

# An online color naming experiment in Russian using Munsell color samples

Galina V. Paramei<sup>1</sup>  | Yulia A. Griber<sup>2</sup> | Dimitris Mylonas<sup>3</sup>

<sup>1</sup>Department of Psychology, Liverpool Hope University, Hope Park, Liverpool, L16 9JD, UK

<sup>2</sup>Department of Sociology and Philosophy, University of Smolensk, Przhevalskij Street, Smolensk 214000, Russia

<sup>3</sup>Department of Computer Science, University College London, Gower Street, London WC1E 6BT, UK

## Correspondence

Galina Paramei, Department of Psychology, Liverpool Hope University, Hope Park, Liverpool L16 9JD, UK.  
Email: parameg@hope.ac.uk

## Funding information

Russian Foundation for Basic Research, Grant/Award Number: 15-03-00733; Engineering and Physical Sciences Research Council (UK), Grant/Award Number: EP/M506448/1-1573073

## Abstract

Russian color naming was explored in a web-based experiment. The purpose was 3-fold: to examine (1) CIELAB coordinates of centroids for 12 Russian basic color terms (BCTs), including 2 Russian terms for “blue”, *sinij* “dark blue”, and *goluboj* “light blue”, and compare these with coordinates for the 11 English BCTs obtained in earlier studies; (2) frequent nonBCTs; and (3) gender differences in color naming. Native Russian speakers participated in the experiment using an unconstrained color-naming method. Each participant named 20 colors, selected from 600 colors densely sampling the Munsell Color Solid. Color names and response times of typing onset were registered. Several deviations between centroids of the Russian and English BCTs were found. The 2 “Russian blues”, as expected, divided the BLUE area along the lightness dimension; their centroids deviated from a centroid of English *blue*. Further minor departures were found between centroids of Russian and English counterparts of “brown” and “red”. The Russian color inventory confirmed the linguistic refinement of the PURPLE area, with high frequencies of nonBCTs. In addition, Russian speakers revealed elaborated naming strategies and use of a rich inventory of nonBCTs. Elicitation frequencies of the 12 BCTs were comparable for both genders; however, linguistic segmentation of color space, employing a synthetic observer, revealed gender differences in naming colors, with more refined naming of the “warm” colors from females. We conclude that, along with universal perceptual factors, that govern categorical partition of color space, Russian speakers’ color naming reflects language-specific factors, supporting the weak relativity hypothesis.

## KEYWORDS

centroids, CIELAB, color naming, color space, gender differences, linguistic segmentation, Russian, web-based experiment

## 1 | INTRODUCTION

According to its color, a visual stimulus is assigned to a certain color category. Identified by a linguistic label (in adult humans), language-specific concepts enable attention to be drawn to certain perceptual attributes of reality. Color names, like other groups of semantically related words, are systems in which one word’s position influences the positions of all

others.<sup>1–3</sup> The aim of this study was to explore Russian speakers’ color term inventory, color-naming strategies and linguistic segmentation of color space; an auxiliary aim was to assess gender differences. Data were collected in an online color naming experiment<sup>4</sup> previously undertaken with English speakers, with the purpose of relating outcomes for the 2 languages and delving deeper into the universal versus language-specific patterns of color naming.

.....  
This is an open access article under the terms of the Creative Commons Attribution License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.

© 2017 The Authors Color Research and Application Published by Wiley Periodicals, Inc.

## 1.1 | Basic color terms: Universalist versus (weak) relativity hypothesis

Berlin and Kay's<sup>5</sup> seminal work introduced the concept of universal basic color terms (BCTs). According to their hypothesis: (1) languages can contain up to 11 BCTs named in English *black, white, red, yellow, green, blue, purple, brown, orange, pink, and gray*; (2) across languages, basic color categories (BCCs) tend to cluster around certain privileged points in perceptual color space—category best examples, or focal colors; (3) BCTs consistently appear in a given language's color lexicon in a constrained order. In a later model, based on data from the World Color Survey, Kay and Maffi<sup>6</sup> elaborated (4) the evolutionary sequence of color category acquisition, while Kay and Regier<sup>7</sup> in their analysis of the World Color Survey data, concluded that (5) color category boundaries may vary between individual languages.

Within the universalist framework, it is conjectured that the relation between BCCs reflects a partition of color space as a form of meaningful information coding of the visible color gamut, a theoretical view put forward by Jameson and D'Andrade.<sup>8</sup> The development of the BCT inventory in a language is nonarbitrary; the lexical refinement implies adding new color categories that maximize color differences between already existing adjacent BCCs, while minimizing color differences within the emerging contiguous categories.

In contrast to the universalist view, the relativist stance holds that the factors governing categorization are particular to a person's culture. In addition, perception of the world is influenced by the semantic categories of a person's native language, and these categories vary across languages with few constraints—a conjecture known as the Sapir-Whorf hypothesis of linguistic relativity.<sup>9</sup>

In the color domain, currently the weak relativity hypothesis is broadly accepted, a reconciliation of the 2 above-mentioned positions, advocated, for example, by Roberson and associates.<sup>10</sup> According to it, boundaries and focal colors of BCCs can vary cross-linguistically, thus affecting color perception and cognition. The weak relativity hypothesis acknowledges that, in addition to universal perceptual factors that govern partition of colors into categories, linguistic, social, and pragmatic factors also drive cognitive processing of color (for reviews see refs. 11 and 12).

The weak relativity hypothesis accommodates a certain aspect of the Berlin-Kay hypothesis—the emergence of new BCCs, beyond the established 11, that are specific to a certain language. However, in addition to the Berlin-Kay partition hypothesis, it also embraces the alternative view, Levinson's<sup>13</sup> emergence hypothesis, whereby new color terms are added to convey hard-to-name colors that have become salient in a language/culture.

Indeed, in recent years, evidence has been accumulated on the emergence of BCTs beyond the 11 postulated by

Berlin and Kay, in particular, linguistic differentiation between light and dark blue in East Slavic and many circum-Mediterranean languages (for a review see ref. 14). Also recently, augmentation of the color inventory was demonstrated for modern British English, with *turquoise* and *lilac* considered as emerging BCTs.<sup>15</sup>

## 1.2 | Russian inventory of BCTs

In their work, Berlin and Kay<sup>1</sup> noted the possibility that Russian has 2 BCTs for “blue”, *goluboj* “light blue”, along with *sinij* “blue/dark blue”. In the following decades this exception to the universal inventory triggered abundant studies on the “Russian blues”<sup>3,16–19</sup> and, in general, on Russian color nomenclature.<sup>1,3,20–29</sup>

Several findings recurred from both linguistic and psycholinguistic studies:

- **BLUE area.** The 2 Russian terms for “blue” are both basic, with *goluboj* “light blue” being a 12th BCT, not a hyponym of *sinij* “dark blue”. Their rankings, between 4 and 6, are high and comparable—with regards to frequency of occurrence in corpus analyses<sup>22</sup> and, in an elicitation task, list frequency and mean list position<sup>16,18</sup>. Psycholinguistic studies further demonstrated that the denotative mappings of the 2 “blue” categories and focal colors are distinct, with *sinij*-naming predominating at low-lightness levels whereas *goluboj* is used for lighter colors<sup>2,17,23,30,31</sup> (for reviews see refs. 32 and 33). The 2 “Russian blues” also reveal a category boundary effect as measured by reaction times in an ABX discrimination task.<sup>19</sup>
- **PURPLE area.** Following Berlin and Kay's<sup>5</sup> work, it is agreed that Russian *fioletovij* most closely meets the criteria for the BCT for “purple”. However, the term has low status among the BCTs and a relatively high degree of inconsistent use<sup>34</sup> probably reflecting its recent entry into the Russian lexicon (18th century). Also, the denotative volume of *fioletovij* (literally translated “violet”) is rather constrained: along with it, the PURPLE area is denoted by several nonbasic highly frequent names. In particular, *sirenevij* “lilac” and *lilovij* “mauve” in a way “compete” for the PURPLE slot with other terms such as *malinovij* “raspberry”, *bordovij* “claret”, *višněvij* “cherry-colored”, and old terms (dating back to the 11th and 14th centuries) *bagrovij* “crimson”, *bagrānyj* “purplish-red”, and *purpurnyj* “cardinal red”.<sup>2,3,22–24,30,34,35</sup>
- **BROWN area.** The Russian BCT for “brown” is *koričnevij*.<sup>5</sup> It has a high ranking although lower than that of primary BCTs.<sup>16,18,36</sup> In spite of broad combinability with nouns, usage of *koričnevij* appears constrained predominantly to collocations with nouns for artifacts.<sup>27</sup> For natural objects, in comparison, its old counterpart *buryj* (‘dust

brown') is used.<sup>27</sup> A recent exception is *koričnevyy saxar* "brown sugar", food item that entered the Russian market more than 10 years ago: the imported status of this natural product probably invited *koričnevyy*, a BCT, as translation of the English *brown*. Notably, brown rice, another natural product newcomer to the Russian market, is translated as either *koričnevyy ris*, or *koričnevyy (buryj) ris*, or *buryj (koričnevyy) ris*. The interchangeable terms in the "brown rice" collocations, along with a bi-stable focal color for Russian *koričnevyy* category (see Figure 5 in reference<sup>28</sup>) likely reflect coexistence of the 2, new (strong) and old (weak), "brown" contenders.

### 1.3 | Gender differences in color naming

Gender differences in color lexicon have been demonstrated in numerous English-language studies (for recent reviews see refs. 37 and 38). Women possess a more extensive color vocabulary than men.<sup>39–43</sup> Also, in addition to BCTs, women use significantly more elaborate terms, BCT hyponyms such as *scarlet*, *chartreuse*, or *beige*; more BCT qualifiers related to hue and saturation,<sup>44</sup> and offer many more "fancy" color terms like *emerald green* or *cerise pink*.<sup>40,42,45</sup> In comparison, men tend to use predominantly BCTs accompanied by various modifiers, as well as compound names comprising BCTs.

The richer color vocabulary of females was also observed in some languages in Central Asia<sup>46</sup> and Caucasus,<sup>47</sup> in German,<sup>48</sup> Chinese,<sup>49</sup> Spanish,<sup>50</sup> and recently, in Estonian, Italian and Turkish.<sup>51</sup> To our knowledge, gender differences in Russian color nomenclature have not been explored.

In this study we investigate color naming of Russian speakers using data obtained from a web-based experiment employing an unconstrained color-naming method and a representative Munsell color sample. An outcome is compared with previously published data for English speakers. In addition to analysis of the whole dataset, we also examine differences in color naming between females and males.

