

## RESEARCH ARTICLE OPEN ACCESS

## Learning Turkish Color Names Through Crowdsourcing

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## ABSTRACT

This study explored common Turkish color names and their denotative meanings to facilitate color communication within and across languages. An internet-based psycholinguistic experiment was conducted (available at: [colornaming.net](https://colornaming.net)) using an unconstrained color-naming method with the following objectives: (a) to collect Turkish color names in wide cultural use and determine their corresponding color ranges; (b) to estimate color coordinates of centroids of 11 Turkish basic color terms (BCTs), as well as of an emerging BCT *lacivert* ‘navy blue’, and compare them to the 11 English BCTs estimated earlier using the same web-based psycholinguistic experiment; and (c) to establish an “indispensable” set of Turkish color terms required for complete coverage of the color gamut. Native speakers of Turkish, recruited as volunteers from crowdsourcing ( $N=637$ ), named freely a sequence of randomly selected colors from 606 samples approximately uniformly distributed in CIELAB color space. Results showed a large color lexicon of unique 268 color descriptors, each offered by more than one observer. The centroids of the 11 Turkish BCTs showed high correspondence with their English counterparts (mean  $\Delta E_{00} < 3$ ) except for *mavi* ‘blue’, which differed more substantially from *blue* ( $\Delta E_{00} = 8.5$ ), while the difference between *lacivert* and *blue* was even greater ( $\Delta E_{00} = 21.2$ ). Frequency, naming consensus, and denotative certainty of *lacivert* support its classification as a 12th BCT in Turkish. An analysis for identifying the minimal set of color terms (CTs) that can name all colors across the full color gamut revealed, in total, 30 Turkish indispensable lexical color categories that enable efficient inter-language communication.

## 1 | Introduction

Color is a key feature of our visual experience, with its many shades and hues adding depth and meaning to what we see. It can be employed during communication of ideas without any written or verbal language [1], making it a visual communication tool in many disciplines [2]. Colors convey meanings, associations, and connotations and are, therefore, vital components of communication in everyday life.

Schirillo ([3]: 179) defined color naming as “one of the most interesting consequence of mental activity”. While there are thousands to millions of discriminable colors [4, 5], they are organized into a limited number of categories, each associated with

a color name used in everyday communication [6]. The study of color naming is an intriguing and demanding subject that has been extensively researched. It is imperative to comprehend the psychology and cultural influences behind color naming as it provides valuable insights into human perception and communication. It involves not only functions such as human vision but also language. The Whorfian hypothesis, a relativist view, posits that languages are molds shaped by culture; thus, color names are non-trivial [7]. The opposite explanation is proposed by the universalist view: according to Berlin and Kay [8] there are up to 11 universal basic color categories (BCCs). At Stage I, the basic color term inventory includes a binary distinction between white/light/warm and black/dark/cool; in the evolutionary sequence this is followed by ‘red’ (Stage II); the fourth and fifth

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color terms are either 'yellow' or 'green'; the sixth color term is 'blue' followed by 'brown', 'orange', 'pink', 'purple', and 'gray' terms. Languages with a developed color lexicon reach Stage VII with 11 universal BCTs (the ceiling) ([8]/1991). As noted by Lucy ([9]: 338), Berlin and Kay interpreted BCTs as counterevidence to Whorf's proposal, arguing instead that universal perceptual and conceptual structures underpin BCCs and constrain their linguistic expression. Subsequent studies provided empirical evidence that refined and qualified Berlin and Kay's original hypothesis [10–15]. Since Berlin and Kay's work, successive studies have increasingly converged on a weak version of linguistic relativity hypothesis, integrating both universal constraints and language-specific influences on color categorization. Weak linguistic relativity allows for the possibility that culturally specific BCCs and BCTs may emerge beyond the proposed set of 11. Berlin and Kay [8] mentioned two cases of languages with 12 BCTs, that is, beyond the proposed 11: Russian *goluboj* 'light blue' and Hungarian *vörös* 'red'. Further studies provided evidence that there are two BCTs for 'blue' in several languages, such as Greek [16], Russian [17, 18], Italian [19], and an emerging BCT *lacivert* 'navy blue' in Turkish [20]. Furthermore, recently, Mylonas and MacDonald [6] suggested augmentation of the BCT inventory in British English, from 11 to 13, including *lilac* and *turquoise*.

The ability to communicate color is crucial in various fields, including trade, advertising, education, and design. While color names may be translated between different languages, their color representations can vary significantly. As a result, previous researches aimed to estimate denotative meanings of CTs in experimental studies [6, 19, 21–27]. Color naming studies have been recognized for their importance in industrial and engineering fields for decades [28]. Researchers continue to explore new ways to meet modern color naming needs, rather than relying solely on simple dictionary translations. Besides the importance of color names extended during the last decades, some studies focused on specific languages (e.g., Japanese: [29]; Arabic: [30]; Italian: [15]; Russian: [18]), gender differences (e.g., [31]), or investigated how color names have evolved throughout history [32]. Recent studies demonstrated advantages of online color-naming experiments, with the World Wide Web as a powerful tool that cannot be underestimated ([33–35]).

The present study investigates Turkish color terms using a web-based psycholinguistic experiment with an unconstrained color-naming method. The aims are to: (a) collect color names in wide cultural use and estimate the color ranges they denote; (b) estimate the color coordinates of the centroids of Turkish BCTs and compare them to the 11 English BCTs established using the same experimental; and (c) establish the set of indispensable Turkish color terms required to name all colors in the sRGB gamut.

## 1.1 | Turkish Color Names

Various researchers conducted linguistic and psycholinguistic studies on color naming in Turkish [36–38]. They concluded that Turkish can be considered a Stage VII language according to the Berlin and Kay evolutionary sequence and that Turkish BCTs align with Berlin and Kay's 11 universal BCTs. Notably, Şahin ([38]: 167) and Ekici et al. [36] (the first author aka Şahin)

reported that, along with basic *mavi* 'blue', 98.8% of their participants knew *lacivert* 'navy blue'.

In comparison, authors of more recent and/or comprehensive studies [20, 27, 31, 39–41] came to the conclusion that Turkish has two basic terms for 'blue' like other circum-Mediterranean languages (Greek, Catalan, Maltese, and Italian) and Russian. It is worth noting that Turkish groups light and medium blues as *mavi* in opposition to dark blues as *lacivert*, similar to the opposition of two Italian 'blue' terms *azzurro* 'light/medium blue' and *blu* 'dark blue' [15], but unlike Russian that groups medium and dark blues as *sinij* in opposition to light blue *goluboj* [18].

The studies cited above employed different methodologies, which may have affected their outcomes. First, in these studies the nature of the employed task varied—a color listing task [20, 27, 31, 40, 41] versus a color-naming task of colored samples [20, 41]. In comparison, Ekici et al. [36] conducted a task that aimed to estimate, in effect, "best exemplars" of most frequent Turkish color terms, whereby participants were given 32 pre-selected chromatic terms and requested to point to the color sample named by that term. Finally, Kadıhasanoğlu [39] used a 2AFC (two-alternative forced choice) task for naming varying blue stimuli to estimate category boundary between *mavi* and *lacivert*.

Furthermore, in the psycholinguistic experiments arrays of employed color stimuli differed, which could have affected discriminability of the two Turkish 'blue' categories. Specifically, Özgen and Davies [20] used 65 Color-Aid Corporation tiles [42]. Rätsep [40, 41] added to these 17 tiles in the dark purple-blue area. Ekici et al. [36] employed the Munsell Color System stimuli, with 10 Munsell charts (out of 40); these covered the hue circle, where each hue was represented by codes 2.5, 5, 7.5 and 10. Kadıhasanoğlu [39] used monitor colors representing blue and green areas of color space.

