An educational experience on the exploration and experimentation of colour associations and relationships

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The following article describes the results of an educational experience conducted within the Color and Perception course at the School of Design of the Politecnico di Milano, in the academic years 2013/2014 and 2014/2015. The students were asked to work on the creation of colour palettes associated with a selection of "evocative terms", or keywords, which found a more or less extensive recurrence in literature and experimental research that addresses synesthetic associations of colour. Next, the students' works went through a review process in order to evaluate the actual presence of associative recurrences, and thus their relevance in the attributes of hue, lightness, and saturation. This check was carried out for each keyword using the NCS - Natural Colour System[1]. Where the number of reference samples proved to be sufficiently interesting to support assessments, the results showed how for some keywords there was a clear association recurrence in the nuance and/or hue.

Introduction

    Among the colour study fields, we can observe how there are some correlated research areas arising that refer to the associative and emotional sphere evoked by colour. Although not always in the presnce of direct references, they also involve the synesthetic aspects induced by colour both related to the visual-verbal associations [1], and the associations between different sensory registers [2]. As Newhall pointed out about the association between colour and temperature, the emotional evocation of warmth and coolness could be limited to the appearance, that is to say to the visual suggestion of colour, or it could truly stimulate an essentially affective response [3].

[1]NCS - Natural Colour System®© property of and used on licence from NCS Colour AB, Stockholm 2017. References to NCS®© in this publication are used with permission from the NCS Colour AB.

The evaluation of the emotional response to colour, called "colour emotion", has involved many researches, which, as Gao and Xin observed, could be divided into two broad categories. The first one was related to the aesthetic experimentation of colour or colour preference, dealing with the evaluative dimensions of colour, while the second one to the descriptive dimensions of colour through connotations such as warm or cool, light or dark, heavy or light, etc. [4].

Compared to the descriptive dimension of colour and the connections with the perceptual attributes of colour, as reported by Gao and Xin [4], the very first studies aimed at establishing relationships with single dimensions such as temperature, and in that case it was the hue attribute that appeared dominant. The most recent researches, on the other hand, made use of the semantic differential method introduced by Osgood *et al.* [5] and they suggested that lightness and saturation had a greater influence than hue [4].

A few of these studies have focused attention on the implications of using not just single colours but combinations of two or more colours.

In particular, Ou *et al.* conducted a study on both single colours and two-colour combinations in relation to those colour-emotion scales that were most used in previous studies. They were warm-cool, heavy-light, modern-classical, clean-dirty, active-passive, hard-soft, tense-relaxed, fresh-stale, masculine-feminine and like-dislike. The harmonious-disharmonious scale was added for the specific case of the two-colour combinations study [6-7]. Similarly to other studies, a number of colour samples were first selected and then presented to observers asking them to establish the association between the colour pair presented and the pair of "colour emotion words" identified, that could be for instance warm-cool [7]. This study confirmed, except for the like-dislike scale, the relationship between emotions evoked by single-colours and two-colour combinations [7].

Kobayashi proposed a systematic classification of colour combinations, built on images inside his Color Image Scale. He developed his database using 130 basic colours to create different colour combinations, and 180 matching image words [8].

The colours were arranged according to their characteristics of hue, lightness and saturation[2] along three axes: warm-cool, soft-hard and clear-greyish. The words and colours that were located at the same point along the axes evoked the same "image" and it was that image that formed the link between word and colour. Within this systematisation, using combinations of three colours as a basic unit of the system, all the possible colour combinations could be classified [8].

The real value of this type of studies, which relates the associations evoked by colour to particular colour combinations, is mainly in the practical consequences they favour.

In fact, for practical purposes, as Hård and Sivik underlined, the interest of numerous studies investigating associations and evaluations with respect to individual colours, is rather limited if we consider that people rarely experience colour in isolated terms [9]. As Albers already observed, with regard to the colour interactions, we are almost never able to see a colour alone, isolated and not in relation to other colours [10].

In this framework, the educational experience held during the Color and Perception course with the students of the School of Design of the Politecnico di Milano[3], in the academic years 2013/2014 and 2014/2015, allowed us to explore and later evaluate, a didactic and research approach aimed at

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[2]The terms used by Kobayashi were "hue" and "tone". He described the "tone" term as the result of the interaction of two factors: brightness or value, and colour saturation or chroma.