## 2 | METHODS

### 2.1 | Interface of the web-based color-naming experiment

The experimental procedure consists of 6 steps (see Figure 1). First, observers are asked to adjust their display to RGB settings, and to adjust the brightness in order to make all 21 steps of a gray scale ramp visible. In the second step participants answer questions relating to the lighting conditions, their environment and display properties. Then, in the third step, participants are screened for possible color vision deficiencies with a web-based Dynamic Color Vision Test

developed at the City University London.<sup>52</sup> The fourth and main part is the unconstrained color-naming (UCN) task: any color descriptor, either a single word, or a compound, or term(s) with modifiers can be produced to describe each of 20 presented color samples. One color (chosen randomly from the sample) is presented twice to each participant, to assess consistency of the participant's responses. Along with the color name typed on a keyboard, response times (RTs) of onset of typing are recorded, defined as the interval between presentation of the color stimulus and the first keystroke. In the fifth step information about the participant's residency, nationality, language proficiency, educational level, age, gender, and color experience is collected. In the final step participants are provided with a summary of their responses and a "Communication Form" for comments.

### 2.2 | Color stimuli

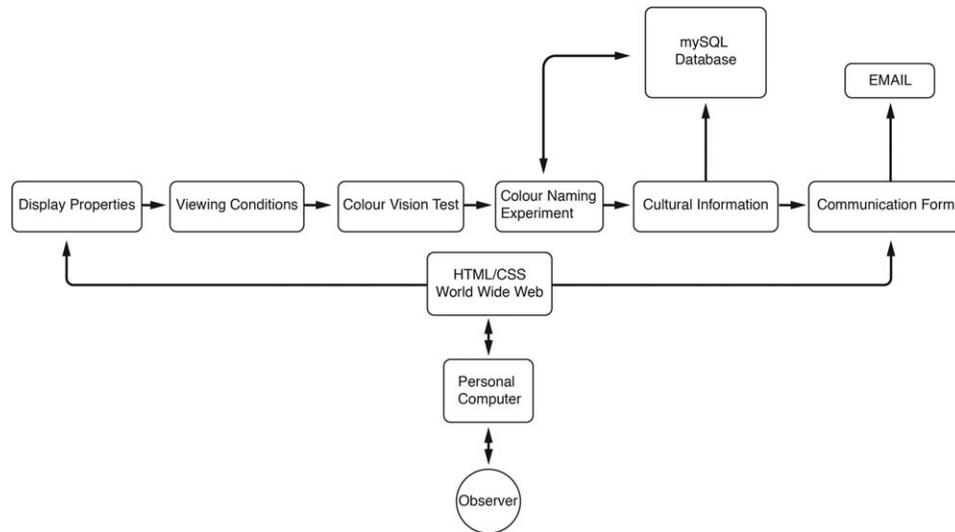
The color-naming experiment makes use of distributed psychophysics and each participant was presented with a sequence of 20 colors randomly selected from the total of 600 samples in the Munsell Renotation Dataset. Following the suggestions of Billmeyer (cited in reference 53), the 600 samples were chosen as an approximately uniformly distributed array from a variable number of hues at different Munsell Value and Chroma (see Figure 2). The color stimuli were specified in the sRGB color space and out of gamut colors were removed. The Munsell system used in the online experiment was designed with the objective of representing perceptually uniform Hue, Chroma, and Value spacing.<sup>54</sup>

The color stimulus size was  $147 \times 94$  pixels; it was presented against a neutral gray of  $L^* = 51$ . Across all observers, each color sample was presented on average 26.2 times ( $SD = 5.37$ ). Detailed specification of the experimental procedure and color stimuli can be found in reference.<sup>4</sup>

### 2.3 | Data analysis

The raw dataset included responses from 865 Russian speakers. However, for further analysis only responses were considered from residents of Russia with normal color vision (90.71%), aged 16 years or older, who entered their responses using the Cyrillic alphabet. We also excluded incomplete responses, vernacular acronyms, numerical terms and color terms written in the Cyrillic alphabet but non-Russian (eg, Ukrainian). This filtering resulted in a dataset for 713 respondents, 380 females and 333 males.

In the obtained lists, spelling errors were regularized: Words that were hyphenated, comma-separated, or contained parts in parentheses were treated as multiword color expressions. Different word orders were considered as different names. In the following Russian color terms are given in English transliteration; in English glosses we were

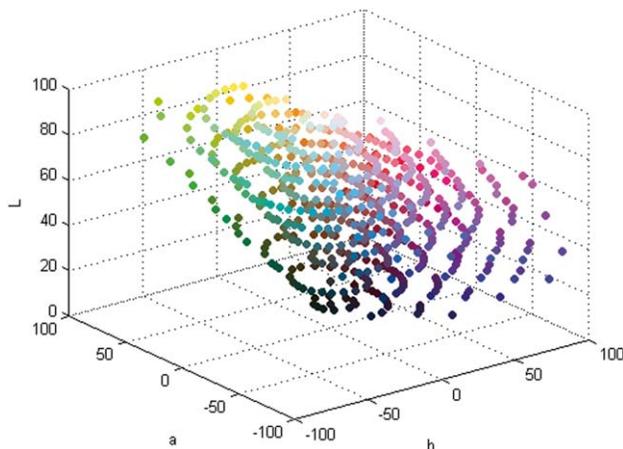


**FIGURE 1** Schematic diagram of the web-based color-naming experiment

guided by Frumkina and Mikhejev<sup>20</sup> and Davies and Corbett.<sup>18</sup>

In the following analysis we focused on 3 aspects: (1) centroids for 12 Russian BCTs compared with those for 11 English BCTs; (2) frequent Russian nonBCTs; (3) gender differences in Russian-speaking respondents. Centroids for each color category were calculated by averaging CIELAB co-ordinates of all color samples under the same name; these were obtained for the whole participant sample and gender-split samples. In addition, centroids for Russian BCTs were compared with English BCTs obtained in our previous study.<sup>38</sup>

Gender-split samples were assessed using several parameters: number of unique color descriptors; number of occurrences of BCTs and monolexic nonBCTs; consistency of color naming; RTs for BCTs and most frequent nonBCTs; lexical segmentation of color space synthetic image visualizing most frequently used color names.



**FIGURE 2** Color stimulus set (in CIELAB) used in the online experiment

## 3 | RESULTS

### 3.1 | Comparison of centroids for 12 Russian BCTs and 11 English BCTs

We compared location of centroids for 12 Russian BCTs estimated in this study with the centroids for 11 English BCTs obtained under controlled laboratory conditions<sup>53</sup> and in a web-based experiment,<sup>38</sup> the latter having employed the present set of color stimuli and design. Table 1 provides CIELAB coordinates of centroids for the 12 Russian BCTs and 11 English BCTs, along with color differences,  $\Delta E^*_{ab}$ , between centroid locations of the BCT counterparts in the 2 languages. The data are visualized in Figure 3, in projection on the CIELAB chromatic plane  $a^*b^*$  (Figure 3 top) and in 3D explicating centroid location along the lightness axis  $L^*$  (Figure 3 bottom).

Both Table 1 and Figure 3 indicate good correspondence between the 3 sets of data. Several discrepancies are noteworthy. These may originate from different sources, reflecting genuine cross-language differences or else differences in methodology, such as color presentation media, color-naming method or (non)uniformity of stimulus distribution in the sample gamut (pointed out by a reviewer).

- Centroids for the 2 “Russian blues” deviate from that of English *blue*, obtained both in the lab-based and web-based experiments. As expected (cf. references<sup>2,17,23,30–33</sup>), *goluboj* is lighter and *sinij* is darker than centroids for *blue* (Figure 3 bottom). In the web-based experiment, also with regards to hue, the centroid for *blue* takes an intermediate position between those for the 2 “Russian blues”, where *goluboj*-centroid is more “greenish” and *sinij*-centroid is more “reddish” (Figure 3 top). In comparison, the *blue*-centroid (of surface colors) in the lab-based experiment is more likely to be named *goluboj* by Russian speakers, as prompted by proximity of the 2 respective centroids.

**TABLE 1**  $L^*a^*b^*$  coordinates for the Russian (R) BCTs ( $n = 12$ ) and the English (E) BCTs ( $n = 11$ ) in the lab-based study (Sturges and Whitfield; S&W)<sup>53</sup> and web-based study (Mylonas et al.),<sup>55</sup> as well as color differences ( $\Delta E^*_{ab}$ ; CIELAB) between the location of centroids

