions may occur. Some of the colour names are specific to each language. For example, how a Frenchman will translate the English word “lime” - “la couleur de citron vert”? Or, does the Romanian “duck’s egg colour” mean something for a foreigner? This confirms the Whorf hypothesis: “The world is known and represented conceptually in terms of language and this fact determines variations in different linguistic communities.” [3]

Other confirmations came from the following documented facts. Dugum Dani (a population from Indonesia) uses only two terms to designate the basic colours: *mola* and *mili*. Mola is associated to white and warm colours and, respectively, mili to black and cold colours [4]. The speakers of Berinmo language from New Guinea have words only for five basic colours [5].

The studies that focused on the colour terms used in non-industrialized societies revealed other interesting facts. Some of these languages do not use different colour terms for blue and green, but rather use only one term to cover all this region of the visible spectrum [6]. Other languages (like Hanunoo from Phillipines [7] and Zuni of Native Americans [8]) have colour terms that can be considered as related to other attributes than chromatic, like dryness and freshness.

However, there are colours that possess a universal character and are independent of any language used, because their meaning is defined by universally shared aspects of perception, cognition and environment. These colours were called focal colours [9] and they are: black, grey, white, pink, red, orange, yellow, green, blue, purple, brown and azure.

There are several colour systems that are used today: Ostwald, Munsell, C.I.E., Natural Colour System, etc. And there are proposals for new systems. For example, Conway [10] proposed three alternate chromatic systems: comparison, qualification and sensory.

Willing to put order in the colour names field, the National Bureau of Standards and Technology (U.S.A.) issued a guide that contains the description of 267 colours, including the hue (28 names: red, orange, yellow, green, blue, violet, purple, pink, brown, olive, black, white, grey, etc.), value (very dark, dark, medium, light, very light) and saturation (grey, moderate, bright and vivid) and value / saturation ratio (brilliant, pale and profound) [11].

A question arises: how good are people in identifying the correct name for a specific colour? Considering that the coding systems are evolving and their complexity is increasing, the number of colours employed by a coding system based on colours is also increasing. If some colours are identified with difficulties, then their use in different chromatic coding systems will lead to errors with possible negative consequences.

2. Experiment design

The present paper is aimed to present the results of researches regarding a particular aspect in the field of communication in architecture and design, respectively the colour naming. Based on the findings of scientific research, the authors formulated two hypotheses:
H1: Focal colours are better identified and named than any other colours.
H2: Value of colours (light, medium or dark) does not influence the colour identification and naming.

The authors decided that the experiment would consist of a single repetitive task, respectively the identification of colour names in two matrices of 48 colours. In the first matrix, the colours were distributed in a specific order and in the second randomly.

The 48 colours were arranged in two 8 x 6 matrices. The matrices were displayed on a computer screen. In all experimental runs, the same computer screen was used. The experiment was performed in a room shaded by dark vertical blinds. The quality of colours was checked using a colour catalogue for postal stamps. The experiment participants were asked to assign a name to each displayed colour. No identical names were allowed for each individual matrix. The results were recorded in handwriting by each participant on a pre-printed form.

The experiment was organised in two phases. In the first phase, a group of participants identified the colour names for the ordered matrix. In the second phase, the random matrix was evaluated by another group of participants. Each participant was involved in only one phase.

3. Experiment results

The experiment was carried out in the Romanian language. In both phases, the process of naming each colour from the 48 set was long and considered tedious by some participants, but almost all completed the task correctly. Three participants quitted in the first phase and four in the second phase. Two completed forms were discarded in each phase because of using twice the same colour name. The raw data obtained from the experiment was processed with a spreadsheet editor.

Fragments of the colour matrices are displayed in Fig. 1 (ordered) and Fig. 2 (random). (Of course, the colour names were not indicated in the actual matrix. The colour names are indicated for the purpose of this paper.)

