Color Naming and Communication of Color Appearance: Is it Different for Native Georgian Speakers?

Ana Amirkhanashvili[1] and Davit Gigilashvili[2]

[1] Literary Georgia; Tbilisi, Georgia
ana4400@yahoo.com
[2] The Norwegian Colour and Visual Computing Laboratory, Norwegian University of Science and Technology, Gjøvik, Norway
davit.gigilashvili@ntnu.no

Abstract. Color is one of the most prominent appearance attributes. The terms used by humans to communicate color appearance and to set categorical boundaries in the color space have long been a point of scholarly interest. Two conflicting theories of universal and culture-relative color naming have been addressed by numerous studies. While the characteristics of color naming have been studied in considerable number of languages, the quantity of basic color terms and the variation of color categories across the languages is still a matter of an ongoing debate. Color naming in English is widely explored and compared with numerous languages, including the languages of non-industrialized societies. Being the unrelated languages, we hypothesize that the basic color terms and the categorical boundaries vary between the English and Georgian languages. To test this hypothesis, we conducted experiments with native Georgian speakers and compared the results with the state-of-the-art in context of English. The results have revealed interesting differences as well as similarities that are worth exploring further.

Keywords: color naming · color terms · Georgian language.

1 Introduction

Color is one of the most significant attributes for description of appearance. In addition to perception of color appearance, i.e. the interpretation of the physical sensory stimuli, humans also need to describe and communicate it to other humans. We need to simplify this process both due to pragmatic, as well as physiological reasons. The proposed number of colors the human visual system can discriminate in a scene varies from several thousand [25] to several million [23], while we are able to memorize just around 300 of them [11]. Therefore, humans tend to categorize large number of the similar color stimuli together and give

Copyright © 2020 for this paper by its authors. Use permitted under Creative Commons License Attribution 4.0 International (CC BY 4.0). Colour and Visual Computing Symposium 2020, Gjøvik, Norway, September 16-17, 2020.

CEUR-WS.org/Vol-2688/paper6.pdf

them labels - leading to the process of *color naming.* The topic has been point of scholarly interest in linguistics, anthropology, vision and color science alike.

There is an ongoing scholarly debate on the regularities and variations in color naming across languages. In 1956, Whorf [32] (cited by [12]) introduced the idea that language shapes human perception. After Berlin and Kay [4] theorized the cross-language universality of color naming, numerous works addressed the question whether color naming patterns are pan-human (proposedly due to physiology [13]) or culture-specific. However, it has been suggested (e.g. [15]) that *"color categories are neither completely universal, nor completely relative"* [34] and the strictly dichotomous approach is considered obsolete by the recent reviews [34, 35]. While color naming peculiarities vary across languages, reflecting socio-cultural and socio-historical character [28], the debates might arise within a particular language too (refer to a recent discussion whether a tennis ball is green or yellow [17]).

In order to explore the process of color categorization, we need to identify what these categories are. A broad range of vocabulary can be used to describe colors, depending on the context and the speaker [34], leading to redundant and sometimes poorly intelligible color categories. Thus, not all categories or terms are equally important. Berlin and Kay [4] have proposed that all languages follow the same evolutionary path and hierarchy in the development of color terms, naming 11 basic color categories: *white, black, red, green, yellow, blue, brown, orange, pink, purple,* and *gray.* Since then, the theory has been supported [7, 8] as well as challenged [6, 26] by numerous studies. The following have been the criteria for *basicness*: the term should be monolexemic (in other words, not to be composite of several independent words, or as explained by Crawford [6] *"the term should not be transparent to the native speaker"*); its usage by native speakers is frequent and consistent; it should not be subset of a larger category (e.g. *ruby* can be a subset of red); it should be context independent - applicable to broad range of objects and materials. Additionally, the term should not include a reference to an object. The number of basic terms in different languages, as well as the legitimate criteria for *basicness* remain debatable. The original definition of *basicness* has been challenged and revised multiple times (see [34] for review). It has been questioned whether the terms need to be monolexemic and independent of object references [5, 18]. Witzel [34] argues that instead of being dichotomous, *"basicness should be conceived as a continuous and gradual charcteristic"* and considers frequency and consistency of the usage, as well as consensus among speakers, promising parameters of the degree of *basicness.*