It should be noted that from the pre-selected 32 CTs, Ekici et al. [36] defined eight CTs as basic (apparently chosen by them as translation equivalents of eight English chromatic BCTs); the other 24 CTs were considered non-basic. The authors reported that Turkish participants selected the most saturated samples for each BCT with good agreement, and there was no substantial variation in Value and Chroma. (As a remark, for each CT, the authors report not all but the most frequent choices of Munsell samples, as a rule within two or three Munsell charts corresponding to a particular hue.) The authors singled out choices for *yeşil* 'green' as mostly from GY (green-yellow) charts of the Munsell Color System, rather than G (green). Further, *kan kırmızısı* 'blood red' was the only non-basic color name with high consensus among other color names in their study, which was defined with fewer color samples (2 color samples) than *kırmızı* 'red' (4 color samples). Ekici et al. [36] mentioned that all participants were able to identify *mor* 'purple'.

In the listing task studies, all these report that the frequency of principal color names abruptly decreased after the 12th term, either *lacivert* 'navy blue' or *gri* 'gray'. Noteworthy, Rätsep [41] found that *yeşil* 'green' and *siyah* 'black' were the most frequent ones (we surmise this is likely due to their symbolic meaning in Islam); these were followed by *sarı* 'yellow'. In a semantic map

derived from their listing data (and reconstructed by multidimensional scaling), Uusküla and Bimler ([27]: 78) showed that Turkish participants cluster four BCTs denoting ‘cardinal hues’ (*kırmızı* ‘red’, *yeşil* ‘green’, *mavi* ‘blue’ and *sarı* ‘yellow’); other clusters group terms for achromatic ‘white’ and ‘black’; and still other secondary BCTs ‘purple’, ‘pink’ and ‘orange’. Frequent non-BCT *lila* ‘lilac’ and *eflatun* ‘mauve’ cluster in close proximity to *mor* ‘purple’, while *turkuaz* ‘turquoise’ is a neighbor of *bej* ‘beige’, *bordo* ‘claret’ and *yavruağzı* ‘peach’, salient non-BCTs in modern Turkish.

Several studies explored in depth the basic status of the two Turkish ‘blue’ terms *mavi* ‘blue’ and *lacivert* ‘navy blue’ [20, 27, 36, 38–41].

In the listing task, *mavi* ‘blue’ was among the most frequent terms ranking between 1 and 3 [20, 27, 41]. In comparison, *lacivert* ‘navy blue’ ranked 12th in Özgen and Davies [20], and a great majority of their participants (86%) considered *lacivert* a kind of *mavi*, which violates B&K’s non-inclusion criterion of the term’s basicness. However, the authors conceive of the possibility of witnessing the formation of the 12th Turkish BCT ([20]: 951). The frequency rank 12 of *lacivert* was confirmed 20 years later by Uusküla and Bimler [27] and Rätsep [41], and in cognitive salience, *lacivert* ranked 11, before *gri* ‘gray’. The authors of both studies are affirmative in that *lacivert* may function as a BCT. Notably, in a semantic map derived from the listing data, while *mavi* was in the cluster of BCTs for the four ‘cardinal hues’, *lacivert* clustered with the secondary BCTs *mor* ‘purple’, *pembe* ‘pink’ and *turuncu* ‘orange’ ([27]: 81).

Şahin [38] and Ekici et al. [36] provided predominant choices of Munsell samples for *mavi* ‘blue’ (Value 5 or 4) and *lacivert* ‘navy blue’ (Value 2), which indicate that *lacivert* is darker than medium-lightness *mavi*. This finding is in accord with focal colors for the two “Turkish blues” (presented in CIE Lu\*v’ renotation) as estimated by Özgen and Davies ([20]: 947). In their color-naming experiment, Özgen and Davies [20] found two tiles with the dominant *lacivert* term, which they interpreted as its focal color, around which the category could form. They showed that *lacivert* occupies a perceptual position between the focal points of *mavi* and *mor* ‘purple’, rather than clearly aligning with either category. Further, a specificity index of *lacivert* was similar to that of *siyah* ‘black’ and higher than indices for *mor*, *turuncu* ‘orange’ and *sarı* ‘yellow’. In contrast, Rätsep [41] found low consensus for *lacivert*, with only one tile reaching 52% dominance, which she interpreted as indicating a doubtful basicness of the term. Interestingly, regardless of *lacivert*’s basic status, in the 2AFC study it was demonstrated that speakers of Turkish are better in discriminating colors in the blue area, compared to speakers of languages with one basic ‘blue’ term, thus, providing evidence of an additional category boundary within blue area [39].

As concluded by Özgen and Davies [20], *lacivert* ‘navy blue’, the breakaway term in Turkish at the blue-black area boundary, may be in a transition to the basic status, which is reflected by the marginal status of some of its measures. Note also that the first and the last reviewed studies (1982 and 2018, respectively) are separated by more than three decades, during which period

the Turkish inventory of BCTs could have undergone further development. The previous studies employed constrained sets of stimuli to investigate CTs in Turkish. In the current study, an unconstrained internet-based color naming experiment was conducted to explore basic and non-basic Turkish color names in wide cultural use offered by a larger number of participants and estimate a ‘translation bridge’ between Turkish and English color languages [2, 34, 43].

## 2 | Methods

### 2.1 | Online Color Naming Experiment

An online color naming experiment (available at: <https://color.naming.net>) was conducted to collect unconstrained color-naming method along with their associated color ranges, with the aim of augmenting intercultural color communication [34]. During the procedure, participants first adjusted their screen brightness and then completed the Dynamic Color Vision Test [44] to screen for potential color vision deficiencies. They then proceeded to the color naming task, where they named colors one by one using the most representative terms, which could consist of one or more words. Participants were free to name as many colors as they wished, with an average of 16 responses per person. Next, they provided information about their background and viewing conditions. At the end of the experiment, participants received a personalized summary of their responses alongside the color patches they had named, and were invited to share the study via social media links to support snowball sampling (for more details, see [6, 34]).

### 2.2 | Color Stimuli

We extended previous research on Turkish color naming by incorporating a broader range of color samples ( $n=606$ ) drawn from the interior of the Munsell color solid, going beyond the highly saturated samples used in earlier studies ( $n=330$ ) ([8]/1991; [45, 46]). The test stimuli consisted of 2-degree uniformly colored discs, each outlined in black (1 pixel width). A total of 589 chromatic samples were selected to approximate a uniform distribution within the Munsell Renotation Data and were constrained to the sRGB gamut. To achieve this sampling, we followed the guidelines proposed by Billmeyer, as cited in Sturges and Whitfield [47]. Additionally, we included 11 achromatic samples and 6 chromatic samples positioned at the corners of the RGB cube. The complete set of 606 color samples was presented individually and in randomized order for each participant, against a neutral gray background [6, 18, 34].

### 2.3 | Participants

The Turkish dataset consisted of responses from over 600 volunteers ( $n=637$ ) with no reported color deficiencies. The participants had a mean age of 32.5 years ( $SD=14.5$ ; age range = 20–63). Females constituted 431 (67.7%) of the participants, males 203 (31.9%), and non-binary individuals 3 (0.4%). Most participants reported being raised in Türkiye (98.5%) and currently residing there (86.2%). Participants were invited to the study through

various methods, including word of mouth, social media, and flyers. Recruited participants were encouraged to invite their network for further snowball sampling at the end of the experiment. The only participation restrictions were age (over 16 years old) and language proficiency in Turkish. Participation was voluntary and anonymous, with experimental sessions conducted after obtaining online informed consent [48].

