Aesthetic Quality of Colour Combinations

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Abstract – Colour harmony seems to involve some higher cognitive processes, which can fuse sensorial characteristics, expressive attributes, and abstract meanings (for instance mathematic relations). We studied how colour combinations set up in accordance with two different theories are evaluated by using a multisensory semantic differential. Results show that aesthetic evaluations in terms of pleasantness are enriched by a number of synaesthetic qualities which can finely differentiate various colour combinations.

Keywords: *color, pattern, harmony*

1 Introduction

Colour perception occurs inside a general framework of more or less accentuated synaesthesia. Since a long time researchers have studied what is common to perceptions derived from different sense organs, and some fundamental common features have been found. No wonder if all perceptions show aesthetical properties, that can be evaluated on scales of beauty. Harmony seems to involve some higher cognitive processes, which can fuse sensorial characteristics, expressive attributes, and abstract meanings (for instance mathematic relations). We studied which psychological reactions people show when observing some particular colour combinations, set up according to the theoretical hypothesis "correspondence/inversion" [1][2].

2 Experiments

To test the suitability of the multisensory semantic differential we proposed to discriminate the aesthetic values of colour combinations, two experiments were performed, differing in the colour combinations studied and in the groups of participants, being the evaluation methodology the same.

2.1 Experiment 1

1) *Material:* three pairs of bicolour combinations were prepared, in which three highly chromatic colours were combined with less chromatic colours to produce either correspondent or vague inverted bi-colour combinations, following the terminology [1]. According to the author, the correspondent combinations are generally pleasant, while the vague inverted bi-combinations most often appear ugly. The combinations are listed in Table 1.

Table 1. Colour combinations used in experiment 1.

10 080 R – 00 30 B90G corresp.	15 65 G – 20 50 R60B vague inv.	20 65 B – 30 40 B20G vague inv.
10 080 R – 10 60 B90G corresp.	15 65 G – 60 40 R60B corresp.	20 65 B – 10 40 B20G corresp.

Each colour combination had the shape of a 2x3 chessboard (Fig. 1), with squares of 5 cm, mounted on a white cardboard (18 x 22 cm) and observed under a simulated D65 light source. [© 2011 NCS Colour AB. All Rights Reserved.]

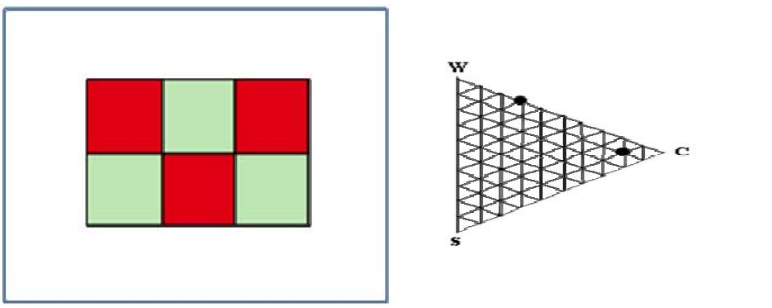

Fig. 1. Example of a colour combination card and the position of its colours in a NCS triangle.

2) Method. Evaluation of aesthetic quality of the colour combinations were made by a multisensory semantic differential, characterised by 9 bipolar scales. Three were the well known factorial scales [3] in verbal form (active – passive; pleasant – unpleasant; weak – strong). The other six are described in Table 2.

Table 2. Multisensory Scales Used in the Experiments

visual	- an orange and a turquoise 10x15 cm rectangle (0090 Y50R - 2060 B50G) on a black background,
tactile	- hot and cold water (about 40° - 10°);
tactile	- two pieces of sandpaper (N 60 and N. 1000; 10 x 15 cm);
haptic	- an empty and a stone filled 1.5 l bottle (about 40 g - 2 Kg),
auditory	- a loud and a faint sound (60 dB difference) in earphones;
auditory	- a high - and a low-pitched sound (5120 Hz_{75} - 32 HZ_{110}; subscript: relative dB) in earphones;

3) Procedure. 25 adults with normal colour vision participated in the experiment. The colour combinations were presented at a distance of about 1 m in random order, and the participant had to evaluate them by crossing one of eight squares a Likert-like scale printed in a stripe of paper.