In the light of the ongoing debate, the Georgian language is an interesting example for two primary reasons: first, Georgian belongs to the Kartvelian language family being unrelated to English and all other Indo-European languages and its lexicon includes color categories different from English; secondly, in context of the *basicness* debate, Georgian provides an instance of an industrialized society broadly using terms that are neither monolexemic, nor free from object references - the characteristic usually observed in the languages of remote, non-industrialized societies. Color term formation in the Georgian language is a specific case and is characterized with the ease of producing or inventing a new color term as a composite word - any material or object name in a genitive case supplemented with a -*peri* (color) suffix is a color name intelligible for most native speakers who are familiar with the named object or material. This ease and flexibility of color term creation leads to unusual color terms in everyday life, art and literature alike (the Georgian historical novel *The Right Hand of the Grand Master* is famous for using more than 70 color terms throughout the narrative). Five Georgian equivalents out of Berlin and Kay's eleven basic color terms do not conform to above-mentioned *basicness* criterion (brown - *kavisperi*, literally translated as "color of coffee"; gray - *natsrisperi*, color of ash; orange - either *stapilosperi, narinjisperi,* or *portokhlisperi*, color of carrot, color of bitter orange, or color of orange; pink - *vardisperi*, color of rose; and purple - *iasamnisperi*, color of lilac). Moreover, even for the basic terms, like orange or gray, there are numerous synonyms used interchangeably among the speakers. In addition to these, a Georgian word *tsisperi* - color of sky, is broadly used and usually distinguished from blue, similarly to Russian "goluboj" potential basicness of which has been broadly addressed [3, 27, 29, 33] and that does not exist in English.

On that account, we hypothesize that specificities of the Georgian language might lead to the primaries different from those of [4]. For studying this hypothesis, we conducted an experimental study implementing the methodology proposed by Davies and Corbett [8]. The results of the study will not only provide a deeper insight into color naming in a particular language, but in broader sense might also reveal interesting indications regarding the universality of color communication across different cultures and languages. The contribution of the study is trifold:

- We identify the most prevalent color categories in the Georgian language.
- We discuss the *basicness* of these terms and how they relate to the proposed *basicness* criteria, also comparing with the 11 basic terms in English.
- We also try to identify the boundaries among particular categories.

To the best of our knowledge, this is the first study of this kind in context of the Georgian language. We want to highlight that the primary objective of this study is to identify trends, and we do not claim accurate quantitative modelling of color categories due to limited control of the experimental conditions. The paper is organized as follows: in the next section, we overview related work. In Section 3, we present research methodology and explain the experimental setup. The results are analyzed and discussed in Section 4. In Section 5, we draw conclusions and propose directions for the future work.

2 Related Work

Potential universality of color naming patterns is yet to be understood, and various cross-cultural similarities [14, 21] and differences [18, 27] in color naming have been described. The World Color Survey initiative [2] investigated 110 unwritten languages from around the world in order to test the universality hypothesis of color naming. Based on this data, Lindsey and Brown [21] argue that all color naming procedures fall into three to six "motifs", i.e. color naming systems being derived from 11 basic terms reflecting historical influences. It has been proposed that the lack of blue term in some languages has a physiological background and is the result of increased exposure to ultraviolet radiation in some geographical regions [20]. Inversely, Winawer *et al.* [33] have demonstrated that language difference might lead to different color discrimination capabilities. Gigilashvili *et al.* [9, 10] have observed that the semantic description of material appearance, including color, gloss and translucency terms, largely varies among subjects and is impacted by individual background, memory and experience.

Few works have addressed color communication in the Georgian language. Manasyan [24] studied emotional associations with color terms. Khomeriki *et al.* [16] conducted two experiments to identify categorical boundaries between red and pink, and between blue and *tsisperi* light blue colors. They concluded that the boundaries vary both due to experimental protocol and inter-subject differences. They also propose that adding white to blue and red (i.e. making them lighter) leads to *tsisperi* and *vardisperi* color categories that are not affected by the semantic meaning of the basis words *vardi* - rose and *tsa* - sky.

3 Methodology

In order to experimentally identify basic color terms in the Georgian language, we used a research methodology proposed by Davies and Corbett [8]. The methodology is derived from the study by Berlin and Kay [4] and consists of two parts: 1. the *list task* - also known as *term elicitation task* to collect all potential candidate terms and to identify the most salient ones. 2. *the color naming task* - to map verbal terms with the actual physical stimuli in the color space and to identify potential boundaries between the color categories. The rationale for selecting this methodology is that it is optimized for practical field study and does not require controlled laboratory conditions. The authors have tested the proposed method in context of the English language and reported the results consistent with Berlin and Kay [4].