[3]Third year students of the first level degree programs of Industrial product design, Communication design, Fashion design and Interior design attended the "Color and Perception" mono-disciplinary course. Professor: Cristina Boeri, Assistants: Marilisa Pastore, Camillo Villa.

investigating the associative implications that may arise between "colour emotion words" and "colour palettes".

In other words, the students were asked to start from a selected number of "evocative terms", recurring in literature and experimentation, and to create 4-colours combinations drawing from an almost unlimited number of colours.

The educational experience with the students of design

As said earlier, in the academic years 2013/2014 and 2014/2015 within the Color and Perception course, we asked our students to work on building colour palettes associated with a selection of "evocative terms", or keywords, which were more or less widely recurrent in experimental research and literature that addressed synesthetic associations of colour [11-14]. The selected keywords were: brillante/brilliant, delicato/delicate, dinamico/dynamic, duro/hard, fragile/fragile, fresco/fresh, leggero/light, morbido/soft, pesante/heavy, pulito/clean, secco/dry, solido/solid, tranquillo/quiet and umido/humid.
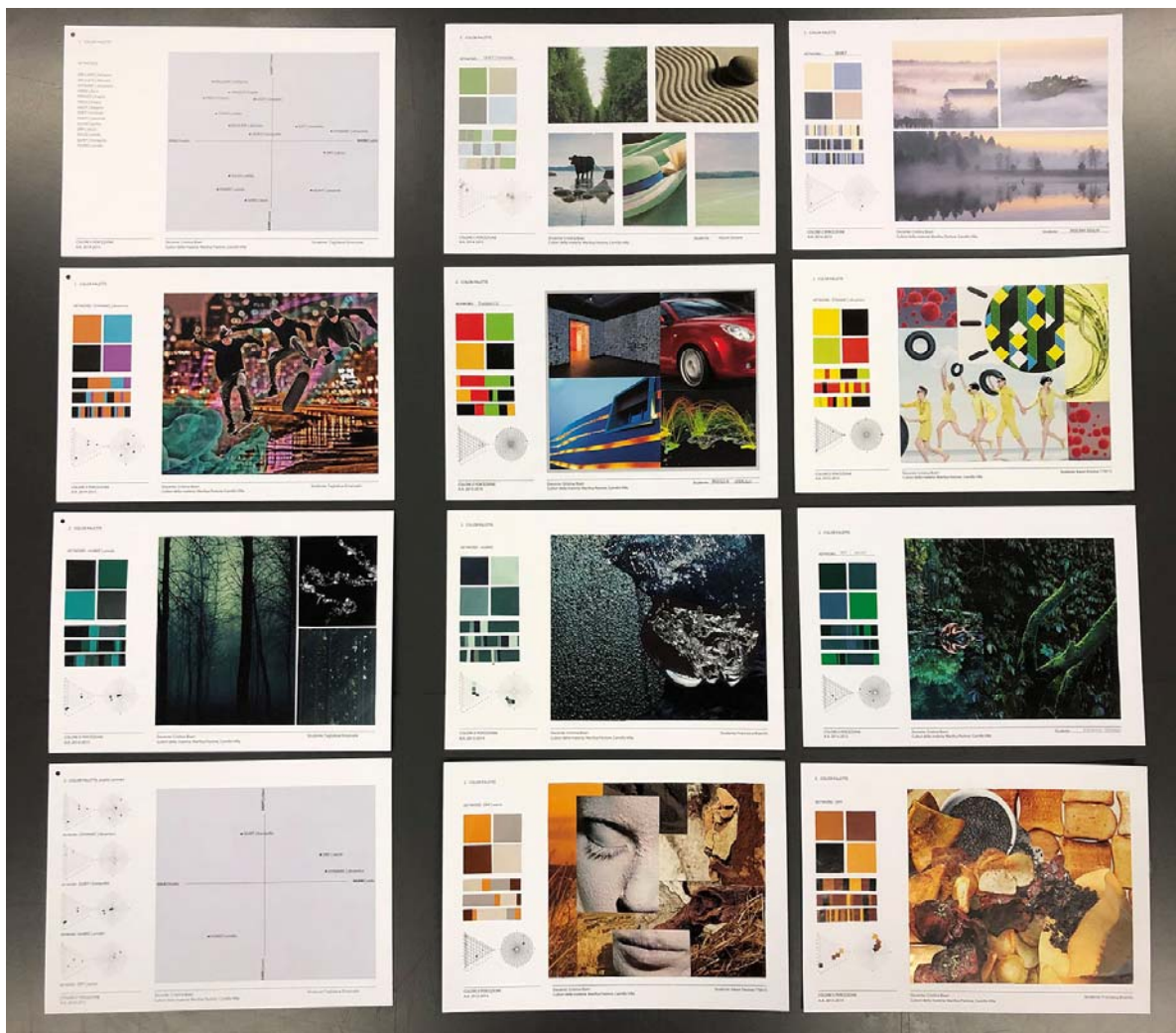

