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Gender differences in colour naming

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Abstract

Gender differences in colour naming were explored using a web-based experiment in English. Each participant named 20 colours selected from 600 Munsell samples, presented one at a time against a neutral background. Colour names and typing onset response times were registered. For the eleven basic colour terms, elicitation frequency was comparable for both genders. Females demonstrated though more elaborated colour vocabulary, with more descriptors in general and more non-basic monolexemic terms; they also named colours faster than males. The two genders differ in the repertoire of frequent colour terms: a Bayesian synthetic observer revealed that women segment colour space linguistically more densely in the “warm” area whereas men do so in the ‘cool’ area. Current “nurture” and “nature” explanations of why females excel in colour naming behaviour are considered.

1. Introduction: gender differences in colour vocabulary, colour naming and colour perception

The importance of richness and variety of colour experience cannot be underestimated. Colour has an affective value and, in everyday life, is used to code, match and identify objects as well as to communicate.

Numerous *linguistic* studies have demonstrated gender differences in colour lexicon: women were invariably shown to possess a more extensive and more elaborate colour vocabulary than men (Lin, Luo, MacDonald and Tarrant, 2001; Nowaczyk, 1982; Rich, 1977; Thomas, Curtis and Bolton, 1978). In addition to basic colour terms (BCTs; Berlin and Kay, 1999) women use significantly more elaborate terms, or BCT hyponyms, such as *mauve, scarlet, chartreuse* or *beige*. Females also offer many more "fancy" colour terms, like *emerald green* or *cerise pink* (Nowaczyk, 1982; Rich, 1977; Simpson and Tarrant, 1991) and more BCT qualifiers related to hue and saturation (Bonnardel, Miller, Wardle and Drews, 2002). In comparison, men tend to use predominantly BCTs accompanied by various modifiers, as well as compound names comprising BCTs.

Furthermore, females' descriptions of colour have greater affective value (Arthur, Johnson and Young, 2007) and display a wider aesthetic range (Yang, 2001). As Frank (1990, 123) illustratively put it: "..."women's colors" are complex, multi-varied, more abstract, and expressive (*raspberry* *sorbet*, *daffodil yellow*, *blush*) while ‘men’s colors’ are simple, straightforward, conventional, real-world (*royal blue, gold, grey*)”.

In *psycholinguistic* tasks, which evoke responses to an array of colour stimuli, already in early childhood (2.5–6 years of age) girls identify primary colours by name better than boys do (Anyan and Quillian, 1971; Johnson, 1977). In adulthood, women have been found to be more accurate, compared to men, in ascribing colour names to colour samples (Greene and Gynther, 1995; Nowaczyk, 1982; Swaringen, Layman and Wilson, 1978); more consistent in their choice of a colour sample matching a given colour name (Chapanis, 1965); and reveal a greater colour-naming consensus (Moore, Romney and Hsia, 2002; Sayim, Jameson, Alvarado and Szeszel, 2005). Temporal characteristics of colour-naming performance indicate, too, that women are faster in a speeded colour-naming task, exceeding men in retrieving colour labels (DuBois, 1939; Golden, 1974; Ligon, 1932; Saucier, Elias and Nylen, 2002; Shen, 2005).

Finally, gender differences have also been observed in tasks relating to *colour sensation* and *colour perception*. In particular, female observers revealed larger Rayleigh anomaloscope matches (Rodríguez-Carmona, Sharpe, Harlow and Barbur, 2008) with a range of unique reds about twice as wide as for male observers (Kuehni, 2001). In colour-discrimination tasks, males were found to have a broader range of poorer discrimination in the middle of the spectrum (530–570 nm) compared to females (Abramov, Gordon, Feldman and Chavarga, 2012). In colour-matching tasks, females were found to have superior abilities relative to males, in particular with regards to hue and saturation (Pérez-Carpinell, Baldovi, de Fez and Castro, 1998). In judging suprathreshold colour differences, women were shown to place more weight on inter-stimulus separation along a red-green axis while males place more weight along a lightness axis (Bimler, Kirkland and Jameson, 2004).