## 2.4 | Data Pre-Processing

The 12008 responses in the raw dataset were treated for consistency in their format and spelling mistakes were corrected using a replacement table constructed by the first author. Hyphenations, comma separators, and words in parenthesis were registered as multiword color expressions while various typographic conventions were removed. Excluded were incomplete responses, numerical responses, or responses in languages other than Turkish, but loanwords such as *lila* 'lilac' were included. On average, each participant named 16 colors. The refined dataset resulted in 10 717 responses.

## 3 | Results

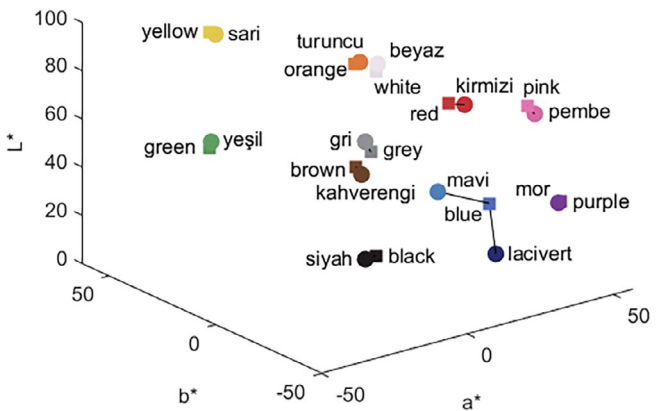
### 3.1 | Comparison of Centroids for 11 Turkish BCTs and 11 English BCTs

We compared the centroid locations of 11 Turkish basic color terms (BCTs) identified in this study with the centroids of 11 English BCTs obtained from a previous web-based experiment that employed the same experimental design [6, 18]. We have also included a comparison of the 12th proposed BCT by earlier studies *lacivert* 'navy blue' against the English blue. Table 1 presents the coordinates of the centroids and the corresponding color differences, while Figure 1 visualizes this data. Overall, we observed

a strong correspondence between the 11 BCTs, with a mean color difference of  $\Delta E_{00}=2.97$ . As anticipated, the largest differences were observed for the blue terms *mavi* 'blue' and *lacivert* 'navy blue', with  $\Delta E_{00}$  values of 8.5 and 21.2 respectively, when compared with English blue. The smallest differences were found for the yellow term *sarı* ( $\Delta E_{00}=0.7$ ) and the purple term *mor* ( $\Delta E_{00}=1.1$ ).

### 3.2 | Frequency and Consensus of Color Naming Responses

The frequency of color naming responses shows 268 distinct color descriptors, with responses given by only one observer excluded as idiosyncratic. One-word descriptors constituted 67% (35% BCTs; 32% non-BCTs), two-word descriptors 31%, and three-word descriptors less than 1% with 0.5% empty responses. Figure 2 shows color names proportionally to their

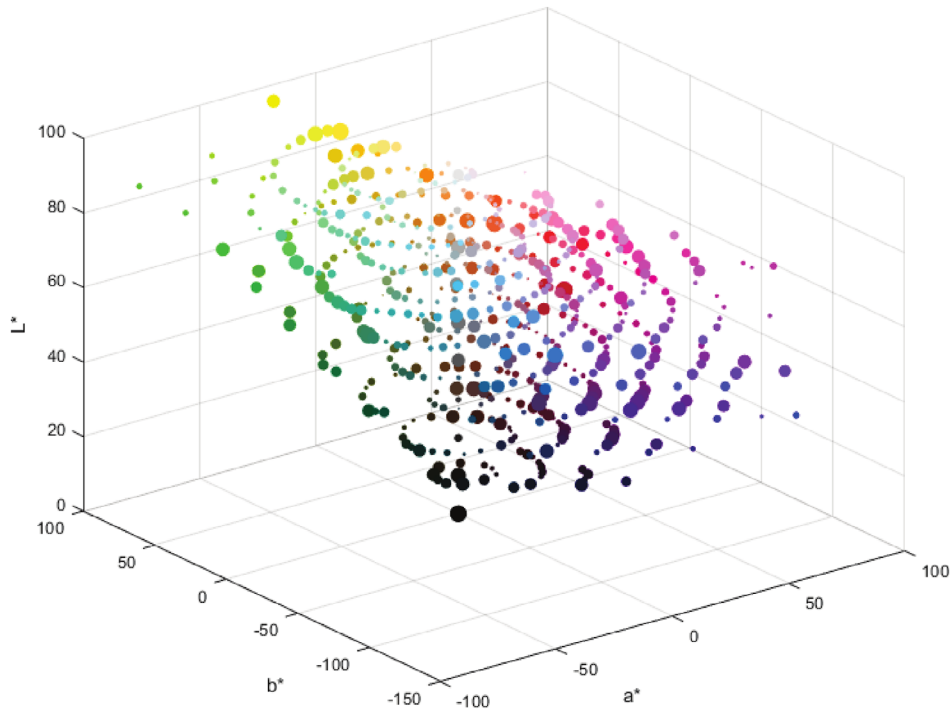


**FIGURE 1** | Location of centroids of the 12 Turkish BCTs (filled circle) compared with centroids of the 11 English BCTs (filled square) in CIELAB.

**TABLE 1** | CIELAB coordinates of centroids of the Turkish BCTs ( $n=12$ ) and the English BCTs ( $n=11$ ) as well as color differences ( $\Delta E_{00}$ ) between their location.

| Turkish           |       |        |        | English       |       |        |        | $\Delta E_{00}$ |
|-------------------|-------|--------|--------|---------------|-------|--------|--------|-----------------|
| BCTs              | L*    | a*     | b*     | BCTs          | L*    | a*     | b*     |                 |
| <i>Beyaz</i>      | 91.39 | 4.00   | -2.30  | <i>white</i>  | 88.34 | 3.19   | -2.39  | 2.16            |
| <i>Siyah</i>      | 10.46 | 1.20   | -0.26  | <i>black</i>  | 11.15 | 4.36   | -0.9   | 4.05            |
| <i>Kırmızı</i>    | 44.11 | 57.01  | 29.66  | <i>red</i>    | 45.03 | 53.02  | 31.5   | 2.28            |
| <i>Sarı</i>       | 80.88 | -5.30  | 61.34  | <i>yellow</i> | 81.55 | -6.02  | 62.9   | 0.72            |
| <i>Yeşil</i>      | 60.04 | -32.97 | 25.30  | <i>green</i>  | 57.18 | -33.01 | 25.96  | 2.58            |
| <i>Mavi</i>       | 52.67 | 0.78   | -35.02 | <i>blue</i>   | 46.77 | 13.15  | -42.3  | 8.51            |
| <i>Kahverengi</i> | 32.47 | 15.16  | 20.68  | <i>brown</i>  | 33.76 | 16.21  | 24.61  | 2.28            |
| <i>Mor</i>        | 36.24 | 40.22  | -37.63 | <i>purple</i> | 35.99 | 41.75  | -36.34 | 1.13            |
| <i>Pembe</i>      | 59.42 | 50.51  | -12.28 | <i>pink</i>   | 63.52 | 48.06  | -12.05 | 3.61            |
| <i>Turuncu</i>    | 61.07 | 35.19  | 49.00  | <i>orange</i> | 61.16 | 33.28  | 48.67  | 0.96            |
| <i>Gri</i>        | 60.20 | 0.12   | -1.74  | <i>gray</i>   | 55.86 | 1.37   | -2.59  | 4.37            |
| <i>Lacivert</i>   | 21.73 | 19.11  | -37.11 | <i>blue</i>   | 46.77 | 13.15  | -42.3  | 21.16           |