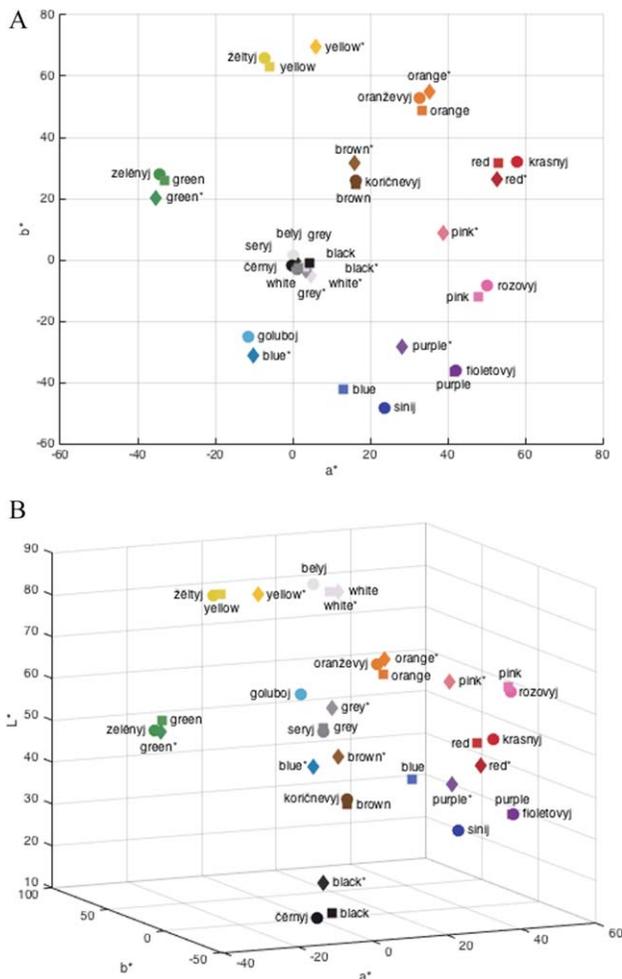
Russian				English				
Web-based [this study]				Lab-based [S&W]				
BCT	$L^*$	$a^*$	$b^*$	BCT	$L^*$	$a^*$	$b^*$	$\Delta E^*_{ab}$ R vs. E
<i>belyj</i>	89.83	0.18	1.51	<i>white</i>	88.35	4.68	-4.95	8.0
<i>černyj</i>	10.57	-0.21	-2.01	<i>black</i>	18.76	1.61	-1.66	8.4
<i>krasnyj</i>	45.49	57.79	32.21	<i>red</i>	40.28	52.62	26.48	9.3
<i>želtij</i>	81.01	-7.32	66.07	<i>yellow</i>	79.99	6.01	69.42	13.8
<i>zelėnyj</i>	54.76	-34.51	27.81	<i>green</i>	55.14	-35.25	20.11	7.7
<i>sinij</i>	34.48	23.67	-48.19	<i>blue</i>	50.24	-10.07	-31.15	40.9
<i>koričėnyj</i>	34.88	16.35	25.95	<i>brown</i>	44.55	15.97	31.64	11.2
<i>fioletovyj</i>	35.82	42.16	-36.11	<i>purple</i>	43.09	28.27	-28.37	17.5
<i>rozovyj</i>	61.73	50.12	-8.30	<i>pink</i>	63.09	38.89	8.98	20.7
<i>oranžėvyj</i>	63.02	32.86	52.91	<i>orange</i>	63.79	35.48	55.05	3.5
<i>seryj</i>	55.07	1.23	-3.00	<i>gray</i>	60.70	3.43	-3.62	6.1
<i>goluboj</i>	66.98	-11.38	-24.97	<i>blue</i>	50.24	-10.07	-31.15	17.9
Web-based [this study]				Web-based [Mylonas et al.]				
<i>belyj</i>	89.83	0.18	1.51	<i>white</i>	88.34	3.19	-2.39	5.15
<i>černyj</i>	10.57	-0.21	-2.01	<i>black</i>	11.15	4.36	-0.90	4.73
<i>krasnyj</i>	45.49	57.79	32.21	<i>red</i>	45.03	53.02	31.50	4.84
<i>želtij</i>	81.01	-7.32	66.07	<i>yellow</i>	81.55	-6.02	62.90	3.47
<i>zelėnyj</i>	54.76	-34.51	27.81	<i>green</i>	57.18	-33.01	25.96	3.40
<i>sinij</i>	34.48	23.67	-48.19	<i>blue</i>	46.77	13.15	-42.30	17.22
<i>koričėnyj</i>	34.88	16.35	25.95	<i>brown</i>	33.76	16.21	24.61	1.75
<i>fioletovyj</i>	35.82	42.16	-36.11	<i>purple</i>	35.99	41.75	-36.34	0.50
<i>rozovyj</i>	61.73	50.12	-8.30	<i>pink</i>	63.52	48.06	-12.05	4.63
<i>oranžėvyj</i>	63.02	32.86	52.91	<i>orange</i>	61.16	33.28	48.67	4.64
<i>seryj</i>	55.07	1.23	-3.00	<i>gray</i>	55.86	1.37	-2.59	0.90
<i>goluboj</i>	66.98	-11.38	-24.97	<i>blue</i>	46.77	13.15	-42.30	36.20

- Centroids of *yellow* and *želtij* obtained in the web-based experiment in English and Russian, respectively, are very close; both, however, are “greenish” deviating from *yellow* centroid obtained in reference 53 for surface colors, a discrepancy that might be due to differences in sampling of the GREEN and YELLOW areas by the 2 stimulus sets.
- Location of centroids for Russian and English counterparts of “red”, “purple”, “pink”, and “brown” obtained in the web-based experiments are similar. Note though that centroids for

“purple” and “pink” estimated in the web-based Russian and English studies are both “redder” and “bluer” than the counterpart English centroids in the lab-based study.<sup>53</sup>

### 3.2 | Centroids for 12 Russian BCTs: females versus males

Figure 4 indicates a very good correspondence between centroids for the 12 Russian BCTs for females and males. Table 2



**FIGURE 3** Location of centroids for the 12 Russian BCTs (filled circle) compared with centroids for the 11 English BCTs, lab-based (filled diamond) and web-based data (filled square)<sup>38</sup>;  $a^*b^*$  plane (top) and  $L^*a^*b^*$  presentation (bottom) in CIELAB

presents inter-gender differences for the Russian sample, assessed by a distance for each pair of the BCT centroids in 3D CIELAB ( $\Delta E^*_{ab}$ ). In addition, BCT centroids for the total Russian sample are related to those obtained in the web-based experiment for English speakers.<sup>55</sup> Note that centroids for *goluboj* and *sinij* were related to that for English *blue*. Inter-gender differences for the English sample are presented too.<sup>38</sup>

Mean centroid difference between Russian speakers of 2 genders,  $\Delta E^*_{ab} = 3.35$ , is small and lower than between English females and males,  $\Delta E^*_{ab} = 6.25$ <sup>38</sup> (Table 2). Among individual Russian BCTs, the highest inter-gender agreement was for *seryj* ( $\Delta E^*_{ab} = 0.68$ ) and *goluboj* ( $\Delta E^*_{ab} = 1.34$ ), whereas the lowest was for *sinij* ( $\Delta E^*_{ab} = 7.02$ ), *zelënyj* ( $\Delta E^*_{ab} = 6.12$ ) and *krasnyj* ( $\Delta E^*_{ab} = 5.45$ ).

### 3.3 | Number of words in color descriptors: total and gender-split samples

For the total sample of Russian respondents ( $n = 713$ ), the refined dataset consisted of 14,260 responses and contained

1422 unique color descriptors. The latter number is comparable to the 1226 obtained in the English-language web-based experiment.<sup>38</sup> Occurrence of color descriptors with varying word number was as follows: BCTs 39%; monolexic nonBCTs 25%; color terms with one modifier or double-compound terms 33%; color descriptors containing  $\geq 3$  words 3%. The corresponding numbers in the English naming experiment were 29%, 23%, 42%, and 6%, respectively.<sup>38</sup>

The Russian respondents' dataset was further analyzed with regards to gender differences in color naming. Females showed a richer color vocabulary with regards to the number of unique color descriptors,  $n_F = 934$  (66%), compared with males,  $n_M = 807$  (57%). Notably, males produced proportionally more BCTs (Figure 5); conversely, females offered more monolexic nonBCTs than males, in accordance with previous findings for English speakers.<sup>37,38,40,42,45</sup>

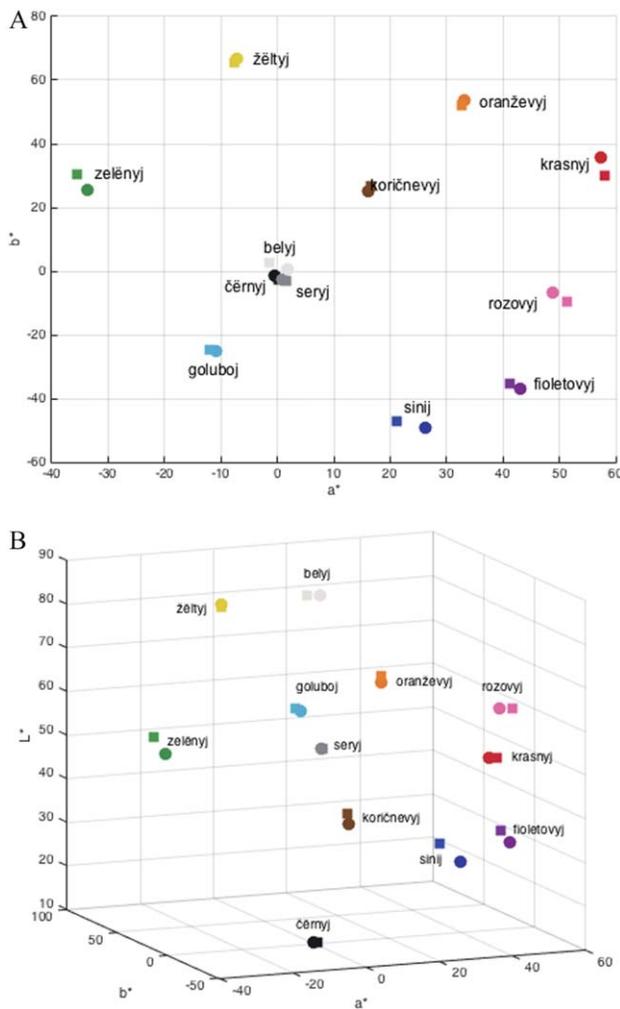
Russian speakers of both genders readily used compound (double or triple) color terms, such as *žëlto-zelënyj* “yellow-green” or *sinevato-fioletovyj* “bluish-purple”, as well as color terms specified by achromatic modifiers, such as *bledno-* “pale,” *svetlo-* “light,” *jarko-* “bright,” *tëmno-* “dark,” *tusklo-* “dull,” *nežno-* “tender” or *grâzno-* “dirty” (cf. references<sup>23,28</sup>). However, usage frequency of polylexemic color names in the Russian gender-split samples (F: 37%, M: 35%) is lower than in English gender-split samples (45% and 49%, respectively).

As prompted by Figure 5, lower proportion of polylexemic terms is complemented by higher proportion of monolexic (basic and nonbasic) terms offered by Russian respondents: 63% for females and 65% for males, compared with those for English, where the gender-split was 55% and 51%, respectively.

### 3.4 | Frequent Russian color names: females versus males

The first 10 most frequent color names are identical for Russian females and males, although the ranking order differed slightly (Figure 6). Along with 8 BCTs, these frequent names included 2 nonBCTs, *sirenevyyj* “lilac” and *birûzovyyj* “turquoise”, which occurred in the 7th and 9th positions for females and 10th and 9th, respectively, for males. The high ranking of *birûzovyyj* is similar to that of *turquoise* for UK speakers, 8th and 9th for females and males, respectively (reference 38, Figure 4) or its close counterpart *teal* for US speakers, 13th (reference 37, Figure 2). Note that responses to repeated color samples were excluded from the frequency analysis (see consistency analysis).

The repertoire of the other most frequent color names (ranks 11–26) demonstrates noticeable gender differences (Figure 6). *Krasnyj* “red” was significantly more frequent in men’s lexicon (rank 11) than in women’s (rank 26) ( $\chi^2 = 18.8$ ,  $P < .001$ ). Furthermore, 4 nonBCTs in women’s lexicon, *beževyyj* “beige” (rank 17), *persikovyyj* “peach” (rank 20), *bolotnyj* “marsh-colored” (rank 21), and *svetlo-fioletovyyj*



**FIGURE 4** Location of centroids for the 12 Russian BCTs for females (filled circle) and males (filled square);  $a^*b^*$  plane (top) and  $L^*a^*b^*$  (bottom) in CIELAB

“light purple” (rank 24), were not among the most frequent terms used by men. Conversely, 4 terms, *purpurnyj* “cardinal red”, *svetlo-koričnevyy* “light brown”, *bledno-rozovyy* “pale pink”, *tëmno-rozovyy* “dark pink”, were high in frequency for men (ranks 20, 22, 25, and 26, respectively), but did not occur among women’s frequent names.