Notably, almost all earlier studies on gender differences in evoked colour names employed a relatively low number of participants, used a constrained number (3–26) of standard reflectance chips and, as a rule, restricted the colour name options to the four chromatic primary BCTs. (An exception is the study by Chapanis (1965) who used 1359 colour samples densely representing Munsell space and allowed 233 colour names.) These design limitations are understandable in the pre-computer era of experimentation: “If you do not limit the number of color terms you allow the observer to use, you will generally end up with such a large assortment of different names, with and without qualifiers, that it is difficult to know what to do with them. There is no easy way of quantifying the outcome of an experiment of that type.” (Chapanis, 1965, 335)

In the present study we explore gender differences in the data for English-speaking respondents obtained in a web-based colour-naming experiment (Mylonas and MacDonald, 2009). This surpasses past design limitations by using a significantly larger set of colour samples; involving a great number of participants, and employing an unconstrained colour-naming method. The data analysis enables assessment of gender differences in: (i) the magnitude of colour vocabulary; (ii) frequency and predominance of certain colour terms; (iii) frequency of colour descriptor categories; and (iv) response times of producing individual colour names. In addition, it allows a validation of the data collected in the online experiment (under less-controlled viewing conditions) against those obtained in rigorous laboratory conditions and using standard pigmented samples.

2. Method

2.1 Interface of the web-based colour-naming experiment

The experimental procedure consists of six steps. First, we ask observers to adjust their display to sRGB settings, and the brightness in order to make visible all twenty-one steps of a grey scale ramp. In the second step participants answer questions relating to the lighting conditions, their environment and properties of their displays. Then, in the third step, we screen our participants for possible colour deficiencies with a web-based Dynamic Colour Vision Test developed at the City University London (Barbur, 2004).

The fourth and main part (Figure 1) is the *unconstrained colour-naming task*: any colour descriptor, either a single word, or a compound, or terms(s) with modifiers can be produced to describe each of twenty presented colour samples. A few colours are presented twice, to check consistency of the participant's responses. Along with the colour name typed on a keyboard, response times (RTs) of onset of typing are recorded, defined as the interval between presentation of the colour stimulus and the first keystroke.

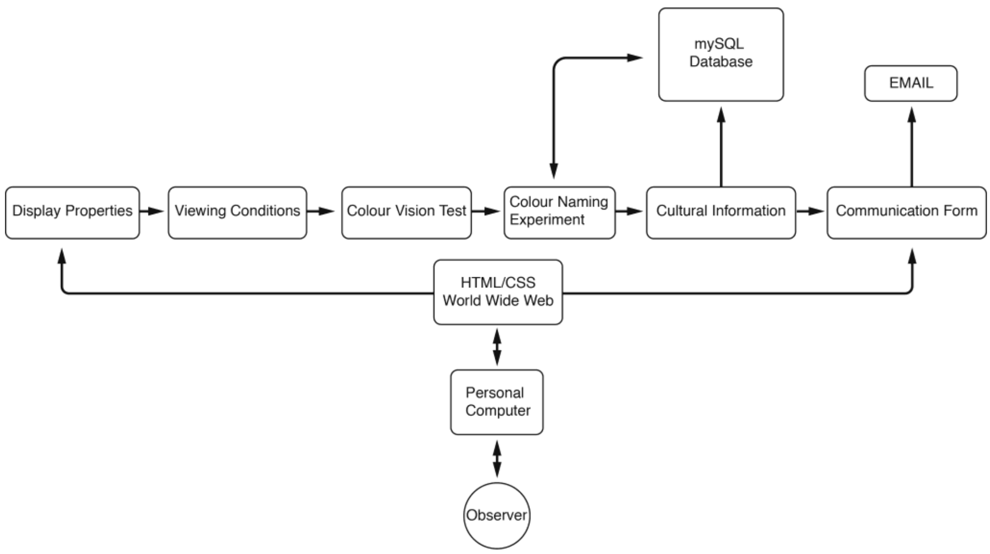


Figure 1. Schematic diagram of the web-based colour-naming experiment

In the fifth step we collect information about the participant's residency, nationality, language proficiency, educational level, age, gender and colour experience. Finally, in the last step we provide participants with a summary of their responses and a "Communication Form" for comments.

2.2 Colour stimuli

The colour-naming experiment makes use of distributed psychophysics and each participant is presented with a sequence of twenty colours randomly selected from 600 total samples from the Munsell Renotation Data. Following the suggestions of Billmeyer in Sturges and Whitfield (1995), the 600 (approximately) uniformly distributed samples were selected from a variable number of hues at different levels of Value and Chroma. The colour stimuli were specified in the sRGB colour space and presented against a mid-neutral grey. Each colour sample was presented across all observers on average 9.04 times (σ=3.04). Stimulus size on the display was 147 by 94 pixels. Detailed specification of the experimental procedure and colour stimuli can be found in Mylonas and MacDonald (2010).