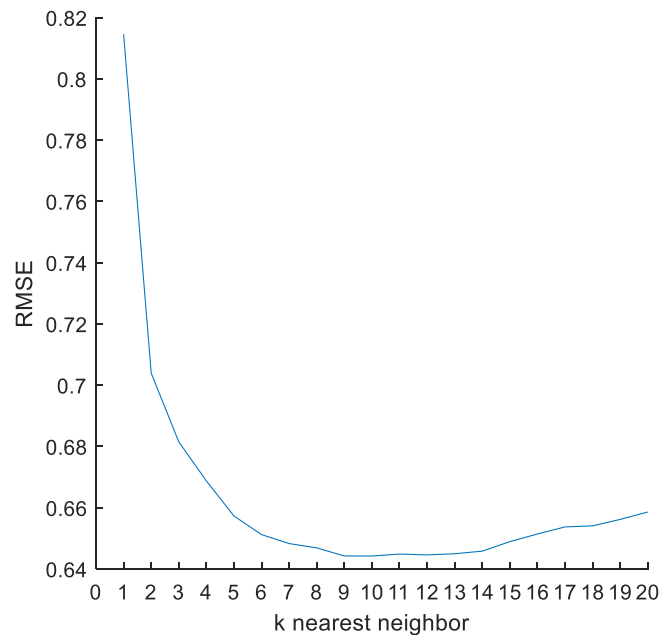
**FIGURE 3** | Color stimuli plotted in CIELAB space, with disc size scaled by the maximum conditional probability  $P(W|c)$ . Larger dots indicate higher naming consensus, marking the focal colors of Turkish color categories. Disc color reflects the surface color of each sample in sRGB.

a consensus value of 0.850, well above *bordo* ‘claret’ (0.786), the 13th term. These findings provide converging visual and quantitative evidence for the classification of *lacivert* as a 12th BCT in Turkish.

### 3.3 | Turkish Color Names Across the Full Color Space

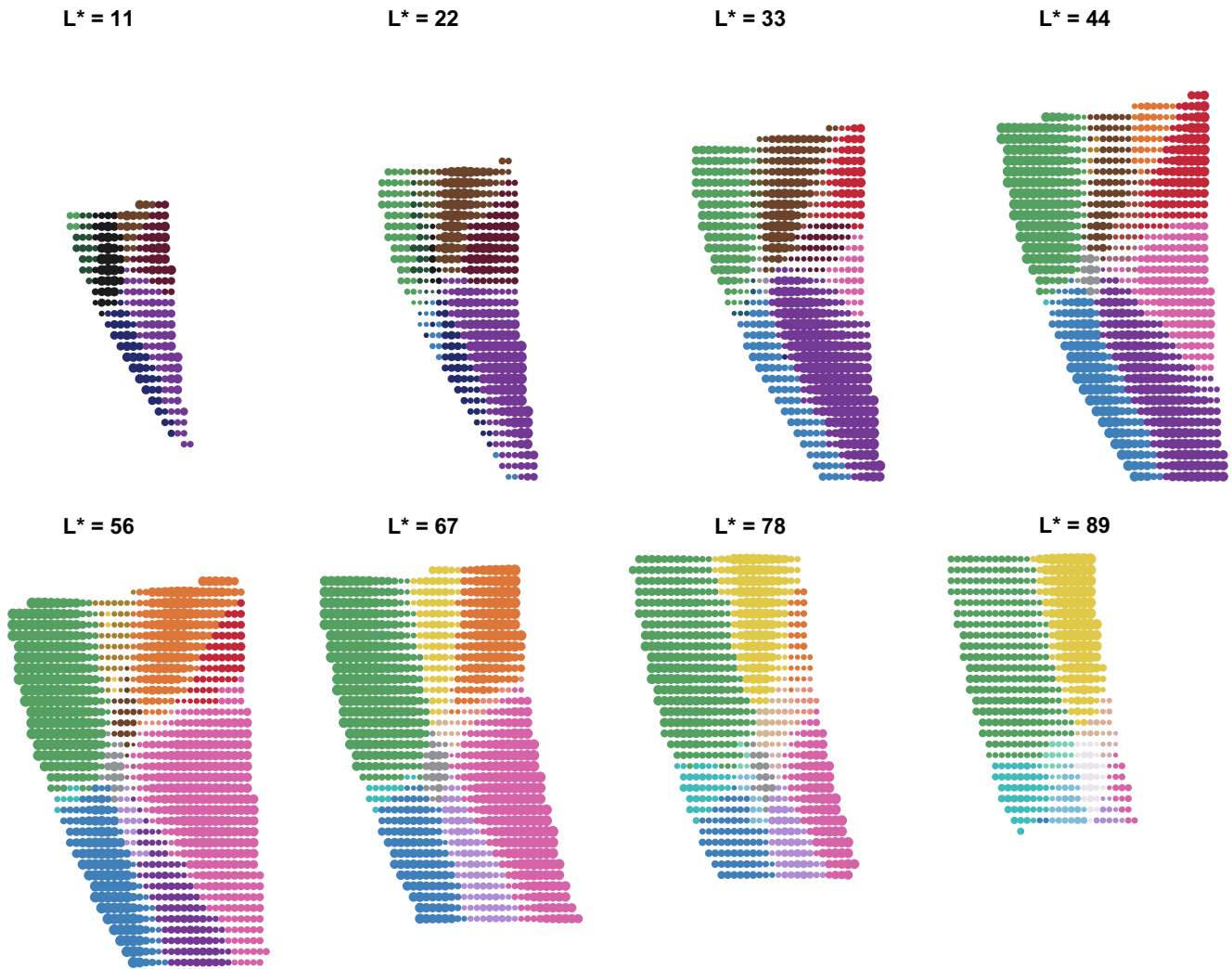
To generalize our observations to any color and identify the indispensable CTs that can label all colors across the full color gamut in the Turkish language, we used a k-Nearest Neighbors (kNN) machine learning algorithm, applied in regression mode and based on the CIE  $\Delta E_{00}$  color difference formula. This approach was selected for its simplicity and strong explanatory power in color classification tasks. Using our training dataset of color points  $X = x_1, \dots, x_n$  with their naming responses  $Y = y_1, \dots, y_n$ , and an optimal  $k$ , a kNN algorithm predicts the naming response for a new test color  $x$  by examining the  $k$  closest colors in the dataset. It aggregates the frequency of color names among these neighbors to estimate the likely name(s) for the new color. We applied this method to classify a grid of 5693 color samples in CIELAB space. These samples were spaced in 4-unit bins across 8 levels of lightness and restricted to colors that can be displayed within the sRGB gamut [49, 50]. To determine the optimal number of neighbors ( $k$ ), we used a leave-one-out cross-validation method (Figure 4). A value of  $k = 10$  yielded the lowest root mean square error (RMSE = 0.6).

Figures 5 and 6 present the identified CCs with their coverage across the sRGB gamut. Areas with high classification confidence appear as solid regions, while boundaries between categories, where naming was more uncertain, are shown with



**FIGURE 4** | Evaluation of optimal number of ( $k$ ) neighbors, in a leave-one-out cross-validation method for kNN.

lower confidence, reflecting greater variability in participants’ responses. This analysis revealed 30 lexical CCs. *Yeşil* ‘green’ dominated with 24.0% coverage, consistent with earlier findings in English and Russian [6, 18], followed by *pembe* ‘pink’ (14.6%) and *mor* ‘purple’ (13.8%). Among the BCTs, *lacivert* ‘navy blue’ shows the smallest coverage (1.5%), confined to a well-defined region at low lightness levels ( $L^* \leq 35$ ), compared to *mavi* ‘blue’ (10.0%). Interestingly, several non-BCTs such as *lila rengi* ‘lilac’ (2.8%), *bordo* ‘claret’ (2.4%), and *turkuaz* ‘turquoise’ (1.8%)



**FIGURE 5** | Coverage of 30 Turkish lexical color categories across the color gamut, estimated using the kNN classification. Segment size reflects spatial extent in the CIELAB space within the sRGB gamut. Color of dots corresponds to the centroids of each color name, and dot size reflects the confidence of classification.