Figure1. Sample of the Ordered Matrix

Figure 2. Sample of the Random Matrix

The first phase of the experiment was carried-out with 133 participants. Their mother tongue was Romanian. They were checked for colour blindness using a simple test based on slight hue variations. All the participants were volunteers and they did not receive any reward for their involvement in this experiment. The gender distribution of the sample was: 70 female and 63 male. The age range was 22 – 24 years, all the participants being students of a great university. It was checked that their background was not in visual arts and that they had no knowledge of colour theory.

The second phase of the experiment was carried-out with 164 participants. Their mother tongue was Romanian. They were checked for colour blindness using a simple test based on slight hue variations. All the participants were volunteers and they did not receive any reward for their involvement in this experiment. The gender distribution of the sample was: 81 female and 83 male. The age range was 22 – 25 years, all the participants being students of a great university. It was checked that their background was not in visual arts and that they had no knowledge of colour theory.

After undertaking the experiment, all responses were recorded and checked. Table 1 shows the results ordered according to the percentage of correct naming for the ordered matrix, the random matrix and the mean of them. The colours are listed according to the value of the mean percentage.

Table 1. Experimental results

Colour	Correct naming [%]				Colour	Correct naming [%]		
	Ordered	Random	Mean			Ordered	Random	Mean
Yellow	85.94	95.73	90.84		Light Violet	31.09	35.37	33.23
Black	82.17	99.39	90.78		Light Blue	23.14	42.68	32.91
Red	84.73	90.24	87.49		Bluish Green	25.41	40.24	32.83
White	81.1	89.63	85.37		Light Azure	23.58	33.54	28.56
Dark Blue	77.95	84.15	81.05		Dark Yellow	30.33	26.22	28.27
Dark Green	79.07	76.83	77.95		Bright Orange	15.32	32.93	24.12
Blue	58.91	77.44	68.17		Dark Cherry	15.13	28.66	21.89
Pale Green	68	67.68	67.84		Light Brown	12.05	31.71	21.88
Green	36.8	85.37	61.08		Light Red	28.69	14.63	21.66
Azure	57.26	57.32	57.29		Pink	24.19	14.02	19.11
Dark Violet	45.83	68.29	57.06		Light Orange	18.49	19.51	19.00
Orange	37.1	73.17	55.14		Dark Pink	9.91	26.22	18.06
Light Pink	59.52	49.39	54.46		Cyclamen	16.95	12.20	14.57
Light Green	30	71.34	50.67		Pale Violet	15.13	13.41	14.27
Violet	35.83	64.02	49.93		Beige	5.08	20.73	12.91
Pale Yellow	32.54	67.07	49.81		Reddish Brown	5.98	18.29	12.14
Dark Brown	46.46	42.68	44.57		Yellowish Green	0	23.17	11.59
Cream	26.01	58.54	42.27		Yellowish Orange	13.01	8.54	10.77
Bright Pink	22.41	61.59	42.00		Light Grey	11.11	6.71	8.91
Pale Pink	35.65	48.17	41.91		Grey	4.84	12.20	8.52
Brown	32.54	46.95	39.75		Purple Pink	6.72	9.15	7.93
Dark Grey	18.11	59.15	38.63		Lilac	1.65	11.59	6.62
Dark Azure	47.97	28.05	38.01		Pale Grey	6.04	4.88	5.46
Dark Red	37.01	37.20	37.10		Reddish Violet	0.85	6.10	3.47

The first observation is that people performed better when the colours were displayed in a random manner than in an ordered manner. The general mean was 32.58 for the ordered matrix and 43.58 for the random matrix. 35 (out of 48) colours scored better in the random manner. The high discrepancies in hue and value helped more than the gradual difference offered by the ordered matrix.

It can be observed that the top four positions are occupied by focal colours (yellow, red, black and white). These colours were correctly identified and named in a high degree (above 80%). The other two focal colours (blue and green) had medium positions with 68.17% and, respectively, 61.08% accuracy of naming. So, even though they are definitely focal colours, they are identified rather poor by people. That means that hypothesis *H1* was not fully confirmed.

The ranked list presented in Table 1 allows making a series of observations. First, people assign to a colour its right name rather poor. The average of correct naming for all 48 colours is 38.08%. Only the first six positions in the list have acceptable percentages of correct naming. Second, it can be easily noticed that the dark colours are named correctly better than the light colours. So, hypothesis *H2* is false.