3.1 List task

Procedure The study was conducted online. The participants were asked to name all color terms they could recall and to list them in the same order as the terms came to their mind. For consistency with [8], the time limit of five minutes was set. The instructions were given in Georgian, translated as follows: *"Write down all color terms which you can recall maximum within 5 minutes. Write them in the same order as they come to your mind - the first color you recalled should be written first, and so forth. It is important to rely solely on your memory and do not use any literature or electronic systems of search".*

Subjects 27 native Georgian speakers participated in the study, including two authors of this paper. 18 of them were female and 9 were male. The age of the participants was within the range of 19-63 years, with 37.8 as a mean and 31 as a median age. Participation was voluntary and the subjects were not compensated. Subjects' color vision was not tested and the results might be affected by unidentified color deficient participants. However, having randomly selected sample of populace, we assume that the number of color deficient participants was not large enough to have considerable impact on the overall trends.

Analysis Davies and Corbett [8] propose two primary metrics for identification of basic terms: *frequency* - i.e. the number of subjects mentioning a particular term (presented as an absolute number in this study; it is possible also to be presented as % of all participants), and *mean position* - i.e. the mean of the ranks given to a particular term by the subjects. According to Rätsep [29], the two metrics are correlated - frequently used terms are named earlier, while less frequent terms are ranked in the end of the list. For this reason, we plot and analyze *mean position* as a function of *frequency*.

On the other hand, the mean position can be strongly affected by the total number of the terms. In order to eliminate this bias and to unify *frequency* and *mean position* into a single metric, Sutrop [30] introduced a *Cognitive Salience Index* (referred below as *congitive salience*), which is found as:

$$S = \frac{F}{N \times mP} \tag{1}$$

where **S** is cognitive salience of a given term, **F** is frequency, **N** is total number of subjects, and **mP** is mean position.

Sutrop's index has also been shown to be prone to bias, such as being unreliable for very low frequencies [29], as well as overestimating salience of the top one or two terms [29, 31]. Since we are interested in comparing 11 most salient terms with the basic colors of Berlin and Kay [4], we do not consider these limitations significant and report Sutrop's Cognitive Salience Index in our analyses.

The terms that are sometimes considered synonymous (e.g. *stapilosperi* (color of carrot) and *narinjisperi* (color of bitter orange)) are included as separate terms, because we lack the information whether the individual subjects use them interchangeably or to describe different stimuli. However, the terms that clearly refer to the same object, but are expressed either with a native Georgian word or a barbarism (foreign language counterpart) are considered the same term (e.g. *zholosperi* (color of raspberry) and *malinisperi* (color of malina); *zholo* is a Georgian term for raspberry, and *malina* is a Russian term for raspberry.).

3.2 Naming task and term boundaries

Procedure The task was conducted online after completion of the list task. The participants were shown 75 color stimuli as square patches and were asked to name the color of the patch. No options were given and the subjects had full freedom in selection of the proper term. They could scroll back and forth the stimuli throughout the experiment. Similarly to [8], the subjects were allowed to write *"I do not know"*, if uncertain. The instructions were given in Georgian and can be translated as follows: *"75 squares of various colors are presented to you. Write below each square what color it is, in your opinion. Write that color term, whichever comes first to your mind. If it is hard to answer, you can write "I do not know."*.

Stimuli We have used 75 color stimuli in total. 65 of the stimuli were exactly the same 65 stimuli selected by Davies and Corbett [8] from the Color-Aid Corporation [1]. The exact CIE color coordinates of the stimuli can be found in Table 1 of [8] (D65 reference white was assumed). In addition to that, we studied 4 stimuli proposed by Khomeriki *et al.* [16] as potential boundaries between *lurji-tsisperi* (blue-sky blue) and *tsiteli-vardisperi* (red-pink), respectively. Finally, in order to check the hypothesis by Khomeriki *et al.* [16] that *tsisperi* and *vardisperi* are blue and red with high lightness, respectively, we considered 3 additional blue and 3 additional red stimuli with the identical chromaticity to B and R stimuli in [8], but with higher CIELAB L* value. The positions of the stimuli in the *CIE xy chromaticity diagram* is illustrated in Figure 1. The stimulus patches were displayed on a white background. This method comes with multiple limitations:

1. Variation among display parameters and observation conditions might have produced different color appearance for different subjects. In the future, we aim to conduct the study on a fully calibrated display in controlled laboratory conditions.
2. Colour-Aid stimuli come in a form of physical tiles rather than digital image. Cross-media color reproduction might render different color appearance for given color coordinates.
3. Unconstrained naming leads to large cross-subject differences [34], as the response depends on subjects' motivation, interpretation of the task, and the levels ("resolution") of categorization (i.e. using either very general vocabulary or a very detailed sub-basic differentiation).