2.3 Data analysis

Responses of English-speaking non-colour-deficient observers over the age of 16 (N=272) were considered, split between females (N_F =159) and males (N_M =113). We corrected any spelling mistakes found in the raw data. Words that were hyphenated, comma-separated, and in parenthesis were treated as multi-word colour expressions, while we rejected responses that involved incomplete or numerical terms or words written in non-English alphabets. The dataset was analysed as follows:

- Validation of the online experimental methodology
- Total and gender-split numbers of colour descriptors offered
- Total and gender-split percentage of occurrence of:
    - colour descriptors of one-word through four-word colour descriptors
    - most frequent colour terms
    - basic colour terms (BCTs)
    - monolexemic non-BCTs
    - colour terms with one modifier
    - colour descriptors containing ≥ 3 words
- Gender-split consistency of colour naming
- Gender-split medians of response times (RTs):
    - for BCTs
    - for most frequent non-BCTs
- Gender-split segmentation of colour space reflecting most frequently used colour names.

3. Results

3.1 Validation of the online experimental methodology

To validate the experimental methodology, we compared the locations of centroids for BCTs in the present study to those obtained under rigorously controlled laboratory conditions (Sturges and Whitfield, 1995). Figure 2 (graphically) and Table 1 (quantitatively) indicate a good correspondence between the centroids calculated for the web-based female and male participants and the centroids in the Sturges and Whitfield study. It is worth noting that the mean colour difference ΔE^*_{ab} =12.5 (for females) or 12.6 (for males) is comparable to inter-individual differences in the Sturges and Whitfield sample. The discrepancy in the blue category might be influenced by the monolexemic nature of Sturges and Whitfield's constrained experiment. The mean colour difference between females and males BCTs was found to be ΔE^*_{ab} =6.3. A larger difference of hue angle was found in the pink category.

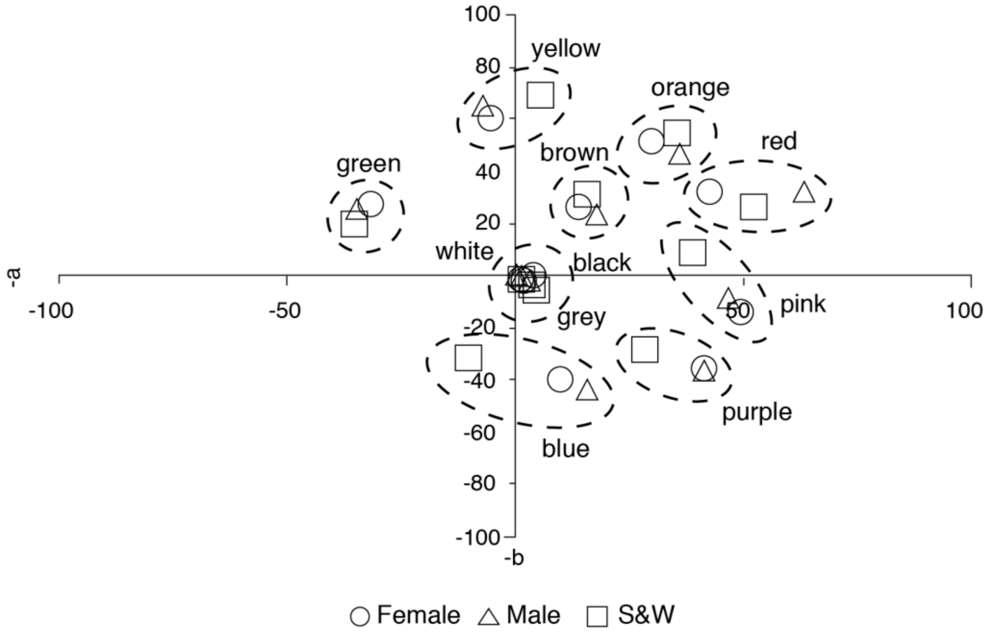


Figure 2. Location of centroids of BCTs in *a**–*b** plane (CIELAB) for females and males in the web-based study vs. the Sturges and Whitfield (S&W, 1995) study.