Figure 1: An example of a complete work produced by a student (left) and other students' works developed on the same keywords (dynamic and humid) and on the opposite keywords (quiet and dry). Color and Perception course, School of Design, Politecnico di Milano, AY 2013/2014 and 2014/2015. Professor: Cristina Boeri. Assistants: Marilisa Pastore and Camillo Villa.

In summary, the students were asked to progress through three phases. The first step was aimed at the exploration of all the assigned keywords by placing them within a map organised on a light/dark vertical axis and a warm/cool horizontal axis. This phase was primarily intended to invite the students to take their time and reflect, weighing all the keywords they were assigned, before deciding which ones they wanted to develop.

In the second step the students were invited to freely choose two keywords among those proposed and then to develop a 4-colour palette associated with each keyword, using homogeneous colour clippings taken from magazines. The table template given to the students foresaw that, for each palette, they would have place to insert some evocative images, useful to establish a contextual setting to the palette with respect to the desired association. Moreover the table templates gave the students the possibility of expressing the visual hierarchies that each colour could assume inside the palette and the characteristics of each colour with respect to the attributes of hue, lightness and saturation using the NCS (Natural Colour System) colour circle and colour triangle (see Figure 1).

The third and final step was a comparison process where the students had to place their identified colour palettes in the initial exploration map in order to assess their findings both with the initial hypotheses and with the work of the other students who worked on the same keywords.

The workshop, which was conceived as an ex tempore, took place over a period of two weeks. From an educational point of view, it was set up to offer the students a practical experience of exploration and experimentation both with the synesthetic implications of colour and the relationships between colours[4] and, lastly, also with the colour attributes.

Verification of the students' works

The works of the students underwent a review aimed at assessing the presence of recurrences both of colours used and of colour combinations adopted, and the variations in respect of the attributes of hue, lightness and saturation.

	Keyword	Total number of works	Female	Male
1	brillante | brilliant	22	15	7
2	delicato | delicate	52	43	9
3	dinamico | dynamic	30	20	10
4	duro | hard	27	15	12
5	fragile | fragile	8	6	2
6	fresco | fresh	38	27	11
7	leggero | light	25	16	9
8	morbido | soft	22	18	4
9	pesante | heavy	23	12	11
10	pulito | clean	6	3	3
11	secco | dry	48	35	13
12	solido | solid	8	6	2
13	tranquillo | quiet	23	15	8
14	umido | humid	28	18	10

Table 1: The total number of works produced by the students for each keyword and the relative distribution between females and males.

[4]Within the relationships between colours, two aspects linked to the coexistence of colours emerge: that of the chromatic interactions, and therefore how colours interact with each other, changing perceptively, and that of colour harmonies, related to the rules, or bonds, to which colour combinations are subject [15].

This verification was conducted for each keyword using the NCS system. The NCS translations provided by the students to describe the colours they had chosen for their palettes were checked and, when necessary, corrected by visual comparison with the standard samples of the second NCS edition. They were first compared and then analysed to identify the presence of recurring colour choices in terms of nuance and/or hue.

The total number of works produced for each keyword did not return equally distributed results, as the students were free to choose the two keywords to develop among those assigned (see Table 1). This provided indications about the existence of some obvious preferences in the keyword choices and made it impossible to proceed with an evaluation of some of the keywords such as fragile, clean and solid.