It is also worth noting that the list of 26 most frequent color terms offered by Russian speakers includes several terms with achromatic modifiers *svetlo-* “light”, *tëmno-* “dark”, or *bledno-* “pale”. The number of such compounds (F: 6, M: 8) is higher compared with *light-* or *dark-*modified frequent terms of English speakers (F: 4, M: 5) used in combination with *blue*, *green*, or *purple* (reference 38, Figure 4).

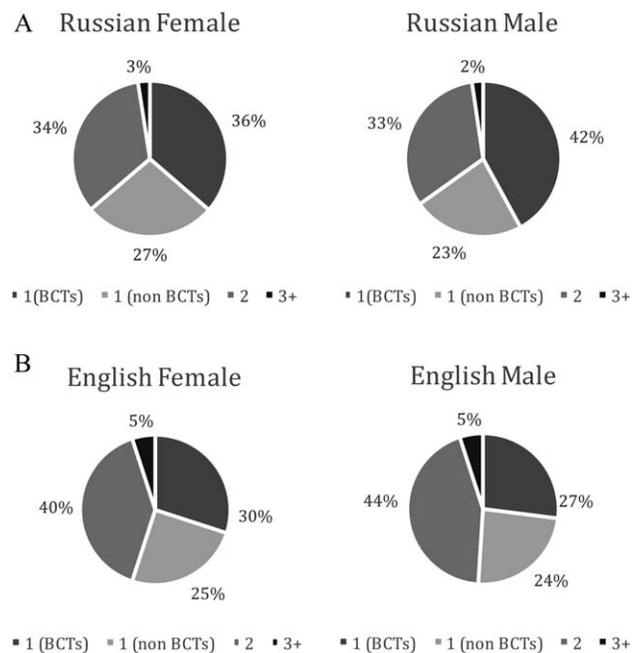
### 3.5 | Occurrence of the 12 Russian BCTs: females versus males

Regardless of the absence of any color-naming constraints, unmodified basic terms were produced very often. Overall

**TABLE 2** Mean color differences ( $\Delta E^*_{ab}$ ; 3D CIELAB) between location of centroids for the 12 Russian (R) BCTs and 11 English (E) BCTs,<sup>55</sup> for the total samples and the corresponding gender-split samples

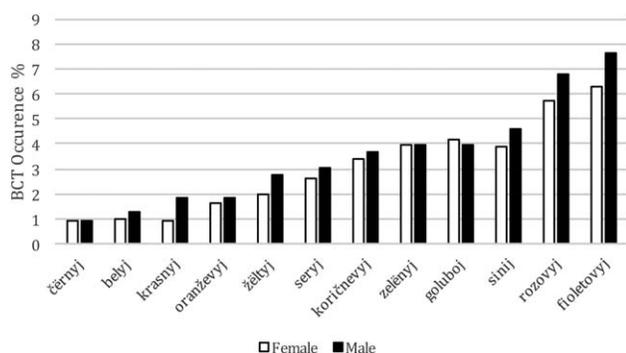
BCT	R vs. E	E <sub>F</sub> vs. E <sub>M</sub>	R <sub>F</sub> vs. R <sub>M</sub>
<i>belyj</i> —white	5.15	6.93	3.81
<i>černyj</i> —black	4.73	2.29	1.44
<i>krasnij</i> —red	4.84	20.56	5.45
<i>želtij</i> —yellow	3.47	4.99	1.58
<i>zelenij</i> —green	3.40	3.70	6.12
<i>sinij</i> —blue	17.22	7.82	7.02
<i>koričnevij</i> —brown	1.75	4.71	2.97
<i>fioletovij</i> —purple	0.50	2.14	3.68
<i>rozovij</i> —pink	4.63	6.21	3.92
<i>oranževij</i> —orange	4.64	7.29	2.15
<i>seryj</i> —gray	0.90	2.17	0.68
<i>goluboj</i> —blue	36.20	...	1.34
<b>Mean 11 BCTs</b>	4.66	6.25	3.53
<b>Mean 12 BCTs</b>	7.29	...	3.35

the frequency of occurrence of the 12 BCTs was significantly greater for men than for women (see Figure 7):  $n_M = 2658$  (42%) versus  $n_F = 2615$  (36%) ( $\chi^2 = 47.5$ ,  $P < .001$ ; Yates’s



**FIGURE 5** Percentage of color descriptors with varying number of words in responses of Russian females and males (top) compared with gender-split responses of English speakers (bottom).<sup>38</sup>





**FIGURE 7** Percentage of occurrence of the 12 Russian BCTs for females and males. The BCTs are ordered according to the combined frequency of female and male responses, from lowest (left) to highest (right)

color space, as shown in previous studies for English.<sup>4,37,43,53,57</sup> However, beyond topology, a language-specific factor seems to play a role: Russian naming of the GREEN category is elaborated by frequent use of *zelěnyj*-compounds (BB), LMB terms and descriptors containing frequent nonBCTs from this category<sup>23,28</sup> (eg, *salatovo-zelěnyj* “lettuce-colored green”, *bolotnyj-zelěnyj* “marsh-colored green”) or alluding to a familiar green shade (eg, *svetoformo-zelěnyj* “traffic-lights green”, *travânoj zelěnyj* “grass green”).

Similar types of elaborated color names are also observed in descriptors containing *fioletovij* “purple”: these include highly frequent Russian nonBCTs denoting the PURPLE category addressed in the next section (eg,

*sirenevo-fioletovij* “lilac purple”, *bordovo-fioletovij* “claret purple”) and adjectives with references to colors of certain objects (eg, *těmno-fioletovij baklažanovij* “dark purple aubergine”). Two other BCTs with rich derivational productivity are *sinij* “dark blue” (F: 261, M: 268) and *goluboj* “light blue” (F: 259, M: 178), evidencing Russian speakers’ categorical—and linguistic—refinement of the BLUE area.<sup>2,3,20</sup>

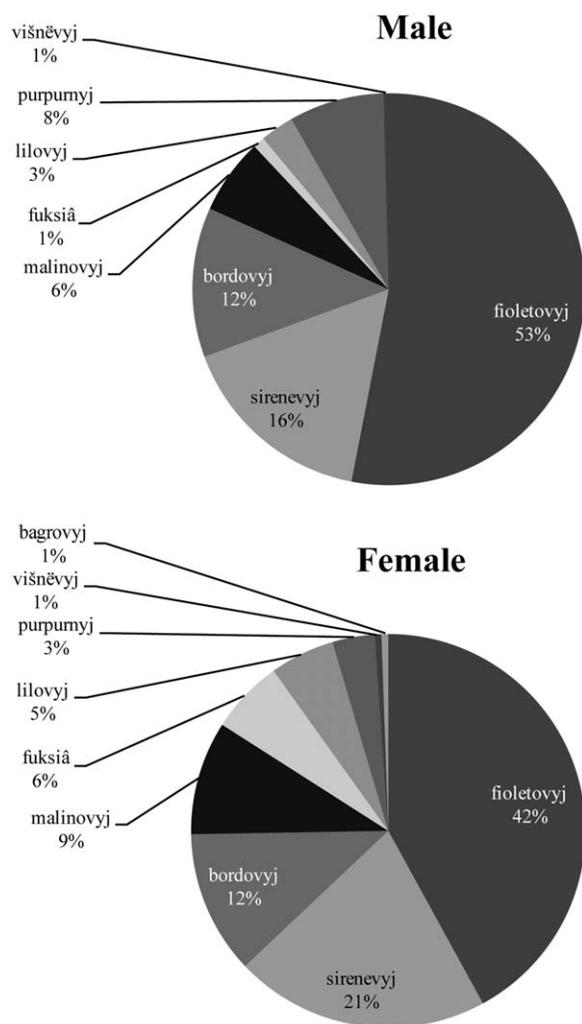
### 3.6 | Russian “purple” terms

As mentioned in the Introduction, the PURPLE area in Russian is denoted by multiple nonbasic terms.<sup>2,3,22,23,28</sup> To further explore this, we compared percentages of occurrence of the ten most frequent “purple” monolexic color names, in females and males (Figure 8). The ranks of these terms, based on frequency of occurrence, are presented in Table 4.

Note that, along with nonbasic “purple” terms reported pre1990s—*sirenevij*, *bordovij*, *malinovij*, *lilovij*, and *višnevij*—the modern Russian inventory has expanded to include *fuksiâ* “fuchsia” (with relatively high rank 30 for females) and *madženta* “magenta”, while 3 “classic” terms diminished, when one compares respective rankings obtained by Davies and Corbett<sup>18</sup> and in this study: *purpurnij* “cardinal red” (rank 20 → 47 for females); *višnevij* “cherry-colored” (rank 24.5 → 115 for females, 140 for males); *bagrovij* “crimson” (rank 54.5 → 136).

**TABLE 3** Derivational productivity of the 12 Russian BCTs, for females and males

Russian BCTs	Females		Males	
	Total number of unique polylexemic descriptors	Frequency of occurrence of polylexemic descriptors	Total number of unique polylexemic descriptors	Frequency of occurrence of polylexemic descriptors
<i>belyj</i>	30	35	23	31
<i>čěrnij</i>	14	17	13	15
<i>krasnij</i>	33	76	38	133
<i>žěltij</i>	48	160	43	146
<i>zelěnij</i>	88	396	80	397
<i>sinij</i>	65	261	54	268
<i>koričnevij</i>	53	172	37	162
<i>fioletovij</i>	61	314	55	313
<i>rozovij</i>	93	436	64	332
<i>oranževyj</i>	33	87	25	58
<i>seryj</i>	46	241	49	202
<i>goluboj</i>	64	259	42	178



**FIGURE 8** Percentage of occurrence of most frequent Russian color names for the PURPLE area elicited in females (top) and males (bottom)

### 3.7 | “Color of X” terms in modern Russian

Following the suggestion that new color terms are derived from names of color objects and enter the language gradually, initially conforming to the pattern *cveta X* “color of X”,<sup>27</sup> we explored the dataset from this perspective. For both genders, a very frequent and entrenched object-derived Russian term is *cvet morskoy volny* “color of sea wave”, a close synonym of *birûzovyyj* “turquoise” (cf. reference2).