Table 1. Mean colour differences (ΔE^*_{ab}; CIELAB) in the location of centroids for BCTs for females (F) vs. males (M) in the present web-based study, for females vs. Sturges and Whitfield (1995) (S&W) and for males vs. Sturges and Whitfield (1995).

	F vs. M	F vs. S&W	M vs. S&W
Mean ΔE^*_{ab}	6.3	12.6	12.5

To validate an extended colour vocabulary, results of the present study were compared with those of the parallel web-based experiment of Moroney (2003). In CIELAB terms, the location of centroids for the twenty-seven most frequent chromatic colour words showed a high linear correlation between the two datasets: for hue angles (h_{ab}) R^2=0.995, for lightness (L^*) R^2=0.94, and for chroma (C^*_{ab}) R^2=0.74 (Mylonas and MacDonald, 2010).

3.2 Number of words in colour descriptors: females vs. males

For the total respondent population, the refined dataset resulted in 5428 responses with 1226 unique colour descriptors. The occurrence of colour descriptors with varying word number was: BCTs 29%; monolexemic non-BCTs 23%; colour terms with one modifier 42%; colour descriptors containing $\geq$ 3 words 6%.

The dataset was analysed with regards to gender differences. Out of the total number of responses, 3171 (58%) were provided by females and 2257 (42%) by males. Both genders were comparable in the occurrence of the one-word through four-word colour descriptors they used to characterize the whole range of the colour samples (Figure 3).

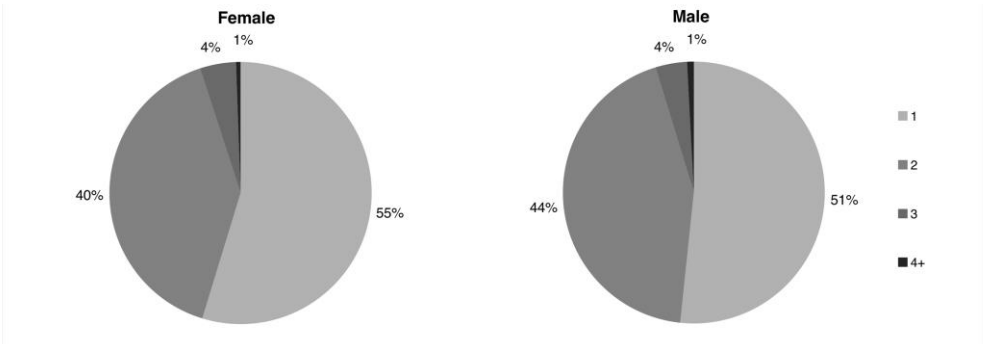
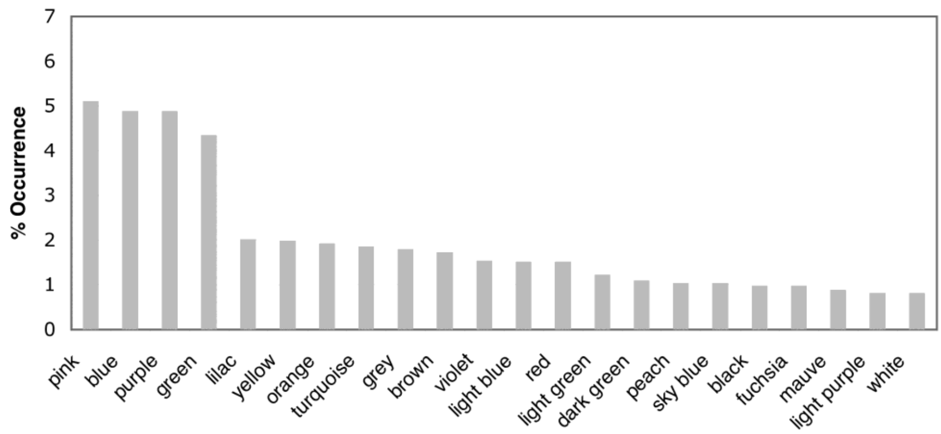


Figure 3. Number of words in colour descriptors for females and males.