Wherever the number of reference samples was sufficiently interesting to support evaluations, the results were made visually readable using the NCS colour triangle and circle to identify both the presence of more or less extensive areas with greater colour concentration and the presence of recurring use of a certain nuance or hue (Figures 2-3).

For example, if you took into account the keyword "delicato/delicate" – the most utilised by the students – you could see how most of the colours used were in the NCS triangle area where the dominant attribute was the lightness, or whiteness, with 76% of the colours enclosed in a rather concentrated area. Instead, you would have observed a less dense area for the hue, ranging from yellow (Y) to blue (B) with some more used hues than others such as yellow (Y) (Figure 2).

This reading, intertwined with that relating to the most used organisational schemes of the relationships inside each palette, offered additional indications regarding the relationship between nuance and hue. In the case of the "delicate" keyword, in fact, you could observe a recurrent colour combination scheme based on the nuance analogy and hue differentiation (Table 2).

| Colour combination schemes	Nuance	Hue
1 brillante | brilliant	• analogy of nuance / identical nuance with the presence of an achromatic or chromatic black	• differentiation of hue with one hue in the area Y
2 delicato | delicate	• analogy of nuance / identical nuance	• differentiation of hue in the area Y-B with steps of 40/50 • differentiation of hue in the area Y-B with steps of 70/80 and one colour in the area B-Y
3 dinamico | dynamic	• analogy of nuance / identical nuance	• differentiation of hue in all the circle with steps of 60/100
4 duro | hard	• differentiation of lightness with prevalence of achromatic or chromatic greys	n/a
6 fresco | fresh	• analogy of nuance (saturation) • analogy of nuance (lightness)	• differentiation of hue in the area R90B-G90Y • analogy of hue in the area R90B-G
7 leggero | light	• analogy of nuance with the presence of an achromatic or chromatic white	n/a
8 morbido | soft	• differentiation of nuance	• analogy of hue
9 pesante | heavy	• analogy of nuance	• analogy of hue
11 secco | dry	• differentiation of nuance	• analogy of hue / identical hue