On the other hand, constrained naming task, when the subjects should select an answer from a pre-defined pool of terms, leads to more consistent results. There are reasons for selecting unconstrained naming scenario in this work: first, we are not able to identify the "optimal" pool of the pre-defined terms - there is no state-of-the-art, as this is the first study of this kind in context of the Georgian language. Relying simply on the terms identified in the list task might have been an option, yet unrealiable, posing a risk of omission of essential vocabulary; secondly, being unaddressed in prior studies, the range of used vocabulary and the extent of individual differences were interesting themselves (e.g. idiolects are common in language communities [22]). This protocol is known to reveal a broad range of the vocabulary existent in a given language [19]. Although the full freedom given to the observers makes it more difficult to identify basic color terms, we assume that with the sufficiently large number of subjects, the effect of individual oddities will be attenuated. We are aware that the above-mentioned limitations might bias the frequency and consistency of color term usage and undermine comparison with other studies. However, this study is primarily of an exploratory nature and the precise quantitative modelling between physical stimuli and perceptual or verbal categorical boundaries should be addressed in the subsequent works.

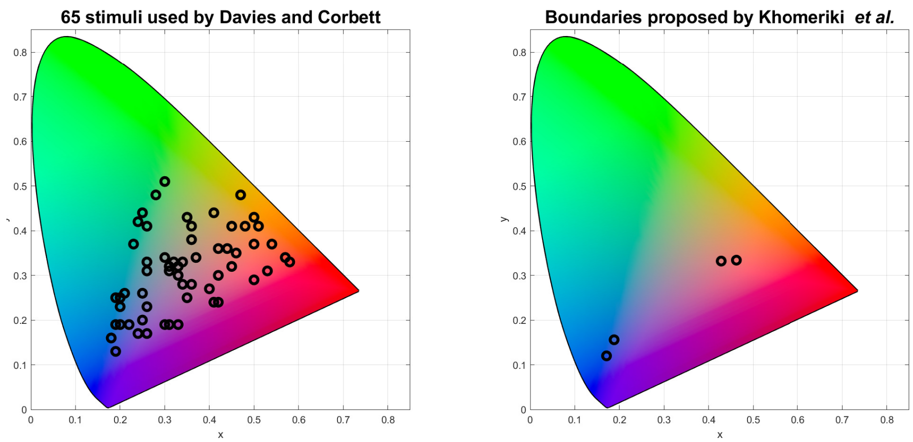

Fig. 1. Location of the stimuli in CIE xy chromaticity space. The left image shows the stimuli used in [8] and the right one corresponds to *lurji-tsisperi* and *tsiteli-vardisperi* boundaries proposed by Khomeriki *et al.* [16].

Subjects 22 native Georgian speakers, including the authors of this paper, completed the task - 16 females and 6 males among them. The age ranged from 20 to 63 years, with 38 as a mean age and 37 as a median. 18 of the subjects had also participated in the *list task*, while 4 of them did not.

Analysis The results of this task are bi-fold: we try to identify basic color terms, and to observe how these color categories are scattered across the color space. For the latter task, we plot the stimuli in the CIELAB color space labelled with the most frequent color terms used to describe them. For the former task, we refer to the concept of dominance - i.e. a particular term being the most frequently used word to describe a given color stimulus. Similarly to Davies and Corbett [8], for all terms we analyze how many color stimuli it has been a dominant term for, for how many of these cases was there a consensus among more than 50% and 75% of the subjects, and how many times this term was used in general. In addition to that we also use the *specificity index* - *"a ratio of the total frequency of use for each term and the total frequency for those stimuli where a term was dominant"*, as formulated by Rätsep [29].

4 Results and Discussion

4.1 List task

66 color terms have been named in total. Minimum 5 and maximum 29 terms were mentioned by an individual subject. 16.5 colors were named on average.