Third, the colours possessing a name composed from a focal colour name plus a differentiator (like light, dark or bright) were more accurately named than colours without a word designating a focal colour. From the latter group, the cream name (which has the highest position) scores only 42.27%.

The other colours from this group (dark cherry, cyclamen, beige and lilac) are placed in the bottom zone of the list. It must be pointed out that, even when synonym names with focal colour were used, these colours were wrongly named.

Forth, the colours that have a halfway position between two focal colours (bluish green, yellowish orange, reddish brown, reddish violet, yellowish green) were rather wrong named. The subjects had difficulties in understanding that the colour had a dual chromatic nature and it was not a simple variation of value (brightness) of a chromatic colour.

Fifth, a conclusion cannot be drawn regarding the correct naming versus the so-called colour temperature. It can be easily observed that warm colours and cold colours are distributed rather uniformly in the list.

Some of the observations pointed out above appear more clear in Table 2, where the rows refer to focal colours; shades of dark, light and pale; isolated colours (like dark cherry or beige) and halfway colours (like yellowish green or reddish brown). Again, it is clear that the halfway colours are the most difficult to name.

Table 2. Results by group of colours

Group of colours	**Correct naming [%]**		
	Min	**Max**	**Mean**
Focal	8.52	90.84	59.45
Dark / Light / Pale	5.46	81.05	37.50
Isolated	6.62	42.27	19.65
Halfway	3.47	32.83	13.12

The data gathered in the first phase of the experiment was analysed in order to find out how properly each focal colour was used in constructing a colour name. Actually, it was counted how many times the right focal colour name was used in the name of each colour. For example, the following colours have the word “green” in their construction: green, pale green, light green, dark green, bluish green and yellowish green. For all these colours, the word “green” was counted. The Table 3 displays the percentages of correct use of the focal colour name.

Table 3. Correct use of focal colour name

Focal colour	**[%]**
Black	90.78
White	85.37
Green	80.45
Red	75.92
Pink	75.09
Yellow	75.00
Blue	74.44
Grey	67.29
Azure	66.92
Orange	51.13
Brown	48.68
Violet	17.92

Some colours (green, red, pink, yellow and blue) scored very well, while one colour in particular (violet) gained a low grade. The explanation for this situation is the existence of alternative names that can be used instead of the focal colour name.

The possible substitutes for green are (in Romanian language): "vernil" (light green), khaki and the "colour of duck's egg". But these names designate very precise colours and they cannot be derived using pale, light, dark, etc. So, the name green scores high.

Other words used in Romanian language instead of red are: "bordo" (bright red), "dark cherry" and the "colour of the brick". Again, these words indicate very precise colours and they cannot be derived using pale, light, dark, etc. So, the name red gets a high position.

The substitutes found by subjects for pink in Romanian language are cyclamen and lilac. Lilac is obviously an error, because it is a shade of violet. Anyway, both colours where indicated seldom by subjects.

The colour yellow does not have an alternative word in Romanian. In these circumstances, yellow should score very high. The reason for its actual position is the cumulative error in naming yellowish orange and dark yellow. Eliminating the last two colours from the experimental data, colour yellow would score an excellent 90.98% in the correct use of the name.

The subjects seldom used "bleumarin" (dark blue) and indigo instead of blue. "Bleumarin" is one of those words that indicate a precise colour. And, as previously found for other colours, indigo was a wrong name. Eliminating the light blue and dark blue from the data, colour blue would score a very good 89.85% in the correct use of the name blue.

The name grey was used correctly for almost all its shades with the notable exception of dark grey which was named light black by some subjects. As it is known, black is a unique achromatic colour that does not allow derivations with light or dark. Without dark grey in experimental data, colour grey would score 83.21%.