4) Results. Two kinds of statistical analysis were performed, an analysis of variance to look for significant differences in the evaluations of the six colour combinations as a function of the kind of combination (correspondent vs. vague inverted; close vs. distant colours in NCS space), and a factorial analysis to study the basic components of the evaluative process. Considering those combinations which are balanced as regard to the kind of combinations and to the distance between its colours, an ANOVA showed that evaluations of the correspondent combinations are significantly different from the vague inverted ones ($F_{5,120}$ =26,49, p < 5.8E-18), while these latter do not differ each other. In particular, there are significant interactions between scales and combinations ($F_{8,192}$ = 8.844, p < 2.5E-10), illustrated in Fig. 2 This means that semantic evaluations in the nine scales are globally different in the two kind of combinations; on the other side they differ not in the combinations differing for their colour distance.

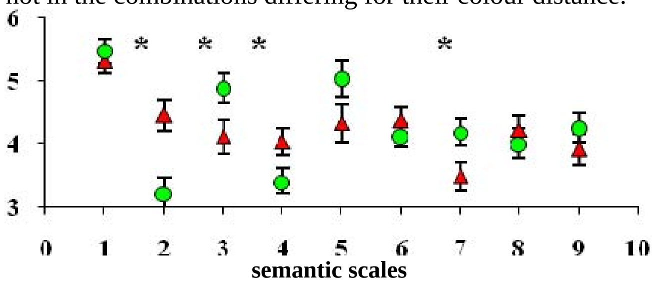

Fig. 2. Mean evaluations as a function of correspondent (green disks) and vague inverted (red triangles) combinations.

Another interesting results deals with the interaction semantic scales – colour combinations: distance between colours is relevant only when correspondent combinations are considered (Fig. 3.b).

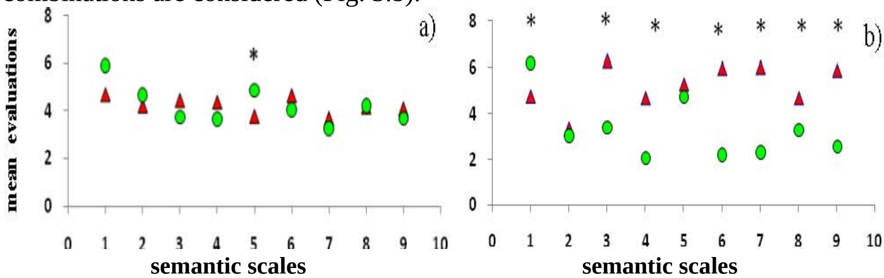

Fig. 3. Mean evaluations as a function of far (green disks) and close (red triangles) colours in the vague inverted (a) and in the correspondent (b) combinations.

An important result relative to scale 4 (pleasant/unpleasant) appears in Fig. 2 and 3: correspondent combinations are significantly different from the vague inverted combinations, in the direction of being more pleasant, according to Spillmann's theory. Moreover also the other semantic scale differentiate very well the different combinations, and therefore can be considered good tools in enriching the qualitative characteristics of the combinations. Factorial analysis reveals the basic criteria used by participants in performing their evaluations. We present in Table 2 two solutions, the first with 4 rotated (Varimax) factors explaining 71% of the variance, and the second with 3 rotated (Varimax) factors explaining 62% of the variance. First of all it is interesting to note that the difference between the two solutions is only in scale 5 (warm-cold), which appears alone in factor 4, while it is together with scale 1 (orangeturquoise) in the solution with3 factors. Probably the simplest solution with 3 factors is also the best, as the two colours were deliberately chosen to visually appear warm and cold.

Table 3. Multisensory Scales Used in the Experiments

		4 factors				3 factors		
		1	2	3	4	1	2	3
1	orange/turquoise			.916				.807
2	active/passive		.774				.769	
3	weak/strong	.769				.753		
4	pleasant/unpleasant		.553				.601	
5	warm/cold				.929			.760
6	light/heavy	.822				.802		
7	smooth/rough	.784				.804		
8	high/low pitched		.725				.712	
9	piano/forte	.795				.797		

The first factors is characterized by the scales: weak/strong, light/heavy, smooth/rough, piano/forte, and therefore can be identified with Osgood's potency; factor 2 is characterized by the scales: active/passive, pleasant/unpleasant, high/low pitched, and seems a mixture of activity and evaluation; the remaining factor is clearly characteristic of heat synaesthetically understood.