Women used the pattern “color of X” in 23 different combinations (50 cases) to denote fuchsia (*cvet fuksiâ*), khaki (*cvet khaki*), asphalt (*cvet asfal'ta*), ripe cherry (*cvet speloj višni*), among others, along with emotionally-laden, ‘poetic’ terms, alluding, for example, to the color of a murky sky (*cvet pasmurnogo neba*), a light blue wave (*cvet goluboj volny*), fresh grass (*cvet svežej travy*), juicy green (*cvet sočnoj zeleni*), so forth.

The pattern “color of X” was used by men in 25 different combinations (36 cases); among these relatively frequent were those denoting skin color (*cvet koži*), dry grass (*cvet*

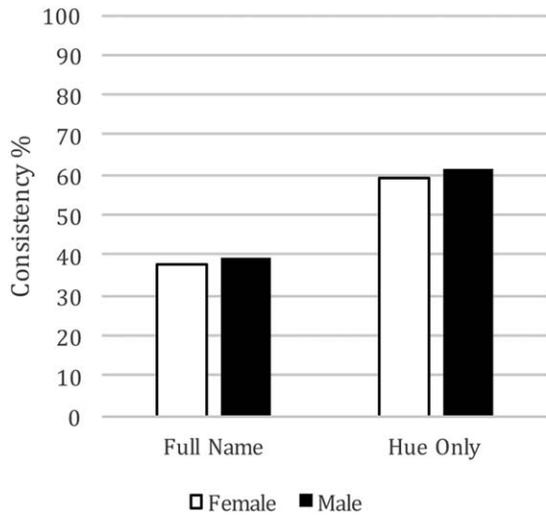
*suxoj travy*), graphite (*cvet grafita*), loam (*cvet suglinka*), mint (*cvet mâty*), sea water (*cvet morskoy vody*), green cabbage (*cvet zelënoj kapusty*), or manganese crystals (*cvet margancovki*) and the brilliant green (*cvet zelënki*) (the 2 latter are widely used by Russians as natural pharmaceutical products). Significantly less frequent were idiosyncratic or exotic compounds, such as water (*cvet vody*), radish (*cvet rediski*), night sky (*cvet nočnogo neba*), dark conifer forest (*cvet tëmno-khvojnogo lesa*), sea salt water (*cvet morskoy solënoj vody*), Uruguay pampas (*cvet urugvajskix pampasov*), fox hair in books (*cvet lis'ej šersti v knigax*), so forth.

### 3.8 | Consistency of color descriptors: females versus males

As indicated in the “Methods” section, for each participant 1 randomly selected color sample was presented twice to measure response consistency. Since color naming was unconstrained, 2 measures of consistency were calculated (cf. reference 57). Specifically, we estimated fully consistent use of color names (Figure 9, left). In addition, we distinguished between instances when an observer used 2 noncognate names for the color in question (eg, *zelëno-želtij* “green-yellow” versus *gorčičnyj* “mustard-colored”) and those when different color names were used but these contained a common hue component (eg, *krasnyj* “red” vs. *tëmno-krasnyj* “dark red”). For an extended analysis the latter names were considered as consistent (Figure 9, right). In this study men appeared to be slightly more consistent in their responses but the difference was nonsignificant ( $\chi^2 = 0.06$ ,  $P = .81$ , using Yate’s correction). This tendency is at odds with previous studies<sup>38,39,42,58</sup> for English speakers that showed women’s higher naming consistency and may be explained by more frequent use of nonbasic and “fancy” terms or polylexemic descriptors by females.

**TABLE 4** Ranks of frequent Russian color terms used for naming the PURPLE area

Russian term	Gloss	Females	Males
<i>fiioletovyj</i>	purple	1	1
<i>sirenevyyj</i>	lilac	7	10
<i>bordovyyj</i>	claret	13	14
<i>malinovyyj</i>	raspberry	14	24
<i>lilovyyj</i>	mauve	27	39
<i>fuksiâ</i>	fuchsia	30	90
<i>purpurnyyj</i>	cardinal red	47	20
<i>višnevyyj</i>	cherry-colored	115	140
<i>bagrovyyj</i>	crimson	136	136
<i>madženta</i>	magenta	174	491



**FIGURE 9** Consistency of responses to repeated color samples for females and males

### 3.9 | RTs for the Russian BCTs and frequent nonBCTs: females versus males

RTs for 25 most frequent Russian color names, separately for each gender, are shown in Figure 10. It demonstrates that RTs were shorter for almost all BCTs compared with nonBCTs (with an exception of nonbasic *alyj* “scarlet”). A Mann-Whitney *U* test indicated that, across color names, RTs (estimated by medians and semi-interquartile ranges, sIQR) did not differ significantly between females (Med = 6.04, sIQR = 1.82) and males (Med = 6.08, sIQR = 2.26),  $U = 895, P = .77$ .

### 3.10 | Synthetic image: color naming segmentation by females versus males

To visualize gender differences in Russian color naming, a probabilistic algorithm based on Maximum a Posteriori (MAP) was used.<sup>55</sup> For each color name  $y$  from a set of Russian color names  $y_1 \dots y_T$  offered by males and females in our experiment more than 20 times, we calculated the

empirical mean  $\mu_y$  and variance-covariance matrix  $\Sigma_y$  of test colors  $x_1, \dots, x_n$ . We could then estimate the probability density function by:

$$\hat{f}_{\text{norm}}(x|y) = \text{const}_y \exp\left(-\frac{1}{2}(x-\mu_y)^T \Sigma_y^{-1}(x-\mu_y)\right), \quad (1)$$

$$x \in \{x_1, \dots, x_n\}$$

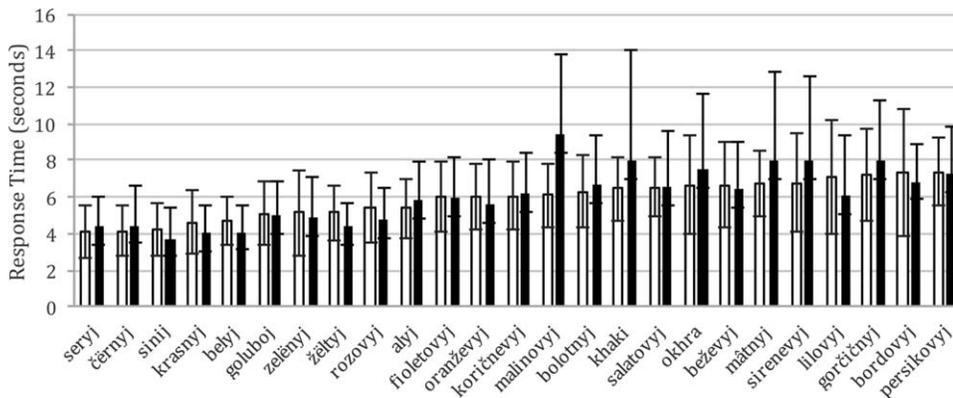
where  $x$  is the test color specified by the triplet  $x = (x_{(L)}, x_{(a)}, x_{(b)})^T$  and  $\text{const}_y$  is a normalizing factor that depends on  $\mu_y, \Sigma_y$  and  $x_1, \dots, x_n$  and ensures that the sum of the probability distribution is equal to 1. Using Bayes’ theorem, the MAP estimator can then be defined as:

$$\hat{y}_{\text{MAP}}(x) = \arg \max_{y \in \{y_1, \dots, y_T\}} \left( \frac{\hat{f}_{\text{norm}}(x|y) \cdot \hat{f}(y)}{P(X=x)} \right) \quad (2)$$

MAP favors color names with high probability  $\hat{f}(y)$  or high normalization factor  $\text{const}_y$  to maintain congruence between the observed and predicted data. This means that  $\mu_y$  is not necessarily equal to the mean of  $\hat{f}_{\text{norm}}(x|y)$  and frequent and consistent color categories tend to subsume less common or inconsistent neighboring categories.

The algorithm was trained separately by the Russian female and male datasets to segment a synthetic image constructed as a diagonal slice through CIELAB<sup>59</sup> to include the most saturated regions of color space, as shown in Figure 11. Coordinates of the centroids of the most frequent descriptors were used to color each name category in the synthetic images for females and males.

The model predicted that females would use a richer color vocabulary to classify the synthetic image than males. As illustrated in Figure 11, female linguistic segmentation (middle) is more refined, particularly, in the upper half of color space, compared with that of males (right). Figure 12 provides the full list of the segmented categories, 27 for females and 19 for males. Figure 11 visualizes sufficiently large segments (19 for females; middle; 15 for males; right).



**FIGURE 10** Median RTs for most frequent Russian color names for females (white) and males (black) ordered by median RTs for females. Bars indicate sIQRs



**FIGURE 11** Left: Synthetic image of color space.<sup>55</sup> Segmentation of synthetic image for Russian speakers: Middle, Females; Right, Males

As indicated by the list of the segmented categories (Figure 12), inter-gender linguistic-density differences are mainly along the red-green axis of color space. Specifically, females tended to lexically differentiate predominantly “warm” colors: they single out “hot” pink (*jarko-rozovyy* “bright pink”) and use frequent nonbasic terms, referring to colors of natural objects (*malinovyj* “raspberry”, *persikovyj* “peach”, *gorčičnyj* “mustard-colored”, *fuksiâ* “fuchsia”) or substance (*pesočnyj* “sand-colored”). In comparison, men revealed refined denotation of “military” colors (*khaki* “khaki”, *sero-zelënyj* “gray-green”, *grâzno-žëltyj* “dirty yellow”).