Of the total of 1226 unique colour descriptors, females revealed a richer colour vocabulary, N_F = 822 (67%), than males N_M = 610 (48%). In particular, females offered more monolexemic non-BCTs (hyponyms) than males, in accord with previous findings (Nowaczyk, 1982; Rich, 1977; Simpson and Tarrant, 1991). Conversely, males produced more colour descriptors containing a monolexemic term accompanied by one modifier (cf. Bonnardel et al., 2002; Frank, 1990).

3.3 Occurrence of most frequent colour names: females vs. males

The repertoire and ranking order of the twenty-two most frequent colour names differed slightly between the genders (Figure 4). Two “fancy” terms in women’s lexicon, *peach* (rank 16) and *fuchsia* (rank 19), were not among the most frequent choices of men. Conversely two “trade” terms, *magenta* and *cyan* (two of the four subtractive primary ink colours used in printing), were high in frequency for men (rank 7 and 11 respectively), but did not occur at all among women's frequent names.



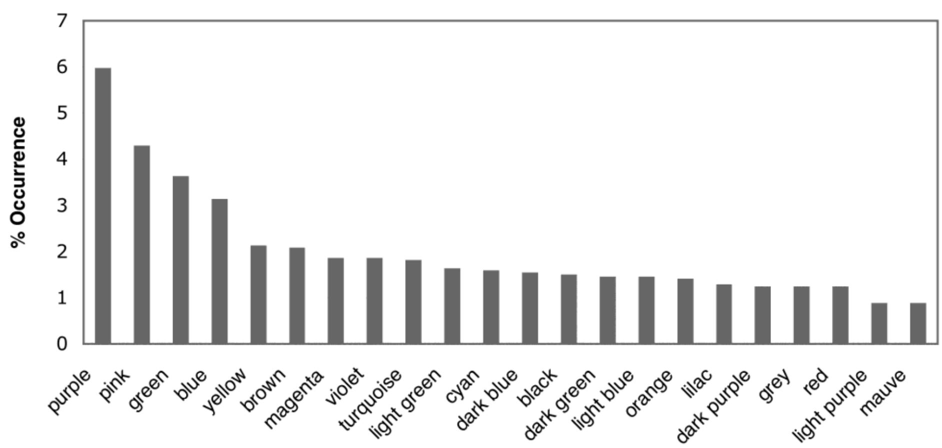


Figure 4. Percentage of occurrence of most frequent colour names for females (top) and males (bottom).

3.4 Occurrence of BCTs: females vs. males

Frequency of occurrence of the eleven BCTs was comparable for both genders: N_F = 939 (29.61%), N_M = 615 (27.25%), as was the case in Bonnardel et al.'s (2002) study. In the present dataset, however, *blue* and *pink* occurred slightly less often for men, and *purple* less often for women (Figure 5).

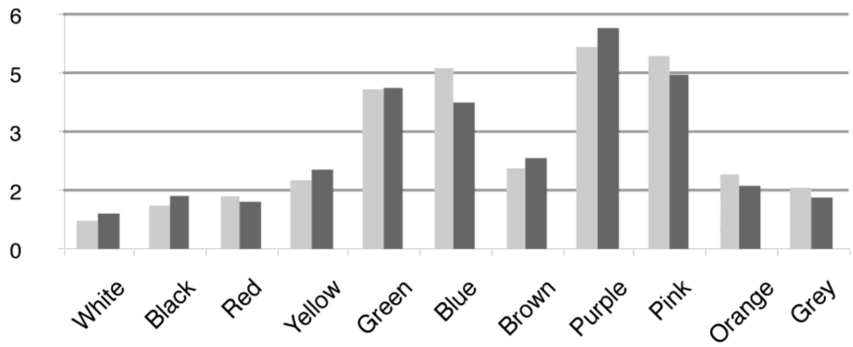


Figure 5. Percentage of occurrence of the eleven BCTs for females (light grey) and males (dark grey).

3.5 Consistency of colour descriptors: females vs. males

As in previous studies (Chapanis, 1965; Greene and Gynther, 1995; Nowaczyk, 1982), women also appeared to be more consistent in their responses to repeated colour samples (Figure 6).