Table 2: The most recurring schemes of relationship adopted by the students to organise the 4 colours present in each palette.
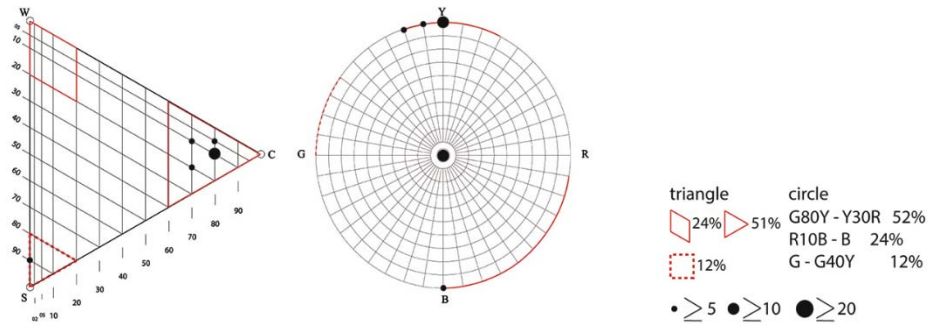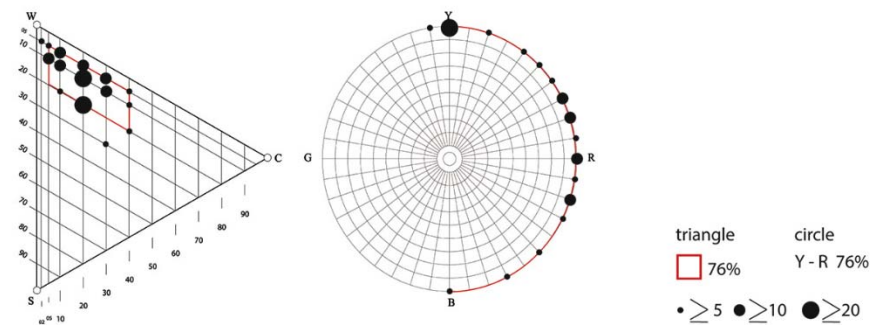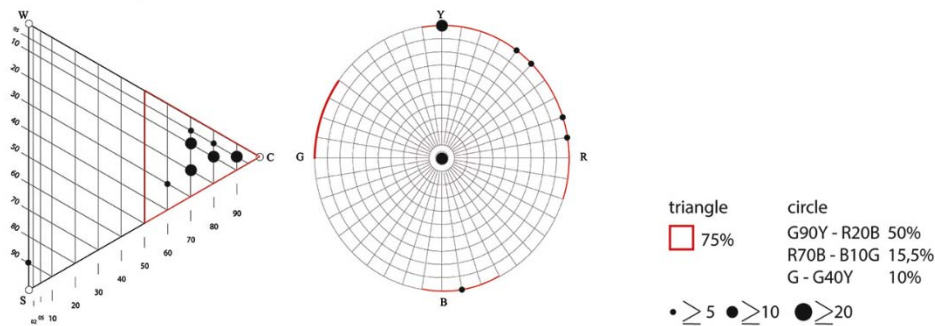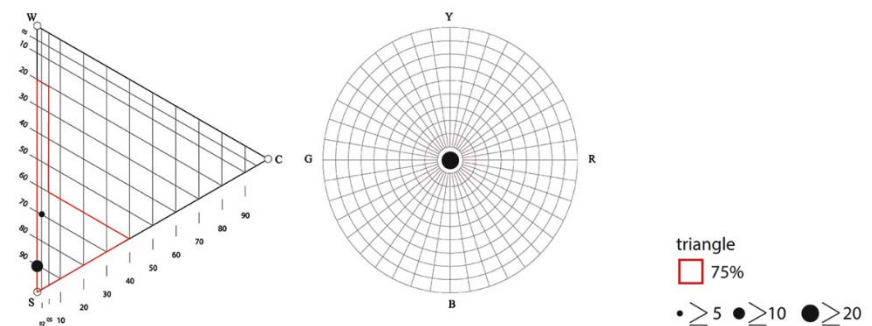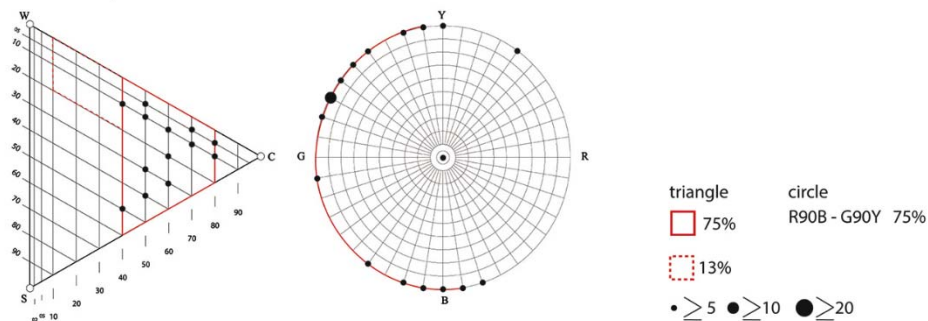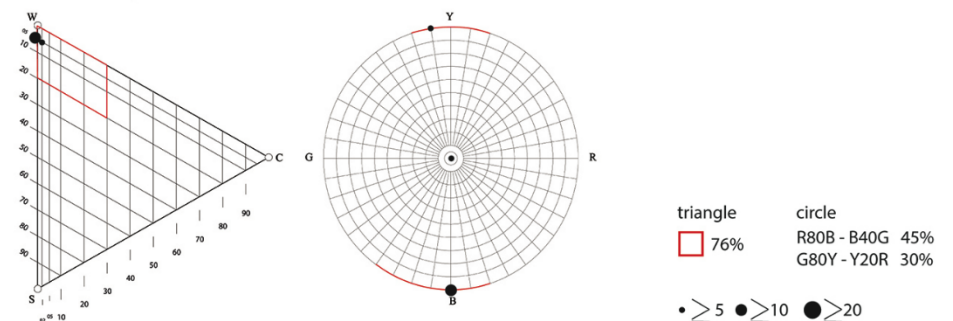
Figure 2: The visualisation, through the NCS triangle and circle, of the areas of greatest concentration of colours for the keywords brillante/brilliant, delicato/delicate, dinamico/dynamic, duro/hard, fresco/fresh and leggero/light. The black dots indicate the presence of the recurring use of a certain nuance or hue (equal to or greater than 5 colours, equal to or greater than 10 colours, equal to or greater than 20 colours).