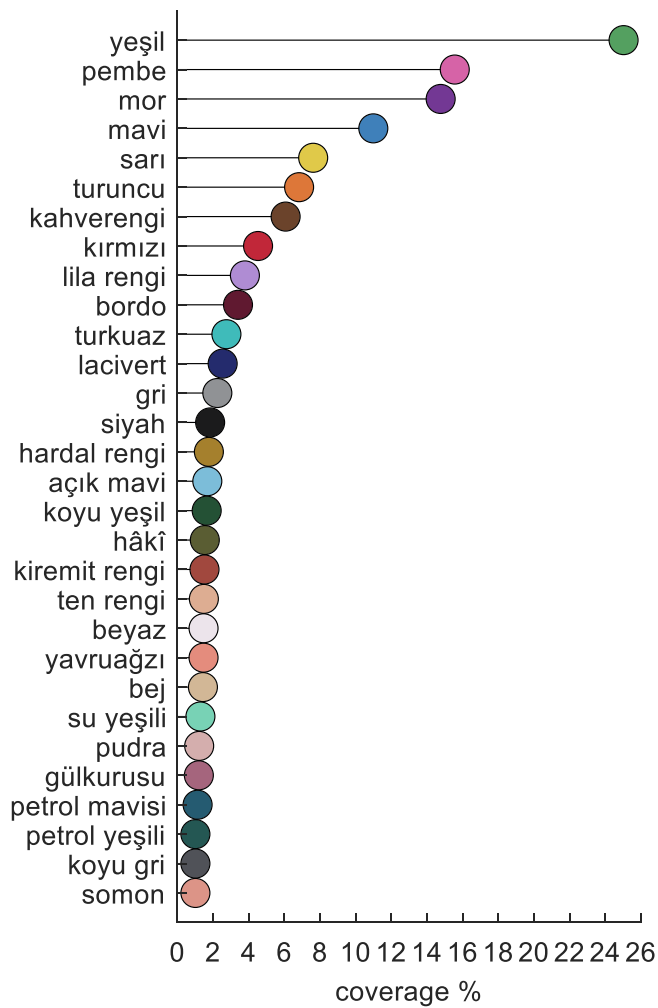
covered larger regions than the achromatic BCTs *gri* ‘gray’ (1.2%) and *siyah* ‘black’ (0.8%), consistent with a gradient view of basicness [51, 52].

To further characterize the denotative stability of each category, we extracted the mean classification confidence, defined as the maximum normalized  $P(W|c)$  assigned by the kNN classifier to the winning color name, for each of the 30 identified categories (See Supplementary Appendix). Figure 7 shows these values ranked from highest to lowest. A clear separation is visible between a high-confidence group of 12 terms and the remaining 18 categories. The top 12 terms —*sarı*, *mor*, *yeşil*, *pembe*, *turuncu*, *mavi*, *siyah*, *kırmızı*, *kahverengi*, *bordo*, *lacivert*, and *gri*—all achieve mean confidence values above 0.66, with *sarı* ‘yellow’ (0.780) and *mor* ‘purple’ (0.777) showing the highest values. *Lacivert* ‘navy blue’ (0.687) is placed clearly within this high-confidence group, comparable to *gri* ‘gray’ (0.662) and well above all non-BCT categories. A marked drop in confidence is observed after *gri*, with *turkuaz* ‘turquoise’ (0.637) leading the non-BCT group. Notably, *beyaz* ‘white’ shows a lower mean confidence (0.580) than expected for a BCT, likely reflecting the

limited number of achromatic samples at high lightness levels in the grid.

#### 4 | Discussion and Conclusions

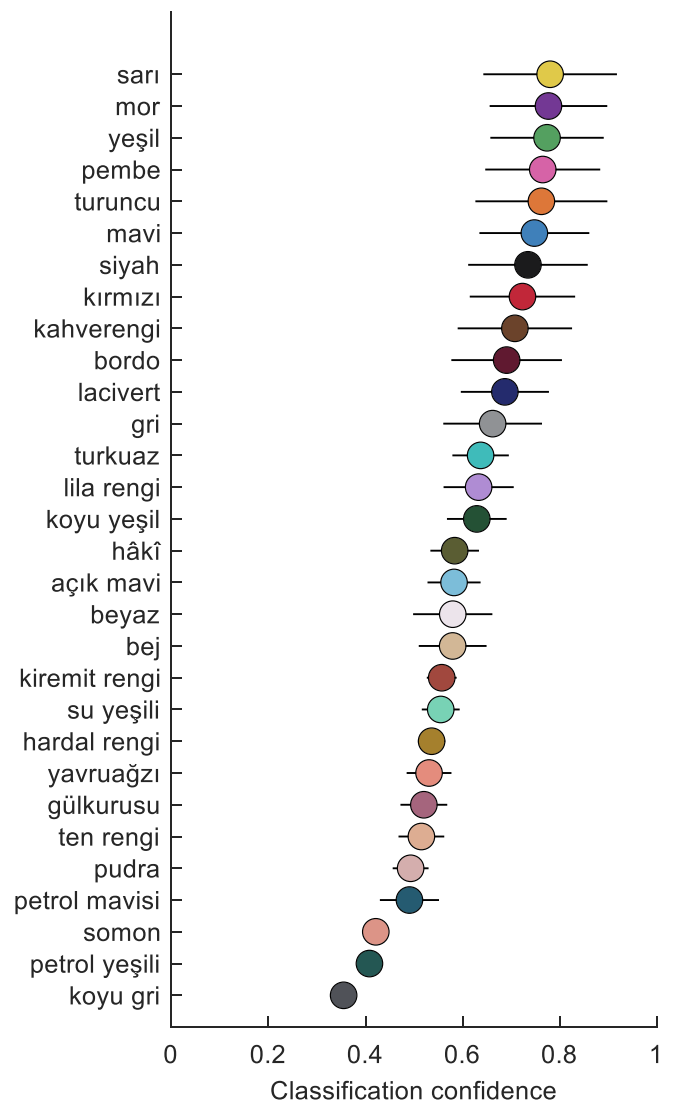
The study investigated Turkish color terms for the first time in a web-based psycholinguistic experiment using the unconstrained color-naming method; it collected data on color names in wide cultural use and estimated their corresponding color ranges. The results show that Turkish has a large color lexicon of 268 color descriptors given more than one observer, with 67% of one-word descriptors. Analyses of the dataset found 30 lexical CCs across the full color gamut that fit well with findings for English [53]. In alignment with Ekici et al. [36] “best exemplars”, centroids of Turkish CTs are highly saturated. Our results show that *yeşil* ‘green’ occupies the largest volume in color space. *Yeşil* ‘green’ was also the most frequent CT in the listing task in Rätsep’s [41] study. Further, according to our analyses, *mor* ‘purple’ is the most frequent CT, which Ekici et al. [36] reported as a color that all participants were able to identify (match the CT and the color sample denoted by it).



**FIGURE 6** | Coverage percentage of the estimated 30 Turkish color categories in the CIELAB space. Disc colors correspond to the centroids of each color name.