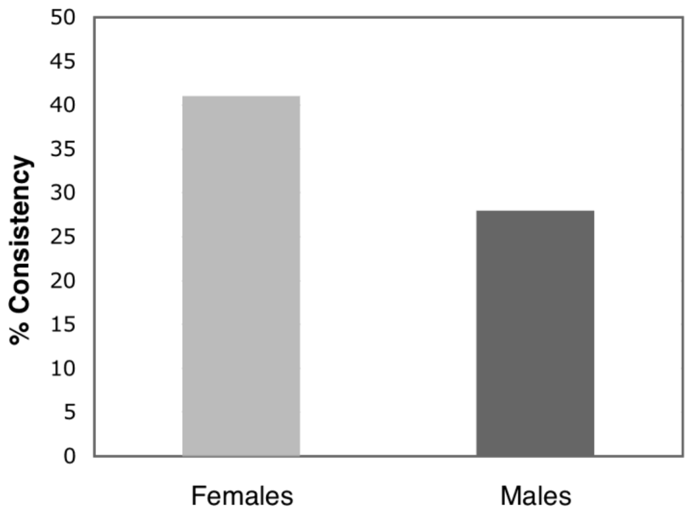


Figure 6. Consistency of responses to repeated colour samples for females and males.

3.6 Response times for BCTs and frequent non-BCTs: females vs. males

The differences in RTs recorded for each colour name between females and males were depicted using box-and-whisker diagrams for BCTs (Figure 7, left) and the next eleven more frequent colour names (Figure 7, right). The response times for BCTs were faster than for the most frequent non-basic colour terms. RTs of female participants were on average 17% shorter than those of males for all BCTs, as indicated in Figure 7 (cf. DuBois, 1939; Golden, 1974; Ligon, 1932; Saucier et al., 2002; Shen, 2005) but this advantage was less prominent for non-BCTs in wide cultural use.

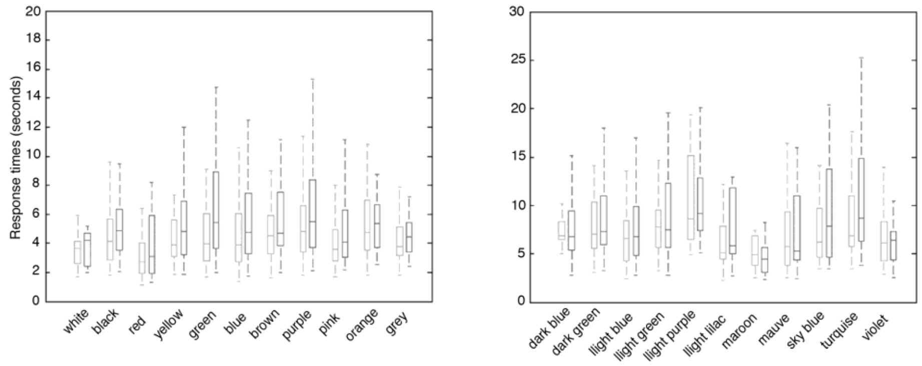


Figure 7. Median RTs of onset of typing for BCTs (left) and most frequent non-basic colour names (right) for females (grey) and males (black).

3.7 Synthetic image: Colour naming segmentation by females vs. males

To visualize gender difference in colour naming, a probabilistic algorithm based on Maximum a Posteriori (MAP) was used (for further details see Mylonas, MacDonald and Wuerger, 2010). This was trained by the present female and male datasets to segment a synthetic image in CIELAB (Weijer, Schmid, Verbeek and Larlus, 2009), as shown in Figure 8. Coordinates of the centroids of the most frequent descriptors were used to colour each name category in the synthetic images for females and males. In total, the model predicted that females would use a richer colour vocabulary to classify the synthetic image than males. However, this advantage is revealed mainly in the warm area as males tended to make subtler colour identifications in the cool area of colour space. Figure 9 reveals the area covered in the synthetic image by each predicted colour name for females and males.

Figure 8. Segmentation of colour space synthetic image using a colour naming algorithm (Mylonas et al., 2010): synthetic image (left); segmentation for females (centre) and males (right).

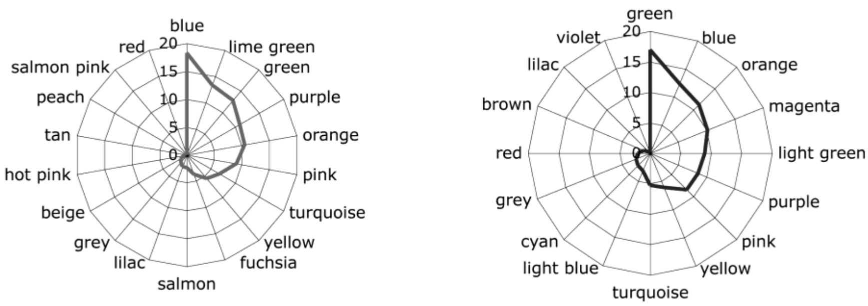


Figure 9. Area in the colour space synthetic image lexicalized by most frequent colour names for females (left) and males (right).