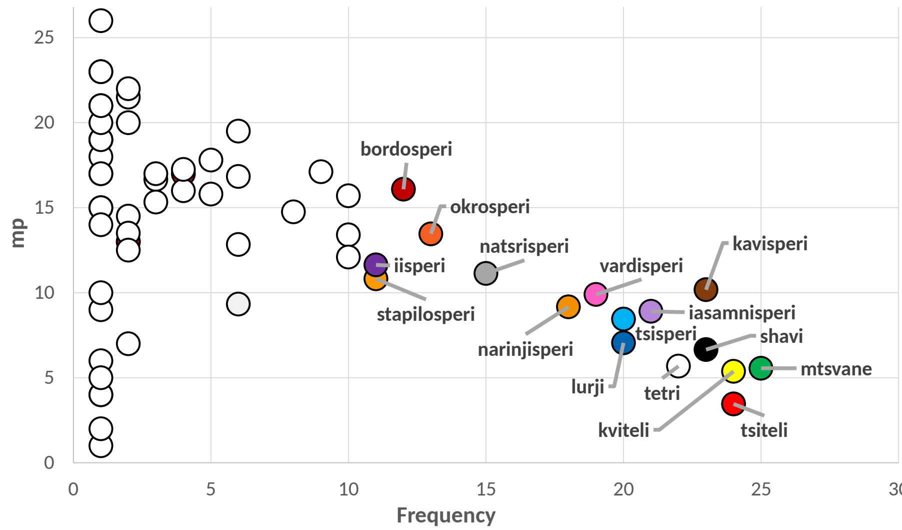

Fig. 2. *Mean position* as a function of *frequency*. The terms that have been used by more than 10 subjects are labeled and colored with the respective color. Except for the terms that have been used just by one subject, generally, *mean position* and *frequency* of usage are negatively correlated.

The results are illustrated in Figure 2. Considering that higher frequency and lower mean position speak of salience and basicness of the term, the terms closer to bottom right corner of the plot are more likely to be basic.

11 most salient as well as most frequently used terms are *mtsvane* (green), *tsiteli* (red), *kviteli* (yellow), *shavi* (black), *kavisperi* (literal translation - color of coffee; closest English equivalent - brown), *tetri* (white), *iasamnisperi* (color of lilac; lilac or purple), *lurji* (blue), *tsisperi* (color of sky; light blue or sky blue), *vardisperi* (color of rose; pink). Also more than 10 people listed *narinjisperi* (color of bitter orange; orange), *natsrisperi* (color of ash; gray), *okrosperi* (color of gold; gold), *bordosperi* (color of Bordeaux; burgundy), *stapilosperi* (color of carrot; orange), and *iisperi* (color of violet; violet). The results for Sutrop's cognitive salience are illustrated in Figure 3. In addition to colors mentioned above, *lalisperi* (color of ruby; ruby), *shindisperi* (color of Cornelian cherry; dark red), *rukhi* (gray or dark gray), *zurmukhtisperi* (color of emerald; emerald), *vertskhlisperi* (color of silver; silver), *salatisperi* (color of salad; light green), *kremisperi* (color of cream; cream) and *shabiamnisperi* (color of blue vitriol; bright blue) are among the 25 most salient ones by cognitive salience index. Interestingly, **all of the six most salient terms are *monolexemic*.**

There have also been various terms that are relatively unusual but still intelligible for most native Georgian speakers. For example, four subjects listed *agurisperi* (color of brick), three of them mentioned *zhangisperi* (color of rust) and *tsablisperi* (color of chestnut), two people named *aspaltisperi* (color of asphalt) and *tsklisperi* (color of water), while *badrijnisperi* (color of eggplant), *mtredisperi* (color of dove), *khokhbiskelisperi* (color of pheasant's neck - seem-