The study reveals high agreement between the estimated CIELAB coordinates of centroids of the 11 Turkish BCTs, with *mavi* as the basic ‘blue’ term, compared to the 11 English BCTs, and establishes the most indispensable Turkish color names that can name almost all colors. The centroids for 10 Turkish BCTs correspond well to previously estimated centroids for their translation equivalents among the English BCTs, with a  $DE_{00} < 3$ , as our previous findings suggested [54]. However, the difference is larger ( $DE_{00} = 8.5$ ) between medium-lightness *mavi* and English *blue*, the latter being slightly darker, more reddish and bluish than the former (Table 1). The difference between *lacivert* and *blue* is even larger ( $DE_{00} = 21.1$ ), not unexpected bearing in mind a considerably darker centroid for *lacivert* ( $L^* = 22$ ) compared to that for *blue* ( $L^* = 47$ ).

The prolonged debate regarding a controversial BCT status of *lacivert* ‘navy blue’ required our further investigation. In daily language, *lacivert* is fully comprehended by speakers of Turkish; moreover, *lacileri çekmek* (‘wearing a navy blue colored suit’) is a vernacular expression that denotes being elegant and graceful ([55]: 169), indicating that the CT has a positive connotation. Another common color association of *lacivert* ‘navy blue’ in



**FIGURE 7** | Mean classification confidence for each of the 30 Turkish lexical color categories identified by the kNN classifier, with error bars indicating one standard deviation across the classified grid samples. Disc color corresponds to the centroid color of each category.

everyday language is *sarı lacivertliler* ‘the Yellow-Navy Blues’, a popular nickname for Fenerbahçe Football Club, one of the largest football clubs in Türkiye, based in Istanbul [56]. The nickname derives from the club crest, which features *sarı* ‘yellow’ (HEX: #FFED00; CMYK: C4, M0, Y89, K0; RGB: R255, G237, B0) and *lacivert* ‘navy blue’ (HEX: #002D72; CMYK: C100, M87, Y32, K13; RGB: R0, G45, B114) [57]. Fenerbahçe Spor Kulübü [58] states that navy blue represents nobility, whereas yellow represents *gıpta*, often translated as emulation or envy [59], felt toward Fenerbahçe. The present study provides converging visual and quantitative evidence in support of *lacivert* as a 12th BCT. An analysis of naming consensus revealed that *lacivert* achieves a consensus value of 0.850, well above the threshold identified by a gap statistic applied to the rank-ordered consensus values of all 268 CTs. The largest discontinuity in the distribution was found between ranks 13 and 14 (0.786 to 0.636, gap = 0.149), partitioning the CTs into a high-consensus group of 13 terms and the remaining 255 lower-consensus terms. The first 12 terms correspond precisely to the 11 established Turkish BCTs plus *lacivert* ‘navy blue’, with *bordo*

**TABLE 2** | Comparison of the identified most frequent eight non-basic lexical color categories with findings in previous studies of the Turkish color names. The most frequent simple, non-basic color terms list from Rätsep [41] is compared with the current study's results.

| Current study results    | Ekici et al. [36] | Rätsep [41]: 60 | Özgen & Davies [20]: 927 | Uusküla & Bimler [27]: 69 |
|--------------------------|-------------------|-----------------|--------------------------|---------------------------|
| Lila rengi 'Lilac'       | —                 | ✓               | ✓                        | ✓                         |
| Bordo 'Claret'           | ✓                 | ✓               | ✓                        | ✓                         |
| Turkuaz 'Turquoise'      | —                 | ✓               | ✓                        | ✓                         |
| Bej 'Beige'              | ✓                 | ✓               | ✓                        | ✓                         |
| Yavruağzı 'peach'        | ✓                 | —               | ✓                        | ✓                         |
| Haki 'Khaki'             | —                 | ✓               | ✓                        | ✓                         |
| Kiremit rengi 'Tile red' | ✓                 | ✓               | —                        | —                         |
| Gülkurusu 'Dusty rose'   | ✓                 | —               | —                        | —                         |

'claret' occupying the 13th position. Rather than treating this as a binary outcome, these results are best understood within a gradient view of basicness, according to which CTs vary continuously in their degree of entrenchment rather than falling into discrete basic and non-basic categories [51, 52]. Within this continuum, *lacivert* is placed clearly among the established BCTs, while *bordo* occupies an intermediate position consistent with its recurring identification across previous studies (Table 2) as the most salient non-BCT in Turkish [20, 27, 41]. Furthermore, two spatially distinct high-consensus regions were identified in the blue and navy area of CIELAB space, corresponding to *mavi* 'blue' and *lacivert* respectively and separated by low-consensus samples, providing visual evidence that the two terms denote separate color categories. The kNN classification further corroborates this, assigning 88 grid samples to *lacivert*—all at  $L^* \leq 35$ —with a mean classification confidence of 0.687, comparable to established BCTs such as *gri* 'gray' (0.662) and above all non-BCT categories, confirming the stability and spatial coherence of *lacivert*'s denotative range in color space.

With regards to the denotative meaning of the two "Turkish blues", our results suggest that the English *blue* is slightly darker than *mavi* (mean  $L^* = 53$ ), indicating that *lacivert* pushes *mavi* into a lighter blue area of color space. Previous studies that examined the use of Turkish color names concluded that *lacivert* has a candidate [20, 27, 40, 41] or even established basic status [39]. The present findings are consistent with the most recent cited research in that *lacivert* augments the Turkish BCT inventory to 12 terms, similar to "two blues" inventories of other circum-Mediterranean languages (Catalan, Greek, Italian, Maltese).

Beyond the Turkish BCTs, Table 2 presents some frequent non-BCTs identified both in the previous studies and among the 30 lexical CCs identified in the present study. Two of these CTs appear across all these studies: *bordo* 'claret' and *bej* 'beige'. It is interesting to note that both the current study results and Özgen and Davies [20] listed *yavruağzı* 'peach' and *somon* 'salmon', whereas Ekici et al. [36] revealed only *yavruağzı* (glossed by them 'salmon'). Uusküla and Bimler [27] and Rätsep [41] glossed *yavruağzı* as 'peach'; however, Rätsep ([41]: 60) listed it as "the most frequent compound term," while it was not included among "the most frequent simple, non-basic color terms," and was therefore not included in Table 2. *Eflatun* 'mauve' and *krem* 'cream' are indicated in all the previous studies [20, 27, 36, 41], but they are not among the 30 lexical color categories of the current study. In our list of the frequent CTs, only three color terms (*açık mavi* 'light blue', *koyu yeşil* 'dark green', and *koyu gri* 'dark gray') have achromatic modifiers.

The differences between these studies may be due to methodological differences. In particular, Özgen and Davies [20], Uusküla and Bimler [27], and Rätsep [41] employed *production-of-terms* tasks—the listing task and color-naming task. In comparison, Şahin [38] and Ekici et al. [36] conducted the *term-to-color-matching* task, whereby they used the pre-selected list of 32 frequent chromatic names compiled from "dictionaries, catalogs from painting, dyeing, textile, carpet industries, theses from language departments, literature" ([38]: 99). For example, Ekici et al. [36] uniquely included *leylak* in their term-to-color-matching task and glossed it as 'lilac', but did not include *lila*, suggesting that these terms require further investigation in future studies.

The results of the present study also enable a discussion of frequently elicited culturally-specific non-BCTs like *kiremit rengi* 'tile red', *patlıcan moru* 'eggplant purple', *gece mavisi* 'night blue', and *çingene pembesi* 'Gypsy pink', with all four terms among frequent non-BCTs also identified by Ekici et al. [36] and apparently reflecting the "color diet" of Turkish speakers.

Among the identified frequent Turkish non-BCTs, we also note loanwords. The previous study ([27]: 79) noted high-frequency *lila* 'lilac' with Mylonas et al. [50] remark that loanwords borrowed from other languages not infrequently do not bear a relationship between perceptual similarities of such cognates and the origin of the word that the color name is derived from. Note also that the addition of *rengi* 'color' in *lila rengi*, as it is elicited in the present study, is similar to the English construction 'color of X', which indicates that the loanword is in the process of being established in the language as a color term proper. In the list of the 30 frequent non-BCTs (Figure 6), one can see some other terms with *rengi*: *hardal rengi* 'mustard color', *kiremit rengi* 'tile red color', *10 rengi* 'skin color'.