4. Discussion

The online experimental methodology provided satisfactory agreement when validated against a previous experiment conducted in a laboratory controlled environment (Sturges and Whitfield, 1995) and a similar web-based experiment (Moroney, 2003).

The analysis of gender differences in the outcome of the present web-based colour-naming experiment confirmed the findings of previous off-line studies that women exceed men in the richness of their colour lexicon, in the variety of elaborate colour terms (Arthur et al., 2007; Frank, 1990; Nowaczyk, 1982; Rich, 1977; Simpson and Tarrant, 1991; Swaringen et al., 1978; Thomas et al., 1978; Yang, 2001), and in speed of naming colours (DuBois, 1939; Golden, 1974; Ligon, 1932; Saucier et al., 2002; Shen, 2005).

For both genders the percentage of occurrence of BCTs is comparable (cf. Bonnardel et al., 2002). The novelty of the present study is that it adds to the understanding of gender differences *beyond use of the BCTs* in the pattern and variety of elaborate colour terms. Specifically, women offer more often *hyponyms of BCTs* (e.g. *pastel rose, vanilla*, *olive*) whereas men tend to use a combination of the BCTs (e.g. *blue-green*, *purplish blue*) or BCTs with modifiers (e.g. *dark purple, pale orange*, *vivid green*). Also, women *segment the colour space linguistically more densely*: e.g. an area named *orange* and *brown* by men is differentiated in women's naming into *orange*, *salmon*, *peach*, *salmon pink*, *beige* and *tan*.

In addition, the genders differ in the *repertoire* of the most frequent non-BCTs (see Figures 8 and 9). For instance, *magenta*, ranking 7 for men, does not figure among higher-ranking hyponyms for women who name this area of colour space by the "fancy" terms *fuchsia* and *hot pink*. Conversely, the blue-green area segregated by men into *turquoise*, *cyan* and *light blue* is named singularly *turquoise* by women.

Further work is still required to investigate gender differences in the *extended* colour vocabulary, as well as age- and vocation-dependent differences for each gender.

In the majority of the reviewed studies it is concluded that gender differences in colour naming have a "nurture" origin – due to different patterns of socialization that probably result in a greater awareness and more distinct internal representations of colour in women (Anyan and Quillan, 1971; Bimler et al., 2004; Greene and Gynther, 1995; Rich, 1977; Simpson and Tarrant, 1991; Swaringen et al., 1978; Yang, 2001). This conjecture is supported by the findings that men whose hobby or occupation (painters, designers, linguists, etc.) is associated with colour and/or language produce a larger number of colour terms comparable to that of women (Ryabina, 2009; Simpson and Tarrant, 1991).

The gender difference in speed of naming colours is suggested to reflect the speed advantage of females in identifying colour concepts (Shor, 1971) and in naming objects more generally (Saucier et al., 2002).

More recent studies offer an explanation that refers to the female “nature”. These differences are suggested to reflect genetic variation in the opponent system responses (Kuehni, 2001) or heterozygosity in X-chromosome allele genes coding for cone photopigments common among females (Rodríguez-Carmona et al, 2008).

Further, genetic differences were found with regards to dimorphisms of the X-chromosome genes that encode retinal long- (L) and middle- (M) wavelength photopigments (the inherited feature observed in ca. 15% of Caucasian women). Such dimorphism in females is considered to result in more refined colour perception and enhanced ability to discriminate colour differences along the red-green axis (Jameson, Highnote and Wasserman, 2001; Jordan, Deeb, Bosten and Mollon, 2010). This proposition is supported by the findings of Sayim et al. (2005, 457) who demonstrated that females with dimorphism of both L- and M-opsin genes exhibited significantly higher consensus in their judgements of colours or colour words compared with three other female genotypes (with no opsin gene diversity or with dimorphism of either L- or M-opsin gene).

The two explanations are not exclusive but complement each other in interpretation of the findings of this study. Future research will cast light on whether women present an advantageous colour-naming behaviour across cultures.

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