The name azure ("bleu" in Romanian language) was replaced sometimes with light blue, which is an error. In other cases, it was replaced with "blue-as-sky" for which is truly a synonym. But these last cases were few. Orange scored poor because of two reasons. First, sometimes shades of orange were wrongly identified as shades of red or brown. Second, the name orange was replaced by the name "colour of the brick". Also, the colour yellowish orange was not correctly named by some subjects. Brown was another colour that was wrongly identified very often. It was erroneously named "grena" (which in Romanian is a shade of red), "colour of the brick" or orange. A shade of brown is beige, but only one subject (from 133) used it erroneously.

The word violet was contested by words like lilac, cyclamen and, especially, mauve. Actually, mauve was far more used than violet. Considering all the shades of violet used in experiment, the word violet was used 121 times and the word mauve – 421 times. The conclusion is that mauve should be the focal colour name used in Romanian instead of violet or purple. The values of Cronbach's alpha coefficients for the two phases of the experiment were 0.78 and, respectively, 0.72, so the results can be considered as consistent.

4. Conclusions

The main outcome of the present experiment is that, in general, people assign the right colour name rather poor.

The yellow, red, black and white focal colours are easier to identify and name than the blue and green ones. On the whole set of 48 colours, the dark colours are identified and correctly named more than the light colours.

The colours possessing a name composed from a focal colour name plus a differentiator (like light, dark or bright) are more likely to be named correctly than colours without a word designating a focal colour.

People have difficulties in naming correctly the colours that have a halfway position between two focal colours (like bluish green, yellowish orange, reddish brown, etc.).
The colours green, red, pink, yellow and blue are used rather well in the construction of shade names, in contrast with brown and, especially, violet. The explanation is that the first colours do not have synonyms in Romanian language, when the last two do have. Mauve proved to be a powerful competitor for violet. Based on the experimental findings, the authors recommend to the architects, designers and other professionals that might use the colours in their work (speaking in Romanian language) the following:

- Use in communication mainly names of focal colours, eventually plus a differentiator (light, dark, etc.);
- Avoid the use of colour names inspired by analogies (like cyclamen, etc.);
- Use with care the colour names that designate shades with a halfway position between two focal colours (like bluish green, etc.).

5. References

[1] Benavente, R., Olive, M., Vanrell, M., Baldrich, R., Colour Perception: A Simple Method for Colour Naming, *2nd Congres Catala de Intelligencia Artificial*, pp. 340-347, 1999.

[2] Steels, L., Belpaeme, T., Coordinating Perceptually Grounded Categories Through Language: A Case Study For Colour, *Behavioral* and *Brain Sciences*, **Vol. 28**, No. 4, pp. 469-89, 2005.

[3] Whorf, B. L., *Language, Thought and Reality*, MIT Press, 1956.

[4] Heider, E.R., Olivier, D.C., The Structure of Colour Space in Naming and Memory for Two Languages, *Cognitive Psychology*, No. 3, 1972.

[5] Roberson, D., Davies I. Davidoff, J., Colour Categories Are Not Universal: Replications and New Evidence from a Stone-Age Culture. *Journal of Experimental Psychology: General*, **Vol. 129,** pp. 369-398, 2000.

[6] Kay, P., Maffi, L., Color Appearance and the Emergence and Evolution of Basic Color Lexicons, *American Anthropologist*, **Vol. 101**, pp. 743–760, 1999.

[7] Conklin, H. C., Hanunóo Color Categories, *Southwestern Journal of Anthropolology*, No. 11**,** pp. 339–344, 1955.

[8] Lucy, J. A., The Linguistic of Color in Color Categories in *Thought and Language*, Hardin, C. L., Maffi, L. (Eds.), Cambridge Univ. Press, pp. 320–346, 1997.

[9] Berlin, B. Kay, P., *Basic Color Terms: Their Universality and Evolution*, University of California, 2000.

[10] Conway, D., An Experimental Comparison of Three Natural Language Colour Naming Models, *Proceedings of East-West International Conference on Human-Computer Interaction*, pp. 328-339, 1992.

[11] Mojsilovic, A., A Method for Color Naming and Description of Color Composition in Images, *Proceedings of International Conference on Image Processing*, **Vol. 2**, 2002.