Among our 30 frequent CTs not infrequent are *petrol mavisi* 'petroleum blue' and *petrol yeşili* 'petroleum green,' whereas only Rätsep [41] mentioned *petrol* 'petroleum' in her study. Four non-BCTs elicited in the present study (*hardal rengi* 'mustard color', *10 rengi* 'skin color', *su yeşili* 'aqua green,' and *pudra* 'powder pink') are not listed in any of the previous studies, whose data, to our knowledge, had been collected at the latest in 2010. The

current list of the elicited terms apparently reflects lexical refinement of the Turkish color inventory in last decades, whose frequent and/or novel terms are denotatively similar to translation equivalents in contemporary American English [46], Serbian [60], Italian [61], and Russian [62], to name just a few. We venture to attribute the popularity of these novel non-BCTs to globalization processes.

Color communication is a vital part of everyday life, with several implementations in trade, design, and so on. Improving color communication between and within languages breaks new ground and enables cutting-edge technologies for different industries. In conclusion, the findings of the current study contribute to several disciplines by revealing the Turkish “indispensable” color lexicon established in the web-based psycholinguistic experiment.

### Author Contributions

**Begüm Ulusoy:** investigation, resources, data curation, writing – original draft, writing – revision and editing. **Lewis D. Griffin:** data analysis, writing – revision and editing, supervision. **Dimitris Mylonas:** investigation, resources, data curation, data analysis, data visualization, writing – original draft, writing – revision and editing.

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### Conflicts of Interest

The authors declare no conflicts of interest.

### Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

### References

1. B. M. Whelan, *Color Harmony* (Rockport Publishers, 1994).
2. D. Mylonas and L. MacDonald, “Colour Naming for Colour Communication,” in *Colour Design: Theories and Applications* (Elsevier, 2012), 254–270.
3. J. A. Schirillo, “Tutorial on the Importance of Color in Language and Culture,” *Color Research & Application* 26 (2001): 179–192.
4. I. Marín-Franch and D. H. Foster, “Number of Perceptually Distinct Surface Colors in Natural Scenes,” *Journal of Vision* 10, no. 9 (2010): 1–7, <https://doi.org/10.1167/10.9.9>.
5. K. Masaoka, R. S. Berns, M. D. Fairchild, and F. M. Abed, “Number of Discernible Object Colors Is a Conundrum,” *Journal of the Optical Society of America. A, Optics, Image Science, and Vision* 30 (2013): 264–277.

6. D. Mylonas and L. MacDonald, “Augmenting Basic Colour Terms in English,” *Color Research & Application* 41 (2016): 32–42.
7. R. W. Brown and E. H. Lenneberg, “A Study in Language and Cognition,” *Journal of Abnormal and Social Psychology* 49 (1954): 454–462.
8. B. Berlin and P. Kay, *Basic Color Terms: Their Universality and Evolution* (University of California Press, 1969/1991).
9. J. A. Lucy, “The Linguistics of Color,” in *Color Categories in Thought and Language*, ed. C. L. Hardin and L. Maffi (Cambridge University Press, 1997), 320–346.
10. G. G. Corbett and I. R. Davies, “Establishing Basic Colour Terms: Measures and Techniques,” in *Color Categories in Thought and Language*, ed. C. L. Hardin and L. Maffi (Cambridge University Press, 1997), 197–223.
11. I. Davies and G. Corbett, “A Cross-Cultural Study of Color-Grouping: Tests of the Perceptual-Physiology Account of Color Universals,” *Ethos* 26 (1998): 338–360.
12. L. D. Griffin, “Similarity of Psychological and Physical Colour Space Shown by Symmetry Analysis,” *Color Research & Application* 26 (2001): 151–157.
13. P. Kay and L. Maffi, “Color Appearance and the Emergence and Evolution of Basic Color Lexicons,” *American Anthropologist* 101 (1999): 743–760.
14. P. Kay and C. K. McDaniel, “The Linguistic Significance of the Meanings of Basic Color Terms,” *Language* 54 (1978): 610–646.
15. G. Paggetti, G. Menegaz, and G. V. Paramei, “Color Naming in Italian Language,” *Color Research & Application* 41 (2016): 402–415.
16. K. Coventry, C. Mitsakis, I. Davies, J. L. Jover, A. Androulaki, and N. Gómez-Peña, “Basic Colour Terms in Modern Greek: Twelve Terms Including Two Blues,” *Journal of Greek Linguistics* 7 (2006): 3–47.
17. G. G. Corbett and G. Morgan, “Color Terms in Russian: Reflections of Typological Constraints in a Single Language,” *Journal of Linguistics* 24 (1988): 31–64.
18. G. V. Paramei, Y. A. Griber, and D. Mylonas, “An Online Color Naming Experiment in Russian Using Munsell Color Samples,” *Color Research & Application* 43 (2018): 358–374.
19. G. V. Paramei, M. D’Orsi, and G. Menegaz, “‘Italian Blues’: A Challenge to the Universal Inventory of Basic Colour Terms,” *Journal of the International Colour Association* 13 (2014): 27–35.
20. E. Özgen and I. R. Davies, “Turkish Color Terms: Tests of Berlin and Kay’s Theory of Color Universals and Linguistic Relativity,” *Linguistics* 36 (1998): 919–956.
21. D. Bimler and M. Uusküla, “A Similarity-Based Cross-Language Comparison of Basicness and Demarcation of “Blue” Terms,” *Color Research & Application* 42 (2017): 362–377.
22. I. R. Davies and G. G. Corbett, “A Cross-Cultural Study of Colour Grouping: Evidence for Weak Linguistic Relativity,” *British Journal of Psychology* 88 (1997): 493–517.
23. I. R. Davies, P. T. Sowden, D. T. Jerrett, T. Jerrett, and G. G. Corbett, “A Cross-Cultural Study of English and Setswana Speakers on a Colour Triads Task: A Test of the Sapir–Whorf Hypothesis,” *British Journal of Psychology* 89 (1998): 1–15.
24. K. A. Jameson and N. Alvarado, “Differences in Color Naming and Color Salience in Vietnamese and English,” *Color Research & Application* 28 (2003): 113–138.
25. H. Lin, M. R. Luo, L. W. MacDonald, and A. W. S. Tarrant, “A Cross-Cultural Colour-Naming Study. Part I: Using an Unconstrained Method,” *Color Research & Application* 26 (2001): 40–60, [https://doi.org/10.1002/1520-6378\(200102\)26:1<40::AID-COL5>3.0.CO;2-X](https://doi.org/10.1002/1520-6378(200102)26:1<40::AID-COL5>3.0.CO;2-X).
26. M. Sekicki, J. Viethen, M. Goudbeek, and E. Krahmer, “The Use of Colour in Reference Production: A Comparison Between Dutch and