1.2 Experiment 2

1) *Material:* three pairs of bicolour combinations were prepared as in the previous experiment, in which three highly chromatic colours were combined with less chromatic colours to produce either correspondent or vague inverted bi-colour combinations. The combinations are listed in Table 1.

Table 4. Colour Combinations Used Experiment 2

10 080 R – 20 40 R30B vague inv.	10 80 Y – 20 40 B60G vague inv.	10 80 R – 20 50 B90G vague inv.
10 080 R – 30 60 B90G corresp.	15 65 G – 30 60 B60G corresp.	10 80 R – 30 20 B90G vague inv.

The method and procedure were the same as in experiment 1, only the participants were a different group of 25 adult with normal colour vision.

4) *Results*. Here too an analysis of variance and a factorial analysis were performed. Considering those combinations which are balanced as regard to the kind of combinations and to the distance between its colours, an ANOVA showed that evaluations of the *correspondent* combinations are significantly different from the vague inverted ones ($F_{1,24} = 11.027$, $p = 0.003$) and also distance between colours significantly affect semantic evaluations ($F_{1,24} = 8.926$, $p = 0.006$) .

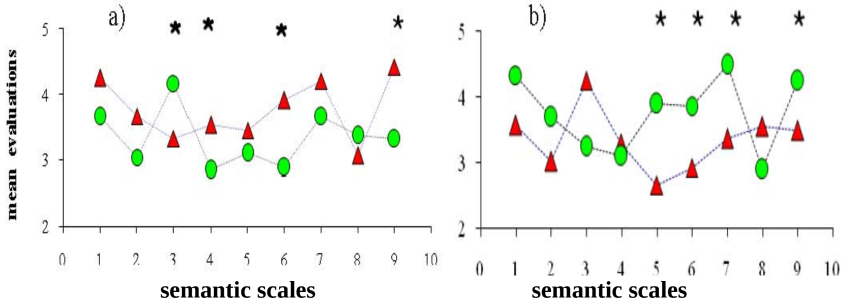

Fig. 3. Mean evaluations as a function of the correspondent (green discs) and vague inverted (red triangles) combinations in a); and as a function of the close (green discs) and the far (red triangle) colours in b).

Fig.3 shows that scale 4 (pleasantness) significantly discriminates correspondent from vague inverted combinations according the predictions [1], but does not discriminates the colour combinations on the basis of their colour distance, against the hypothesis [2].

Mean evaluations

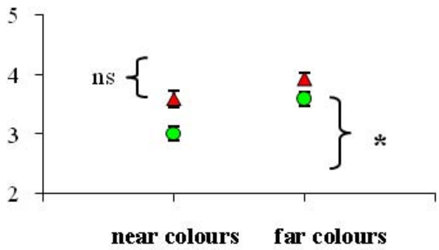

Fig. 4. Mean evaluations as a function of the correspondent (green discs) and vague inverted (red triangles) combinations.

Figure 4 shows that only correspondent combinations are differently evaluated as a function of colour distance, while vague inverted combinations are not affected by distance in agreement with results of the previous experiment.

We present in Table 5 two solutions of the factorial analysis, as in experiment 1,, the first with 4 rotated (Varimax) factors explaining 58% of the variance, and the second with 3 rotated (Varimax) factors explaining 47% of the variance, quite lower than in experiment 1.

Table 5. Multisensory Scales Used in the Experiments

		4 factors				3 factors		
		1	2	3	4	1	2	3
1	orange/turquoise			.804		.414		
2	active/passive		.787			.471		
3	weak/strong		-.629			-.637		
4	pleasant/unpleasant				.765			.763
5	warm/cold			.508		.623		
6	light/heavy				.670			.670
7	smooth/rough	.850					.830	
8	high/low pitched	.638					.628	
9	piano/forte	.501	-.413			-.503		

First of all it is interesting to note that the two solutions are quite different, and in the first solution factor 4 is characterised by scale 4 (pleasant/unpleasant) and 6 (light/heavy), which seems to be a rather logical association. Importantly factor 3 include scale 1 (orange/turquoise) and scale 5 (warm/cold) exactly as in the previous experiment. Factor 2 is characterised by active/passive and strong/weak scales which are basic Osgood's factors, and forte/piano, which seems to be closer to active/passive.