## 4 | DISCUSSION

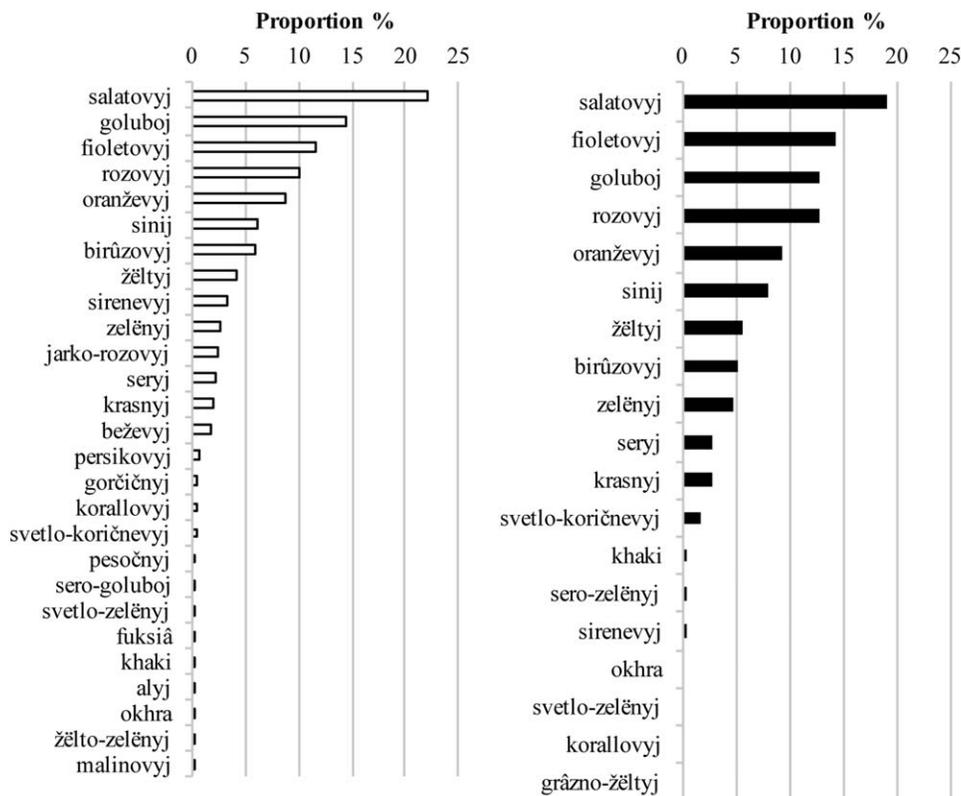
The present outcome for Russian color naming in the online experiment provided satisfactory agreement when validated

against earlier lab-based and web-based experiments for English speakers.<sup>38,53</sup>

### 4.1 | Russian versus English color names: cross-language differences

#### 4.1.1 | Basic color terms

Several departures of centroids for the Russian and English BCT counterparts were found. An inspection of the 3D CIE-LAB plot (Figure 3, bottom) shows that, in accord with previous findings, Russian *goluboj* and *sinij* are lighter and darker, respectively, than English *blue*.<sup>23,24,31,32</sup> Also, centroids for *sinij* and *goluboj* are separated along the 2 chromatic dimensions (cf. reference 28). In particular, as is obvious in the *a\*b\** projection (Figure 3, top), in hue Russian *goluboj* is



**FIGURE 12** Most frequent Russian color names lexicalizing areas in the color space synthetic image, for females (left) and males (right)

closer to English *blue* and is “greener” than *sinij*. Conversely, the centroid of *sinij* is closer to the centroid of *purple* and is “redder”. Similar clustering of Russian *fioletovij* and *sinij* was recently shown based on analysis of listing task data.<sup>51</sup>

The centroid for *fioletovij* is very close to that for English *purple*, thus empirically confirming that Berlin and Kay’s nomination of *fioletovij* as the Russian counterpart of the latter was correct. It also appears that Russian *krasnyj* is lighter and more vivid than English *red*.

Both web-based studies, in Russian and English, indicate that the centroids for “yellow” are “greener” and lighter compared with that in the lab-based study of Sturges and Whitfield,<sup>53</sup> a discrepancy that might be due to differences in sampling the GREEN and YELLOW areas by the corresponding stimulus sets. Thus, we cannot exclude that some of the delineated discrepancies are manifestations of differences in methodology rather than of genuine cross-language effects.

### Color presentation media

In this study, as in the English-naming web-based experiment,<sup>55</sup> self-luminous monitor colors were employed, compared with surface colors, the gloss Munsell samples used by Sturges and Whitfield.<sup>53</sup> Note that color naming is impacted by the presentation media: as demonstrated by Hedrich and Bloj,<sup>60</sup> the naming agreement between the 2 presentation media varies between 65% and 82%; the reason for the discrepancy supposedly depends on the illuminant of surface colors implying differences in stimulus spectral composition.

### Variation of the color-naming method

In the present study, the UCN was employed, allowing polylexemic color descriptors, unlike monolexic naming (MN) in the Sturges and Whitfield<sup>53</sup> study. In an earlier study<sup>61,62</sup> that compared the 2 method variations, while employing the same stimulus set and participants, the UCN was shown to result in greater naming refinement and precision. Notably, polylexemic terms, with modifiers, compounds or object glosses, were predominantly used to denote hard-to-name colors, that is, less saturated colors in the “inner core” of color space and colors straddling BCT boundaries. Consequently, color space areas denoted by BCTs become more circumscribed and include only “better”, saturated examples of the category, and BCT centroids (category “centers of gravity”) are expected to be shifted to areas of saturated colors, closer to the gamut perimeter.

## 4.2 | Richness of Russian nonBCTs

Russian color inventory is rich in frequently used secondary color terms, as evidenced in linguistic<sup>16,20,25–27,30</sup> and psycholinguistic studies.<sup>2,23,25,26,28</sup> Among these are terms such as the high frequency *salatovij* “lettuce-colored”, *birúzovij*

“turquoise”, *cvet morskoy volny* “sea wave color” and *kirpičnyj* “brick-colored” (see Table 2 in reference<sup>28</sup>).

Notably, the most frequent nonbasic terms *sirenevij* “lilac” and *birúzovij* “turquoise”, revealed in this study for Russian speakers, have equally high cognitive salience in color vocabularies of both genders, which is similar to findings on counterparts of these nonbasic terms in English<sup>53,63</sup> and German.<sup>64</sup> Mylonas and MacDonald,<sup>15</sup> who reported a composite index of basicness for 30 most frequent English monolexic color terms, suggest an extension of the English color inventory from the 11 BCTs to 13, augmented by *lilac* and *turquoise*.

Uusküla and Bimler,<sup>51</sup> who reconstructed clusters of most frequent color terms according to their cognitive salience, found a recurring dichotomy in the way the glosses for “lilac” and “turquoise” are conceptualized in 14 European languages, including Russian. In particular, it was found that, with regards to its cognitive salience, Russian *birúzovij* clusters with the 2 most frequent “purple” nonBCT, *sirenevij* “lilac” and *lilovij* “mauve”. In other languages, in comparison, glosses for “turquoise” belong to a cluster of either “blues” (eg, in Estonian or Hungarian) or “greens” (eg, in Italian); their cognitive salience is lower and comparable to that of “beige”, “gray”, or terms denoting metallic sheen (Turkish, Spanish, Swedish, Finnish, Czech).

The high salience of nonbasic *sirenevij* is suggested to be a consequence of the existence of the 2 Russian BCTs for “blue” complemented by 2 “purple” terms: while *fioletovij* “purple” designates the intersection of *sinij* “dark blue” with red, the intersection of *goluboj* “light blue” with red is lexicalized by *sirenevij*.<sup>3,24</sup>

## 4.3 | Differences in the naming strategies between Russian and English speakers

Russian speakers have a higher frequency of single-word color-term usage than English speakers. The latter use much more frequently modifiers and compounds of both BCTs and nonbasic monolexic terms. This can be indicative of differences in naming strategies between Russian and English in the use of polylexemic names.

This finding of Russian speakers relying more frequently on MN is surprising and counterintuitive in view of the findings of Vasilevich,<sup>21</sup> Rakhilina,<sup>25</sup> Kul’pina<sup>65,66</sup> and, also, more recent findings that demonstrate color-naming expressive complexity in modern Russian language (cf. references<sup>67–71</sup>). Richness and linguistic elaboration in color naming by Russian speakers is also confirmed by our response set, containing numerous complex and expressive names, such as *cvet osennej travy* “color of autumn grass” or *asfalt na zakate* “asphalt color at sunset”.

The frequent use of monolexic CTs found in the present experiment may disguise the fact that these can serve to

communicate denotative meaning with great specificity due to two factors. First, Russian possesses a great variety of (non)BCTs to denote color space subareas that in English require a compound term (eg, *goluboj* vs. *light blue*; *vasil'kovyj* vs. *cornflower blue*; *salatovyj* vs. *lettuce-colored*; *gorčičnyj* vs. *mustard-colored*; *brusničnyj* vs. *cowberry-colored*, etc.). The great variety of Russian monolexemic nonBCTs are adjectival derivatives of object glosses. Although in English a new color term (adjective) emerges as an equivalent of the “parent” object, without any change in the grammar form (eg, *coral*), in Russian several adjectival forms are derived from the noun of the “parent” object (eg, *korall* “coral” → *korallovyj*; *baklažan* “aubergine” → *baklažannyj* or *baklažanovyj*,<sup>68</sup> p. 59).

Second, monolexemic color names, along with other Russian adjectives, can be modified by various diminutive or expressive suffixes (*-at-*, *-en'k-*), which enables the conveyance of specific nuances of the CT meaning (eg, *krasnyj* “red” vs. *krasnovatyj* “reddish”; *oranževyj* “orange” vs. *oranževen'kij* “~joyful, nonprominent [of extent] orange”) (cf. references<sup>65,67–69</sup>).

#### 4.4 | Female versus male color naming in Russian

Analysis of gender differences in the outcome of the present color-naming experiment in Russian confirmed the findings of previous offline studies of English speakers that women exceed men in the richness of their color lexicon<sup>37,38,40–42,45,72–75</sup>; however, we found no evidence that women exceed men in regard to color-naming speed.<sup>76–78</sup> Despite naming having been unconstrained, unmodified BCTs were produced often by females and males alike and were used more consistently and named faster than other terms.

Mean centroid difference between Russian speakers of 2 genders is lower than the difference between centroids for English females and males. The higher value in the latter case might have resulted from methodological aspects of Mylonas et al.'s study,<sup>38</sup> viz. lower numbers of participants (F: 159, M: 133) and/or denotative variation of BCT concepts among speakers of English across the world (UK, USA, Australia, Canada, etc.), whose data were pooled for the analysis. Alternatively, the smaller inter-gender difference obtained here may reflect genuinely higher consensus among Russian speakers due to a culturally entrenched color-naming strategy.

The genders do differ, however, in the the pattern and variety of elaborated color terms. Specifically, men demonstrated a higher percentage of occurrence of BCTs, whereas women used more often monolexemic nonBCTs (eg, *beževyj* “beige”, *persikovyj* “peach”). Investigation of the PURPLE area in this study reveals different mapping structure of this

area by men and women: whereas men often use BCT *fiol'etovyj* “purple”, women prefer monolexemic nonBCTs, such as *sirenevyyj* “lilac” or *fuksiâ* “fuchsia”.