- Greek,” in *In Proceedings of the Annual Meeting of the Cognitive Science Society* (Cognitive Science Society, 2014), 247, 1407–1412. CogSci 2014, Québec City, Canada.
27. M. Uusküla and D. Bimler, “From Listing Data to Semantic Maps: Crosslinguistic Commonalities in Cognitive Representation of Colour,” *Folklore* 64 (2016): 57–90, <https://doi.org/10.7592/FEJF2016.64.colour>.
28. A. Chapanis, “Color Names for Color Space,” *American Scientist* 53 (1965): 327–346.
29. J. Stanlaw, “Two Observations on Culture Contact and the Japanese Color Nomenclature System,” in *Color Categories in Thought and Language*, ed. C. L. Hardin and L. Maffi (Cambridge University Press, 1997), 240–260.
30. A. S. Al-rasheed, “Further Evidence for Arabic Basic Colour Categories,” *Psychology* 5 (2014): 1714–1729.
31. K. Rätsep, “Some Remarks on Gender Differences in Turkish Colour Vocabulary. In Proceedings of the Second Central European Conference in Linguistics for Postgraduate Students. Second Central European Conference in Linguistics for Postgraduate Students (CECIL’s 2), Pázmány Péter Catholic University, Piliscsaba, Hungary, 24–25,” (2012).
32. R. W. Casson, “Color Shift: Evolution of English Color Terms From Brightness to Hue,” in *Color Categories in Thought and Language*, ed. C. L. Hardin and L. Maffi (Cambridge University Press, 1997), 224–239.
33. N. Moroney, “Unconstrained Web-Based Color Naming Experiment. Color Imaging VIII: Processing, Hardcopy, and Applications,” (2003) Proc. SPIE, 5008:36–46.
34. D. Mylonas and L. W. MacDonald, “Online Colour Naming Experiment Using Munsell Colour Samples,” in *In Conference on Colour in Graphics, Imaging, and Vision* (Society for Imaging Science and Technology, 2010), 27–32.
35. U. Reips, “The Web Experiment Method: Advantages, Disadvantages, and Solutions,” in *Psychological Experiments on the Internet*, ed. M. H. Bornbaum (Academic Press, 2000), 89–118.
36. E. Ş. Ekici, C. Yener, and N. Camgöz, “Colour Naming,” *Optics and Laser Technology* 38 (2006): 466–485.
37. H. A. Kiyak, “Interlingual Interference in Naming Color Words,” *Journal of Cross-Cultural Psychology* 13 (1982): 125–135.
38. E. Şahin, *Color Naming* (Bilkent Üniversitesi, 1998).
39. D. A. Kadıhasanoğlu, *A Cross-Cultural Study on Color Perception: Comparing Turkish and Non-Turkish Speakers’ Perception of Blue*. Master’s Thesis (Middle East Technical University, 2007).
40. K. Rätsep, “Preliminary Research on Turkish Basic Colour Terms With an Emphasis on Blue,” in *New Directions in Colour Studies*, ed. C. P. Biggam, D. R. Simmons, C. Kay, and C. Hough (John Benjamins, 2011), 133–145.
41. K. Rätsep, *Colour Terms in Turkish, Estonian and Russian: How Many Basic Blue Terms Are There?* (University of Tartu, 2018), <https://core.ac.uk/download/pdf/187733469.pdf>.
42. D. Jonauskaite and D. T. Lindsey, “Bridging Color Standards: Aligning the Color-Aid System With the International Commission on Illumination (CIE) and the Munsell Book of Color Coordinates,” *Color Research & Application* 51 (2026): e70087, <https://doi.org/10.1002/col.70087>.
43. D. Mylonas, L. MacDonald, and S. Wuerger, “Towards an Online Color Naming Model,” in *Color and Imaging Conference* (Society for Imaging Science and Technology, 2010), 140–144.
44. J. L. Barbur, J. Harlow, and G. T. Plant, “Insights Into the Different Exploits of Colour in the Visual Cortex,” *Proceedings of the Royal Society of London, Series B: Biological Sciences* 258 (1994): 327–334.
45. P. Kay, B. Berlin, L. Maffi, W. Merrifield, and R. Cook, *The World Color Survey* (CSLI Publications, 2010).
46. D. T. Lindsey and A. M. Brown, “The Color Lexicon of American English,” *Journal of Vision* 14 (2014): 17, <https://doi.org/10.1167/14.2.17>.
47. J. Sturges and T. A. Whitfield, “Locating Basic Colours in the Munsell Space,” *Color Research & Application* 20 (1995): 364–376.
48. C. K. Varnhagen, M. Gushta, J. Daniels, et al., “How Informed Is Online Informed Consent?,” *Ethics & Behavior* 15 (2005): 37–48, [https://doi.org/10.1207/s15327019eb1501\\_3](https://doi.org/10.1207/s15327019eb1501_3).
49. J. Heer and M. Stone, “Color Naming Models for Color Selection, Image Editing and Palette Design. Proceedings of the 2012 ACM Annual Conference on Human Factors in Computing Systems 2012, CHI’12: 1007–1016,” (2012), <https://doi.org/10.1145/2208516.2208547>.
50. D. Mylonas, S. Caparos, and J. Davidoff, “Augmenting a Colour Lexicon,” *Humanities & Social Sciences Communications* 9 (2022): 1–12, <https://doi.org/10.1057/s41599-022-01045-3>.
51. S. Kerttula, “Relative Basicness of Colour Terms,” in *Anthropology of Color: Interdisciplinary Multilevel Modeling*, ed. R. E. MacLaury, G. V. Paramei, and D. Dedrick (John Benjamins Publishing, 2007), 151.
52. C. Witzel, “Misconceptions About Colour Categories,” *Review of Philosophy and Psychology* 10 (2019): 499–540, <https://doi.org/10.1007/s13164-018-0404-5>.
53. L. D. Griffin and D. Mylonas, “Categorical Colour Geometry,” *PLoS One* 14 (2019): e0216296, <https://doi.org/10.1371/journal.pone.0216296>.
54. B. Ulusoy, L. D. Griffin, and D. Mylonas, “Turkish Colour Naming on the Net. In Proceedings of the 13th AIC Congress,” (2017).
55. B. Sezgin, *Yeni Argo Sözlüğü [New Slang Dictionary]* (Cinius Yayınları, 2013).
56. M. Oguz, “How Similar Are the Colour Idioms of Different Languages?: A Comparative Study of Estonian, Swedish, and Turkish,” in *Progress in Colour Studies: Colour Expression and Cognition*, ed. C. P. Biggam, D. Jonauskaite, M. Uusküla, and D. Mylonas (John Benjamins Publishing Company, 2026), 74–112, <https://doi.org/10.1075/z.244.05ogu>.
57. Fenerbahçe Spor Kulübü, “Fenerbahçe SK,” (n.d.), <https://www.fenerbahce.org/kulup/fenerbahce-sk>.
58. Fenerbahçe Spor Kulübü, *Fenerbahçe Spor Kulübü Tüzüğü* (Fenerbahçe Spor Kulübü, 2023).
59. Tureng, “Gıpta. Tureng Turkish–English Dictionary,” (n.d.), <https://tureng.com/en/turkish-english/g%C4%B1pta>.
60. I. Jakovljević and S. Zdravković, “The Colour Lexicon of the Serbian Language – A Study of Dark Blue and Dark Red Colour Categories. Part 1: Colour-Term Elicitation Task,” *Psihologija* 51 (2018): 197–213, <https://doi.org/10.2298/PSI160521002J>.
61. M. M. Del Viva, S. Castellotti, and G. V. Paramei, “The Italian Colour Lexicon in Tuscany: Elicited Lists, Cognitive Salience, and Semantic Maps of Colour Terms,” *Humanities and Social Sciences Communications* 10 (2023): 900, <https://doi.org/10.1057/s41599-023-02393-4>.
62. Y. A. Giber, A. I. Ivleva, V. D. Solovyev, and G. V. Paramei, “The Russian Colour Lexicon and Its Diatopic Variation: Elicited Lists, Cognitive Salience of Colour Terms, and Neologism Boom,” *Humanities and Social Sciences Communications* 13 (2026): 681, <https://www.nature.com/articles/s41599-026-07021-5>.

## Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Data S1:** col70121-sup-0001-Supinfo.docx.