8. MORBIDO | SOFT

triangle | circle
□ 75% | Y - R30B 75%
• ≥5 ● ≥10 ● ≥20

9. PESANTE | HEAVY

triangle | circle
□ 77% | Y - R 75%
• ≥5 ● ≥10 ● ≥20

11. SECCO | DRY

triangle | circle
□ 31% | Y10R - Y80R 75%
 | Y - R10B   87%
• ≥5 ● ≥10 ● ≥20

13. TRANQUILLO | QUIET

triangle | circle
□ 75% | R70B - Y 75%
• ≥5 ● ≥10 ● ≥20

14. UMIDO | HUMID

triangle | circle
□ 76% | R80B - G90Y 75%
• ≥5 ● ≥10 ● ≥20

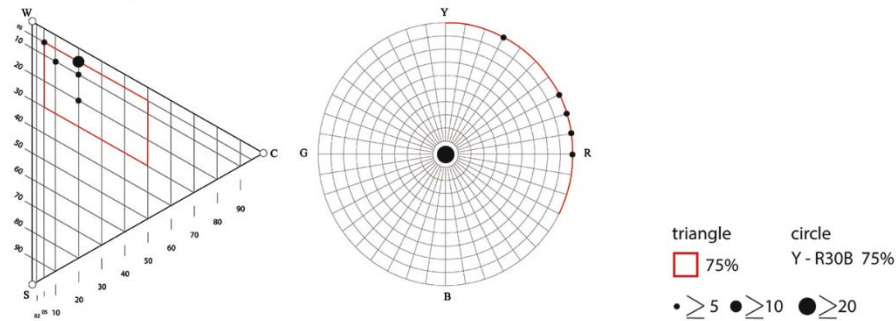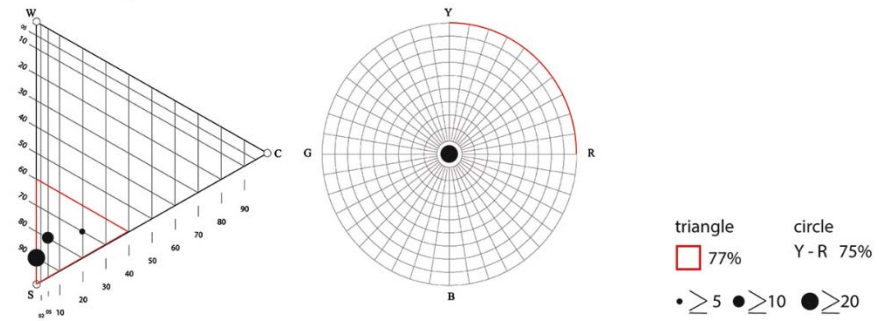*Figure 3: The visualisation, through the NCS triangle and circle, of the areas of greatest concentration of colours for the keywords morbido/soft, pesante/heavy, secco/dry, tranquillo/quiet and umido/humid. The black dots indicate the presence of the recurring use of a certain nuance or hue (equal to or greater than 5 colours, equal to or greater than 10 colours, equal to or greater than 20 colours).*
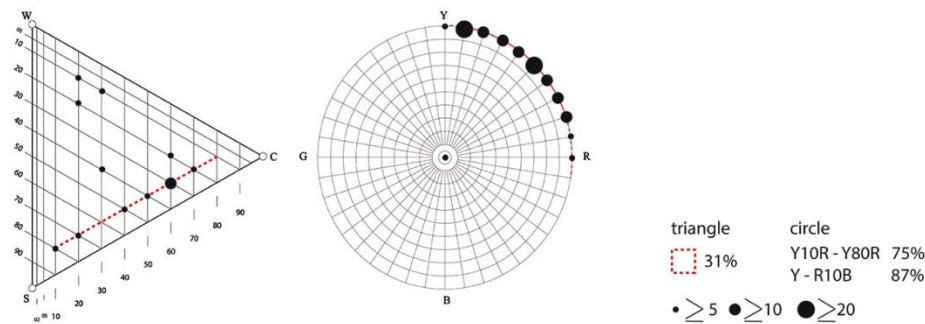
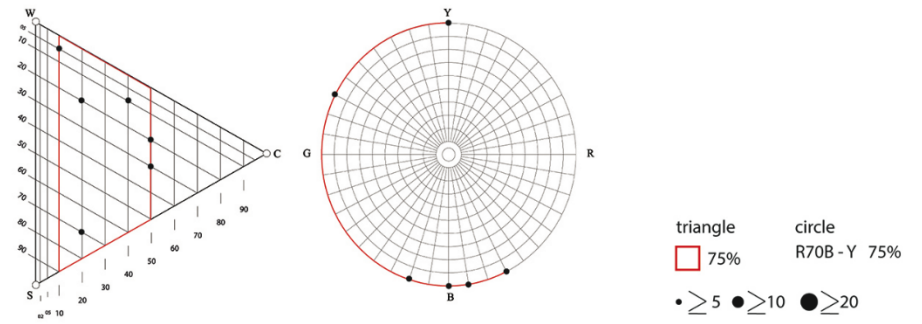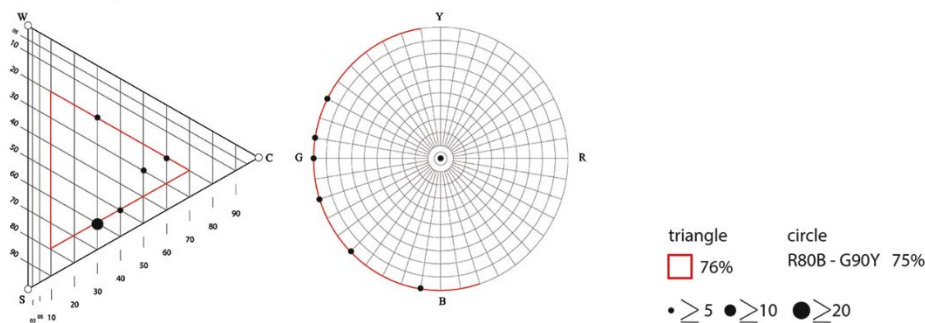By briefly reviewing the keyword analysis, we found that "brillante/brilliant" showed the greatest variety of interpretations and organisation logics of the colours, correlated to the use of at least one colour in the yellow area (Figure 2). The most recurring interpretation and scheme has seen the use of three colours with the same or a similar chromaticness, ranging from 60 to 90, and contrasting hues, with the presence of an achromatic or chromatic black (Table 2).