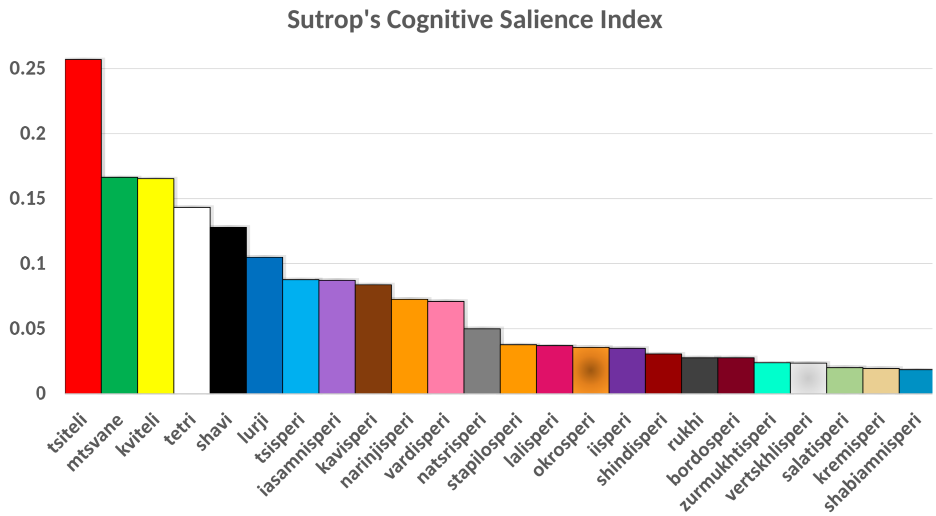

Fig. 3. 25 most salient color terms by Sutrop's Cognitive Salience Index. For illustration purposes, the bars are colored with the respective hues.

ingly, recalled from above-mentioned novel *The Right Hand of the Grand Master*), *ghvinisperi* (color of wine), *lobiosperi* (color of peas), *marjnisperi* (color of coral) by one person each. Also one subject listed *upero* (colorless, achromatic). While the most salient terms identified in this study are largely consistent with Berlin and Kay's [4] 11 basic colors, there are some differences too: *iasamnisperi* (color of lilac) is among the most salient color terms; in Georgian it is oftentimes used interchangeably with lilac, purple and violet. In this case, it can be considered the equivalent to English purple. *Tsisperi* (color of sky) is also among the most frequently used ones. While this term is absent in English, it can potentially be a basic term in Georgian, similarly to Russian "goluboj" [3, 27, 29, 33]. There are two widely used terms to describe orange color in Georgian: *narinjisperi* (color of bitter orange) and *stapilosperi* (color of carrot). They are used either interchangeably, or according to individual interpretation. The same is the case for gray: terms *natsrisperi* (color of ash) and *rukhi* are used as synonyms, *rukhi* having a connotation of slightly darker shade of gray in some specific contexts. Intriguingly, *rukhi* is not among the most salient terms, even though it is *monolexemic*. Even if we count all mentions of *narinjisperi* and *stapilosperi* as the same term, and we assume the same for *natsrisperi* and *rukhi*, they will be tied with *tsisperi* and *vardisperi* by frequency. In terms of cognitive salience index, *tsisperi* still remains ranked among the top seven most salient terms.

4.2 Naming task and term boundaries

The results for the naming task are summarized in Table 1. It is worth mentioning that the frequency depends on the number of stimuli examined, as well as the sampling of the stimuli across the color space. In order to make our results comparable with [8], at first only 65 color stimuli used by them are analyzed.

Table 1. Dominant terms for 65 color stimuli. Only those terms are reported that were considered dominant for at least one stimulus. **DI** - Dominance Index, the number of stimuli this term has been dominant for. For some stimuli, there were more than one dominant term, so the sum exceeds 65. **DI>50%** and **DI>75%** - the number of stimuli this term has been dominant for with the respective percent of consensus. **D. Freq.** - frequency of this term considering only the stimuli it has been dominant for. **Freq.** - frequency of this term throughout the entire task. **Spec.** - Specificity Index.

Dominant term	**DI**	**DI >50%**	**DI >75%**	**D. Freq.**	**Freq.**	**Spec.**
iasamnisperi (color of lilac) [purple]	**9**	4	0	98	122.5	0.80
vardisperi (color of rose) [pink]	8	**6**	2	110	124	0.89
lurji (blue)	7	5	2	98	135	0.73
mtsvane (green)	7	**6**	**5**	**115**	134	0.86
natsrisperi (color of ash) [gray]	6	2	0	54.5	82	0.66
I don't know	6	0	0	49	**154**	0.32
kavisperi (color of coffee) [brown]	5	2	0	61.5	66.5	**0.92**
stapilosperi (color of carrot) [orange]	4	1	0	37	43	0.86
tsisperi (color of sky) [light blue]	4	3	1	56.5	67.5	0.84
tsiteli (red)	3	2	1	44	54.5	0.81
tchaobisperi (color of swamp) [swamp green]	2	0	0	13	23	0.57
agurisperi (color of brick) [brick red]	2	0	0	11	21	0.52
kviteli (yellow)	1	1	1	20	25	0.80
khakisperi (color of khaki) [khaki]	1	0	0	6	15	0.40
shindisperi (color of Cornelian cherry) [dark red]	1	0	0	8	20.5	0.39
iisperi (color of violet) [violet]	1	0	0	7	40	0.18
salatisperi (color of salad) [light green]	1	0	0	5	6	0.83
zholosperi (color of raspberry) [raspberry]	1	0	0	10	17	0.59
shavi (black)	1	0	0	11	34	0.32