Females' frequent color terms, revealed by segmentation of the color space synthetic image, are descriptive and derived from object glosses—names of domesticated or wild plants (such as *malinovyyj* “raspberry”, *persikovyj* “peach”, *fuksiâ* “fuchsia”), food (*gorčičnyj* “mustard-colored”) or natural materials (*pesočnyj* “sand-colored”, *korallovyj* “coral”). The tendency for women to use significantly more descriptive than abstract color terms was also previously observed in Russian<sup>46,47</sup> and German.<sup>48</sup> Notably, among Russian descriptive color terms those designating the “warm” part of the spectrum dominate.<sup>21,23,25,28</sup> This is also in accord with observations on color vocabularies in English,<sup>4</sup> Hungarian,<sup>79</sup> and Italian.<sup>80</sup>

To a great extent gender differences in color naming are considered to have social and cultural origins: due to predominant upbringing patterns, women develop a greater awareness of color, reflected by its elaborated linguistic representation, and a finer appreciation of differences between colors.<sup>28,47</sup> The similarity of inter-gender differences in color lexicon of Russian speakers (this study) and English speakers<sup>37–45,73–75</sup> may, though, reflect both “nurture”, that is, gender-specific patterns of socialization, similar in modern Russian society and the Anglo-Saxon world, and the “nature” origin of the phenomenon, that is, genetically determined inter-gender differences in the visual system (summarized in reference38).

#### 4.5 | Ongoing changes in color term usage in modern Russian

The Russian National Corpus ([www.ruscorpora.ru](http://www.ruscorpora.ru); 18th to 21st centuries) records the ongoing emergence of new color terms in the Russian color lexicon and increase of use of previously infrequent terms. Among color descriptors offered in the present experiment, terms that are relatively new in the Russian color vocabulary are not infrequent, such as *lajm* “lime”, *fuksiâ* “fuchsia”, *madženta* “magenta”, *lavandovyyj* “lavender”, etc. Another observed tendency, especially in youth lexicon, is shortening of existing adjectival color terms to their noun stems, the phenomenon predominantly relating to adjectives derived from objects (eg, *nebesnyj* → *nebo*, *šokoladnyj* → *šokolad* “chocolate-colored” or *baklažanovyj* → *baklažan* “aubergine-colored”, etc.), that is, the method of derivation typical in English. These changes appear to have emerged or accelerated after 1991, that is, in the post-Soviet era, and result from the significantly intensified trade/market contacts with English-speaking partners, accompanied by a great influx of western products, whose advertisements often include English color names transliterated into Russian.<sup>21,71,81</sup>

Further work and additional analysis is required to investigate Russian nonbasic terms denoting colors straddling the boundaries between BLUE and GREEN or PURPLE and RED areas of color space—the regions demonstrated to be much more linguistically refined in Russian compared with other languages, with the potential for further emerging BCTs.

## ACKNOWLEDGMENTS

Y.G. was supported by the Grant 15-03-00733 of the Russian Foundation for Basic Research. D.M. was supported by the Doctoral Training Grant EP/M506448/1–1573073 from the Engineering and Physical Sciences Research Council (UK). The authors are grateful to 2 anonymous reviewers whose detailed and constructive comments to an earlier version of the manuscript were helpful for improving the article. We also thank Ricky Morton and David Bimler for proofreading the article.

## ORCID

Galina V. Paramei  <http://orcid.org/0000-0003-2611-253X>

## REFERENCES

- [1] Vasilevich AP. Psixolingvističeskij podxod k ustanovleniju leksičeskix sootvetstvij (na materiale bolgarskix, russkix i anglijskix cvetonaimenovanij) [A psycholinguistic approach to estimation of lexical equivalents (on material of Bulgarian, Russian, and English color terms)]. *Sapostavitelno Jezykosnanie (Sofia)*. 1983; 8:5–17 (in Russian).
- [2] Frumkina RM. *Cvet, Smysl, Sxodstvo. Aspekty Psixolingvističeskogo Analiza [Color, Meaning, and Similarity: Aspects of Psycholinguistic Analysis]*. Moscow: Nauka; 1984 (in Russian).
- [3] Moss A. Russian blues and purples: A tentative hypothesis. *Quinquaireme*. 1988;11:164–177.
- [4] Mylonas D, MacDonald L. Online colour naming experiment using Munsell colour samples. In: *Proceedings of the 5th European Conference on Colour in Graphics, Imaging, and Vision (CGIV)*. Joensuu, Finland: IS&T, Springfield; 2010:27–32.
- [5] Berlin B, Kay P. *Basic Color Terms: Their Universality and Evolution*. Berkeley and Los Angeles, CA: University of California Press; 1969/1991.
- [6] Kay P, Maffi L. Color appearance and the emergence and evolution of basic color lexicons. *Am Anthropol*. 1999;101:743–760.
- [7] Kay P, Regier T. Resolving the question of color naming universals. *Proc Natl Acad Sci USA*. 2003;100:9085–9089.
- [8] Jameson KA, D'andrade RG. It's not really red, green, yellow, blue: an inquiry into cognitive color space. In: Hardin CL, Maffi L, eds., *Color Categories in Thought and Language*. Cambridge, UK: Cambridge University Press; 1997:295–318.
- [9] Saunders BAC, van Brakel J. Are there non-trivial constraints on colour categorisation? *Behav Brain Sci*. 1997;20: 167–232.
- [10] Roberson D. Color categories are culturally diverse in cognition as well as in language. *Cross-Cult Res*. 2005;39:56–71.
- [11] Dedrick D. *Naming the Rainbow: Colour Language, Colour Science, and Culture*. Dordrecht: Kluwer; 1998.
- [12] Hardin C. Explaining basic color categories. *Cross-Cult Res*. 2005;39:72–87.
- [13] Levinson SC. Yélf Dnye and the theory of basic color terms. *J Linguist Anthropol*. 2000;10:3–55.
- [14] Bimler D, Uusküla M. A similarity-based cross-language comparison of basicness and demarcation of “blue” terms. *Color Res Appl*. 2017;42:362–377.
- [15] Mylonas D, MacDonald L. Augmenting basic colour terms in English. *Color Res Appl*. 2016;41:32–42.
- [16] Morgan G, Corbett GG. Russian colour term salience. *Russ Linguist*. 1989;13:125–141.
- [17] Laws G, Davies I, Andrews C. Linguistic structure and non-linguistic cognition: English and Russian blues compared. *Lang Cognitive Proc*. 1995;10:59–94.
- [18] Davies IRL, Corbett GG. The basic color terms of Russian. *Linguistics*. 1994;32:65–89.
- [19] Winawer J, Witthoft N, Frank MC, Wu L, Wade AR, Boroditsky L. Russian blues reveal effects of language on color discrimination. *Proc Natl Acad Sci USA*. 2007;104:7780–7785.
- [20] Frumkina RM, Mikhejev AV. *Meaning and Categorization*. New York: Nova Science; 1996.
- [21] Vasilevich AP. *Jazykovaja Kartina Mira Cveta. Metody Issledovanija i Prikladnye Aspekty [A Language View of the Color World. Methods of Investigation and Applied Aspects]*. Postdoctoral dissertation. Moscow: Institute of Language Studies; 2003 (in Russian).
- [22] Corbett GG, Morgan G. Colour terms in Russian: Reflections of typological constraints in a single language. *J Linguist*. 1988;24: 31–64.
- [23] Korzh NN, Penova IV, Safuanova OV. Denotativnye značeniya cvetonaimenovanij [Denotative meanings of color terms]. *Psikhologičeskij Zhurnal*. 1991;12(4):69–79 (in Russian).
- [24] Davies IRL, Corbett GG. A statistical approach to determining basic color terms: an account of Xhosa. *J Linguist Anthropol*. 1994;4:175–193.
- [25] Rakhilina EV. *Kognitivnyj Analiz Predmetnyx Imën: Semantika i Sočetaemost' [Cognitive Analysis of Object Names: Semantics and Collocations]*. Moscow: Russkie slovari; 2000 (in Russian).
- [26] Rakhilina EV. Linguistic construal of colors: The case of Russian. In: MacLaury RE, Paramei GV, Dedrick D, eds., *Anthropology of Color: Interdisciplinary Multilevel Modeling*. Amsterdam/Philadelphia: John Benjamins; 2007:365–380.
- [27] Rakhilina EV, Paramei GV. Colour terms: Evolution via expansion of taxonomic constraints. In: Biggam CP, Hough CA, Kay CJ, Simmons D, eds., *New Directions in Colour Studies*. Amsterdam/Philadelphia: John Benjamins; 2011:121–131.
- [28] Safuanova OV, Korzh NN. 2007. Russian color names. Mapping into a perceptual color space. In: MacLaury RE, Paramei GV, Dedrick D, eds., *Anthropology of Color: Interdisciplinary*