For the "dinamico/dynamic" keyword, we found that 75% of the colours used were in the triangle area where the dominant attribute was chromaticness. As far as the hue was concerned, the situation appeared more fragmented with a greater concentration in the area between G90Y and R20B and the presence of two other areas of lower concentration between R70B and B10G and between G and G40Y (Figure 2). Also in this case, the analysis of the most common colour combination schemes offered us an additional interpretation of the relationship between nuance and hue, where, in the same way as in the "delicate" keyword case, the use of colours that had an analogy of nuance and contrast of hue prevailed (Table 2).

Further, we found that for the "duro/hard" keyword there was a greater concentration of colours in the triangle area where the dominant attribute was the blackness and along the axis of the achromatic and chromatic greys. The hue, instead, seemed to be irrelevant with a heterogeneous distribution along the entire circle (Figure 2).

Examining the "fresco/fresh" keyword, we detected a recurrence of colours characterised by hues ranging from R90B to G90Y and nuances mostly characterised by a chromaticness between 40 and 80 (Figure 2).

As was shown from the analysis of the palettes, and the images used to describe them, the Italian word of the "fresco/fresh" keyword, was understood by the students mainly in the meaning of active/lively/energetic. They used rather saturated colours and differentiated by hue[5]. A second and less recurring understanding, in its meaning of temperature, produced instead colour palettes characterised by the prevalence of light colours and hues most concentrated in the area between R90B and G (Table 2).