3 Discussion

The two experiments offer results globally in favour of Spillmann's hypothesis [1][4][5], and moreover add to the simple characterization of pleasantness attributed to bi-colour combinations a series of qualities derived from multisensory associations.

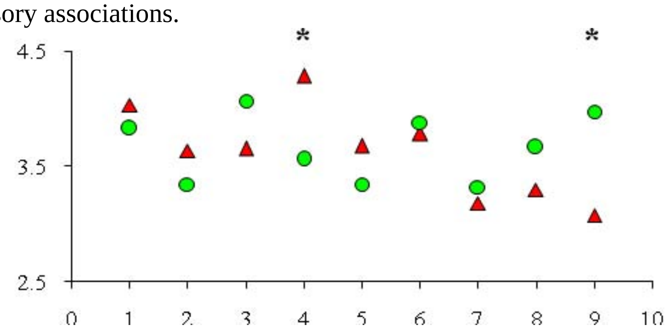

Fig. 5. Mean evaluations as a function of the correspondent (green discs) and vague inverted (red triangles) combinations from data common to both the experiments.

Also in an analysis of variance performed within subjects (from both experiments) pleasantness (scale 4 in Fig. 5) is evaluated in a significantly higher level for correspondent than for vague inverted combinations. Moreover another relevant finding is its association with scale 9 (piano/forte), which gives to the experience of pleasantness a quite accent. By merging all data from the two experiments, results of a factorial analysis are remarkably interesting.

Table 5. Multisensory Scales Used in the Experiments

		4 factors				3 factors		
		1	2	3	4	1	2	3
1	orange/turquoise			.811				.790
2	active/passive				.924		.716	
3	weak/strong	.688				.734		
4	pleasant/unpleasant		.863				.587	
5	warm/cold			.762				.776
6	light/heavy	.640				.615		
7	smooth/rough	.614				.565		
8	high/low pitched		.636				.598	
9	piano/forte	.801				.764		

First of all the difference between the solution with 4 factors and that with 3 factors is only in scale 2 which is alone in the first case and included in factor 2 in the second case. The solution with 4 factors seems better as the two Osgood's basic factors *evaluation* (pleasantness) and *activity* are there separated. In this case we also find that pleasantness appears together with high. On the other side pleasantness is paired with high pitched sound, probably in the sense of a bright impression. Scale 1 (orange/turquoise) appears again together with scale 5 (warm/cold) confirming the importance and universality of this synaesthetic quality of heat assigned to colours [6]. The remaining scales (3- weak/strong; 6- light/heavy; 7- smooth/rough; 9- piano/forte) seem to give the factor a property which spreads from a delicate and soft character to powerful and hard. These characterizations enrich the potency factor with multisensory features. In conclusion the methodology here adopted seems very suitable for evaluating various aspects and qualities of our experience, independently from the sensorial nature of the object which is being evaluated.

References

[1] W. Spillmann, "The concepts of lightness ratio of hues in colour combination heory", Mondial Couleur '85 – Proceedings of the 5th AIC Congress – Monte- Carlo, 1985, pp. 1-6.
[2] P. Moon and D.E. Spencer, "Geometric formulations of classical color harmony", Journal of the Optical Society of America, Vol. 34(1), 1944, pp. 46-60.
[3] C. Osgood, G. Suci, P.H. Tannenbaum, The Measure of Meaning, University of Illinois Press, Urbana, III, 1957.
[4] O. da Pos, "The Pleasantness of Bi-Colour Combinations of the Four Unique Hues" In H. Arnkil, E. Hamalainen, Aspects of colour. UIAH,Helsinki, 1995, 164- 174.
[5] O. da Pos, "Color Combinations in Capucci's Work". International Journal of Costume, 4, 2004, pp. 81-99.
[6] O. da Pos, V. Valenti "Warm and col colours". In Y.E.Guanrong, X.U. Haisong, AIC Colour Science for Industry. Color Association of China, AIC

Conference Proceedings, Hangzhou, 2007, pp. 41- 44.