Out of 1430 (65×22) responses, 154 i.e. more than 10% of all responses were "I do not know", speaking of an inherent difficulty of the task. It was also the most frequently used term throughout the entire task. Davies and Corbett [8] reported that dominant terms (i.e. the most frequently used terms for a given stimulus) were the 11 basic terms. Unlike their results, this is not the case for our data. While white was not considered dominant for any single stimulus, *iasamnisperi* (literally - color of lilac) has the highest dominance index, being dominant for 9 stimuli, followed by pink, blue, green, and gray. This can be explained by the fact that *iasamnisperi* is interchangeably used for lilac, purple, violet and all their shades, while red that was dominant for 3 stimuli only has lower overall frequency, because broader range of words can be used in Georgian to describe reddish hues, such as *vardisperi* (pink), *agurisperi* (brick red), *shindisperi* (Cornelian cherry, dark red), *zholosperi* (raspberry) all being dominant for at least one stimulus. *Tsisperi* was also widely used, while *kavisperi* (color of coffee; brown) has highest specificity - i.e. when this term is used, most of the time it is dominant, and it is rarely used for the stimuli it is not dominant for. This can be explained by the fact that for all lighter shades of it, several other terms exist broadly used by native Georgian speakers (e.g. *agurisperi, narinjisperi*).

The stimuli labelled with the dominant term are plotted in the CIELAB color space, shown in Figures 4-5. It is worth highlighting that although *vardisperi* (pink) and *tsisperi* (sky blue) are lighter (refer to Fig. 5), they are well separated from *tsiteli* (red) and *lurji* (blue), respectively, even in the chromaticity plane only (Fig. 4). This questions the proposal by Khomeriki *et al.* [16] that *vardisperi* and *tsisperi* are simply lighter shades of red and blue. The location of the *vardisperi* stimuli in the color space makes us hypothesize that *vardisperi* is used to describe shades of magenta, not red, as previously thought. On the other hand, *lurji* (blue) and *iasamnisperi* (color of lilac) are not clearly separated further supporting our hypothesis about the broad understanding of the latter term and the interchangeable usage of it for various hues and shades that makes it the dominant term for the highest number of stimuli. Finally, it is also interesting that the stimuli with dominant "I do not know" are either between blue and green, or near the center. The former can be explained with the lack of words in Georgian to describe cyan and blue-green hues (blue, green, emerald and turquoise are often interchangeably used), while the former can be the result of confusion between gray and particular hue for dark weakly chromatic stimuli (all four are in the lower end of the L* axis, refer to Figure 5).

We studied 10 additional stimuli to address the proposals in [16]. Interestingly, both *tsiteli-vardisperi* boundaries reported by them were considered pink in our study, while for *lurji-tsisperi* the boundary from one of their experiment was considered *tsisperi*, while the other was still blue. Besides, we increased lightness of the red (R) and blue (B) stimuli from the Color-Aid dataset (refer to [8]). The original stimuli were considered *shindisperi* (color of Cornelian cherry) and *lurji* (blue). After increasing their CIELAB L* parameter gradually (from 40.75 to 50.75, 70.75, 90.75, and from 36.94 to 46.94, 66.94, 86.94, respectively), all lighter shades of red were considered pink (*vardisperi*), while blue was still