- Multilevel Modeling*. Amsterdam/Philadelphia: John Benjamins; 2007:55–74.
- [29] Ryabina E. Differences in the distribution of colour terms in colour space in the Russian, Udmurt and Komi languages. *J Estonian and Finno-Ugric Linguistics*. 2011;2:191–213.
- [30] Frumkina RM, Mikhejev AV. Vozmožnosti sopostavitel'nogo izučeniya leksiki v eksperimente (na materiale russkix prilagatel'nyx-cvetooboznačenij) [Possibilities of a comparative study of the vocabulary in an experiment (exemplified by Russian adjectives-color terms)]. *Sapostavitelno Jezykosnanie (Sofia)*. 1983;8:51–63 (in Russian).
- [31] Jameson KA. Why GRUE? An Interpoint-Distance Model analysis of composite color categories. *Cross-Cult Res*. 2005;39:159–204.
- [32] Paramei GV. Singing the Russian blues: An argument for culturally basic color terms. *Cross-Cult Res*. 2005;39:10–38.
- [33] Paramei GV. Russian 'blues': Controversies of basicness. In: MacLaury RE, Paramei GV, Dedrick D, eds., *Anthropology of Color: Interdisciplinary Multilevel Modeling*. Amsterdam/Philadelphia: John Benjamins; 2007:75–106.
- [34] Moss A, Davies I, Corbett GG, Laws G. Mapping Russian basic colour terms using behavioural measures. *Lingua*. 1990;82:313–332.
- [35] Vasilevich AP. Cvetonaimenovaniya i problema perevoda teksta [Colour terms and problems of text translation]. In: Komissarov VN, Chernjakhovskaja LA, Latyshev LK, eds., *Text i Perevod [Text and Translation]*. Moscow: Nauka; 1988:84–96 (in Russian).
- [36] Corbett GG, Davies IRL. Linguistic and behavioural measures for ranking basic colour terms. *Stud Lang*. 1995;9:301–357.
- [37] Lindsey DT, Brown AM. The color lexicon of American English. *J Vision*. 2014;14:17. <https://doi.org/10.1167/14.2.17>
- [38] Mylonas D, Paramei GV, MacDonald L. Gender differences in colour naming. In: Anderson W, Biggam CP, Hough CA, Kay CJ, eds., *Colour Studies: A Broad Spectrum*. Amsterdam/Philadelphia: John Benjamins; 2014:225–239.
- [39] Chapanis A. Color names for color space. *Am Sci*. 1965;53:327–346.
- [40] Rich E. Sex-related differences in colour vocabulary. *Lang Speech*. 1977;20:404–409.
- [41] Thomas LL, Curtis AT, Bolton R. Sex differences in elicited colour lexicon size. *Percept Motor Skills*. 1978;47:77–78.
- [42] Nowaczyk RH. Sex-related differences in the color lexicon. *Lang Speech*. 1982;25:257–265.
- [43] Lin H, Luo MR, MacDonald LW, Tarrant WS. A cross-cultural colour-naming study. Part I: Using an unconstrained method. *Color Res Appl*. 2001;26:40–46.
- [44] Bonnardel V, Miller S, Wardle L, Drews E. Gender differences in colour-naming task. *Perception*. 2002;31(Suppl):71.
- [45] Simpson J, Tarrant AWS. Sex- and age-related differences in colour vocabulary. *Lang Speech*. 1991;34:57–62.
- [46] Luria AR. *Cognitive Development: Its Cultural and Social Foundations*. Cambridge, MA: Harvard University Press; 1976.
- [47] Samarina LV. Gender, age, and descriptive color terminology in some Caucasus cultures. In: MacLaury RE, Paramei GV, Dedrick D, eds., *Anthropology of Color: Interdisciplinary Multilevel Modeling*. Amsterdam/Philadelphia: John Benjamins; 2007:457–466.
- [48] Zollinger H. *Color: A Multidisciplinary Approach*. Zürich: Verlag Helvetica Chemica Acta; 1999.
- [49] Moore CC, Romney AK, Hsia T-L. Cultural, gender, and individual differences in perceptual and semantic structures of basic colors in Chinese and English. *J Cogn Cult*. 2002;2:1–28.
- [50] MacDonald L, Mylonas D. Gender differences for colour naming in Spanish and English. In: Ortiz G, Ortiz C, Ramirez R, eds., *Color, Culture and Identity: Past, Present and Future. AIC 2014 Proceedings*. Oaxaca: AMEXINC; 2014:422–427.
- [51] Uusküla M, Bimler DL. From listing data to semantic maps: Cross-linguistic commonalities in cognitive representation of color. *Electron J Folklore*. 2016;64:159–180.
- [52] Barbur J. 'Double-blindsight' revealed through the processing of color and luminance contrast defined motion signals. *Prog Brain Res*. 2004;144:243–260.
- [53] Sturges J, Whitfield T. Locating basic colours in the Munsell space. *Color Res Appl*. 1995;20:364–376.
- [54] Newhall SM, Nickerson D, Judd DB. Final report of the O.S.A. Subcommittee on the spacing of the Munsell Colors. *J Opt Soc Am*. 1943;33:385–411.
- [55] Mylonas D, MacDonald L, Wuerger S. Towards an online color naming model. In: *Proceedings of the 18th Color and Imaging Conference: Color Science and Engineering Systems*. San Antonio, TX: IS&T, Springfield; 2010:140–144.
- [56] Simpson J, Tarrant AWS. A study of colour names in common use. In: *CIBSE National Lighting Conference*. London: CIBSE; 1992:151–163.
- [57] Guest S, Van Laar D. The structure of color naming space. *Vision Res*. 2000;40:723–734.
- [58] Greene K, Gynther MD. Blue versus periwinkle: Color identification and gender. *Percept Motor Skill*. 1995;80:27–32.
- [59] van der Weijer J, Schmidt C, Verbeek J, Larlus D. Learning color names for real-world applications. *IEEE Trans Image Process*. 2009;18:1512–1523.
- [60] Hedrich M, Bloj M. Basic colour names for 2D samples: Effects of presentation media and illuminants. *Ophthalm Physiol Opt*. 2010;30:638–645.
- [61] Alvarado N, Jameson KA. The use of modifying terms in the naming and categorization of color appearances. *J Cogn Cult*. 2002;2:53–80.
- [62] Jameson KA, Alvarado N. Differences in color naming and color salience in Vietnamese and English. *Color Res Appl*. 2003;28:113–138.
- [63] Davies IRL, Corbett GG, Laws G, McGurk H, Moss AE, Smith MW. Linguistic basicness and colour information processing. *Int J Psychol*. 1991;26:311–327.
- [64] Witzel C, Gegenfurtner KR. Is there a lateralized category effect for color? *J Vision*. 2011;11:16. <https://doi.org/10.1167/11.12.16>
- [65] Kul'pina VG. *Lingvistika Cveta: Terminy Cveta v Pol'skom i Russkom Jazykax [Color Linguistics: Color Terms in Polish and Russian Languages]*. Moscow: Moskovskij Licej; 2001 (in Russian).
- [66] Kul'pina VG. Sistema cvetooboznačenij russkogo jazyka v istoričeskom osveščeni [Colour term system in the Russian language from

- a historical viewpoint]. In: Vasilevich AP., ed., *Naimenovaniya Cveta v Indoevropejskix Āzykax: Sistemnyj i Istoričeskij Analiz [Color Terms in the Indo-European Languages: Systematic and Historical Analyses]*. Moscow: KomKniga; 2007:126–184 (in Russian).
- [67] Vasilevich AP, Kuznetsova SN, Mishchenko SS. *Cvet i Nazvanija v Russkom Jazyke [Color and Terms in Russian Language]*. Moscow: KomKniga; 2005 (in Russian).
- [68] Astakhova JA. *Cvetooboznačeniya v russkoj jazykovoj kartine mira [Color Terms in the Russian Linguistic Worldview]*. PhD thesis. Moscow: MPGU; 2014 (in Russian).
- [69] Nasibullina FF. *Kolorativnaja leksika i ee funkcionirovanie v reklama inter'era (na russkom i nemeckom jazykax) [Colorative Lexis and Its Functioning in Interior Advertisement (in Russian and German Languages)]*. PhD thesis. Kazan: TGGPU; 2010 (in Russian).
- [70] Serov NV. *Cvet kul'tury. Psihologija, kul'turologija, fiziologija [Color of Culture. Psychology, Cultural Studies, Philology]*. St. Petersburg: Reč'; 2004 (in Russian).
- [71] Gornacheva VV. *Gendernye osobennosti cvetooboznačenij v sovremennom russkojazyčnom reklamnom diskurse [Colour term gender specificity in modern Russian-language advertisement discourse]*. *Visnik Zaporiz'skogo Nacional'nogo Universitetu. Filologični Nauki*. 2009;1:22–28 (in Russian).
- [72] Swaringen S, Layman S, Wilson A. Sex differences in color naming. *Percept Motor Skill*. 1978;47:440–442.
- [73] Frank J. Gender differences in color naming: Direct mail order advertisements. *Am Speech*. 1990;65:114–126.
- [74] Yang Y. Sex and language proficiency level in color-naming performance: an ESL/EFL perspective. *Int J Appl Linguist*. 2001;11:238–256.
- [75] Arthur H, Johnson G, Young A. Gender differences and color. Content and emotion of written descriptions. *Soc Behav Personal*. 2007;35:827–834.
- [76] DuBois PH. The sex difference on the color-naming test. *Am J Psychol*. 1939;52:380–382.
- [77] Saucier D, Elias LJ, Nylen K. Are colours special? An examination of the female advantage for speeded colour naming. *Pers Indiv Differ*. 2002;32:27–35.
- [78] Shen X. Sex differences in perceptual processing performance on the color-kanji Stroop task of visual stimuli. *Int J Neurosci*. 2005;115:1631–1641.
- [79] MacLaury RE, Almási J, Kövecses Z. Hungarian *piros* and *vörös*: Color from points of view. *Semiotica*. 1998;114:67–81.
- [80] Paggetti G, Menegaz G, Paramei GV. Color naming in Italian language. *Color Res Appl*. 2016;41:402–415.
- [81] Griber YA, Mylonas D. *Kartografija cveta: èmpiričeskij analiz cvetonaimenovaniy russkogo jazyka [Color mapping: an empirical analysis of Russian color names]*. *Čelovek i Kul'tura*. 2015;6 (in Russian). [http://www.e-notabene.ru/ca/article\\_16636.html](http://www.e-notabene.ru/ca/article_16636.html).

## AUTHOR BIOGRAPHIES

**GALINA V. PARAMEI** is Professor of Psychology at Liverpool Hope University, UK. She graduated from and obtained a PhD in general psychology at Lomonosov Moscow State University, Russia. Her *Habilitation* (postdoctorate degree) in Cognitive Psychology is from Ruhr-University Bochum and *Venia legendi* in cognitive neuroscience from Otto-von-Guericke University of Magdeburg, Germany. Prof. Paramei specializes in color vision psychophysics and color cognition. She is coeditor of collective monograph *Anthropology of Color: Interdisciplinary Multilevel Modeling* (2007, John Benjamins, Amsterdam/Philadelphia) and Co-Chairwoman of the *Study Group "Language of Color"* of the International Colour Association (AIC).

**YULIA A. GRIBER** is Professor of Sociology and Philosophy at the University of Smolensk, Russia. She graduated from the University of Smolensk in linguistics and from the University of Hagen, Germany, in sociology. She obtained a PhD in philosophy at Moscow State Pedagogical University, Russia; her postdoctorate degree in cultural Studies is from St. Petersburg State University of Culture and Arts, Russia. Research of Prof. Griber focuses primarily on color in culture and color in urban environment. Since 2017 she is Co-Chairwoman of the *Study Group "Environmental Colour Design"* of the International Colour Association (AIC).

**DIMITRIS MYLONAS** obtained an M.S. in digital color imaging from the University of the Arts, London, and completed M. Res. in media and arts technology at the School of Electronic Engineering and Computer Science, Queen Mary University, London, UK. He held a research position at School of Psychology, University of Liverpool, and in the Wellcome Laboratory of Neurobiology, University College London. Currently he is a doctoral student in the Department of Computer Science, University College London, researching color naming in different cultures. Since 2015 Dimitris Mylonas is Chairman of the *Study Group "Language of Color"* of the International Colour Association (AIC).

**How to cite this article:** Paramei GV, Griber YA, Mylonas D. An online color naming experiment in Russian using Munsell color samples. *Color Res Appl*. 2017;00:000–000. <https://doi.org/10.1002/col.22190>