As regards the "leggero/light" keyword, we could see the prevailing use of colours characterised by high whiteness and white, while for the hue there were two areas of concentration ranging from R80B to B40G and G80Y to Y20R (Figure 2).

As regards, instead, the "morbido/soft" keyword the concentration of nuances was mostly in the area of the triangle characterised by blackness between 05 and 30 and chromaticness between 05 and 50. The hue was concentrated in the circle area between Y and R30B (Figure 3).

Examining the "pesante/heavy" keyword, we detected a greater concentration of colours in the triangle area where blackness was the dominant attribute, and the hue was clustered in the area between Y and R (Figure 3).

For the "secco/dry" keyword, there was a clear recurrence in the hue, with 75% of the colours used in the area between Y10R and Y80R, which became 87% when considering the area between Y and R10B. Further there was a diversified situation compared to the nuance that did not lead to highlight any area in particular if not a concentration of colours along the dotted line of equal contents of whiteness 10 (Figure 3).

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[5]The term "fresco" can assume different meanings in Italian; it is translatable in English as "fresh" in its meaning of "new", "unadulterated", or "lively" and "spontaneous" but also as "cool" (temperature). The English term given to the students together with the Italian term "fresco" was "fresh", however the students were left free in the keyword interpretations.

It was evident that the "tranquillo/quiet" keyword had a fairly wide range of recurring nuances, including colours with chromaticness between 10 and 50. Even the "hue" area was also quite large ranging from R70B to Y (Figure 3). The same occurred for the "umido/humid" keyword where we found a rather extensive area of greater use of the hues ranging from R80B to G90Y. Instead, the most recurrent nuances appeared to be concentrated in an area of the triangle with a blackness of not less than 20 (Figure 3).

From the analysis of the organisation logics of the colours used in the palettes that belong to the "quiet" and "humid" keywords, it could be observable that there was a variety and differentiation of solutions rather than the presence of one or more recurrent schemes.

Conclusions

The results of the verifications carried out on the students' work were compared with some of the polarities examined by previous studies, which addressed the synesthetic associations induced by colour, confirming some recurrences [11-12, 14].

Particularly for the light-heavy polarity, we found that where "light" was associated with light-cool and "heavy" to dark-warm [11-12, 14], the association of "light" with the lightness attribute was confirmed – while that with the cool appeared uncertain –, and so the association of "heavy" with dark and warm.

As regards the soft-hard polarity, where "soft" was associated with light-warm and "hard" to dark-cool [12-14], the association of "soft" with warm was confirmed – while the area of the light was more flexible – and so that of dark with "hard". However, we could observe an area of achromatic and chromatic greys that could also be medium-light, prevailing over the hue's influence.

In the case of dry-wet polarity, where "dry" was associated with orange [11] and "wet" to the green, green-blue [11-12], we saw the association of the "dry" confirmed chiefly with the characteristic of the hue, between the yellow and the red, while more uncertain was an indication of the hue for the "wet", which covered a fairly large area of the circle that went from blue to yellow.

The possibility of comparison with other polarities and other studies examined would have been more complex [4, 6-7], although there were congruencies with respect to, for example, the dependence of the "activity" factor with the saturation attribute [4].

The verification carried out on the presence of recurring colour choices, and their relevance with respect to the colour attributes, seemed to confirm the possibility of dealing with associations and evaluations with combinations of four colours, and thus to reinforce the practical design implications offered by this area of research and by this type of study [9]. In the course of this study, other practical and design implications were taken into consideration and/or occurred. One of these implications could be a direct consequence of the graphic model used to display the results. In fact, the visualisation through the use of the NCS triangle and circle, a graphic solution similar to that adopted by the Sivik study through isobars in the NCS model [16], showed to be effective especially for the purposes of understanding, and therefore of the design translation, of the experimentation outcomes. During some following training courses for interior designers and architects, we found that the designers who had been provided the results in this graphic form, were able to use them as a basis for developing new colour palettes and chromatic-material suggestions of interiors associated with emotional keywords. Other interesting aspects could arise from the possibility, as was shown in the course of the study, to identify recurrences not only in the colours used but also in the colour scheme adopted. The latter is an

aspect that, if supported by further studies in this direction, could highlight strong links with the implications raised by that area of colour research that deals with colour harmonies.

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