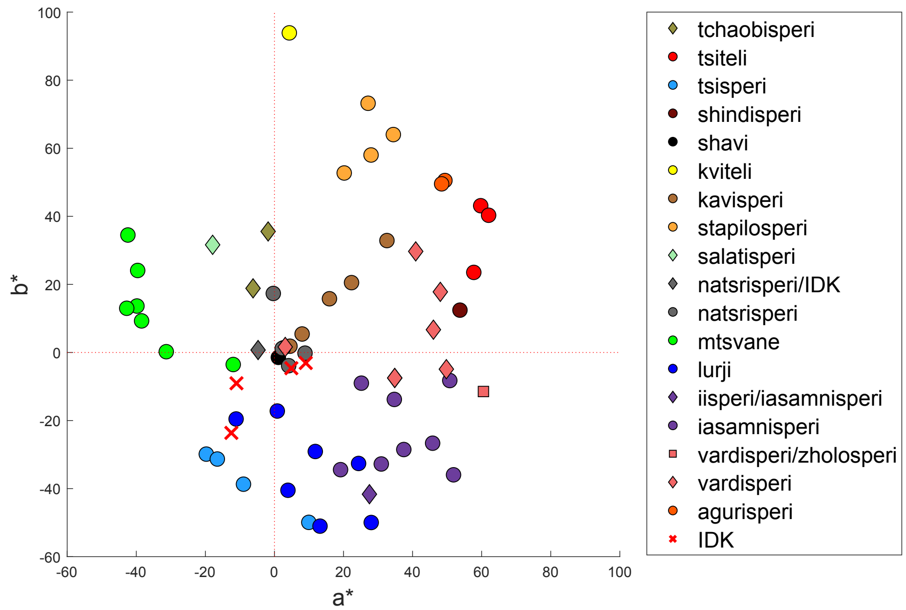

Fig. 4. 65 stimuli in CIELAB a*-b* plane labelled with the most frequent (dominant) term used to describe them. The stimuli with two dominant terms are shown as a separate category. IDK stands for "I do not know". D65 reference white point was assumed when converting CIE 1931 XYZ values to CIELAB.

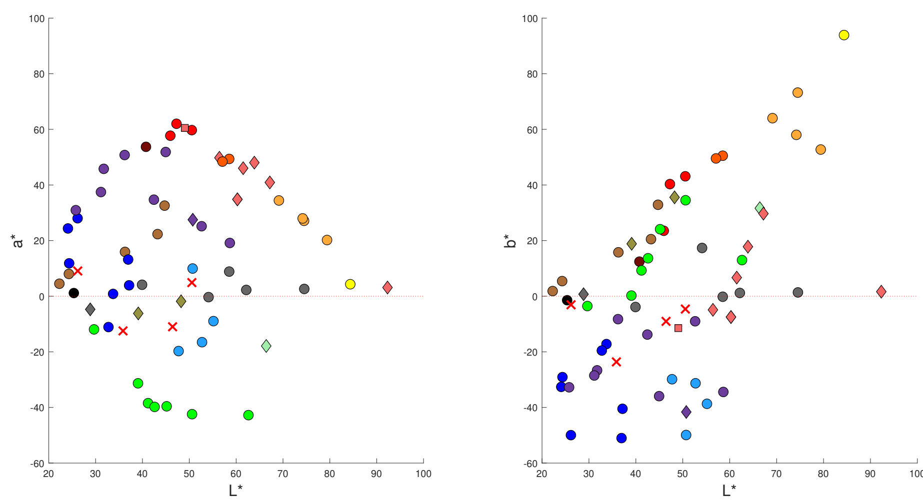

Fig. 5. 65 stimuli in CIELAB L*-a* and L*-b* planes. The legend of Fig. 4 applies.

considered blue for L*=46.94, while becoming sky blue (*tsisperi*) for L*≥66.94. This indication is consistent with the statement by Khomeriki *et al.* [16] that *"in order to determine the boundaries of blue - tsisperi it is necessary to add more white, i.e. it is necessary to make blue lighter in comparison with red – pink"*.

While all above-mentioned hypotheses need to be studied quantitatively in controlled laboratory conditions, several interesting trends can still be identified. The listing task has revealed that the all of the six most salient terms by Sutrop's Cognitive Salience Index - *tsiteli* (red), *mtsvane* (green), *kviteli* (yellow), *tetri* (white), *shavi* (black) and *lurji* (blue) - are all *monolexemic*. This can be an indication that **Georgian has six basic color categories**. They are also consistent with Berlin and Kay's evolutionary hierarchy of the basic color terms [4]. Interestingly, monolexemic terms have not been *dominant terms* in the naming task that can be attributed to unconstrained naming conditions, particularly, usage of a very detailed, sub-basic categorization by subjects, potentially motivated by their individual assumptions that originality was encouraged. Using constrained naming task in the future will reveal how much of the bias can be attributed to this limitation of the method. Nevertheless, multiple *bi-lexemic* terms (e.g. *tsisperi*) have satisfied other *basicness* criteria, such as context independence, frequency and consistency of usage by the speakers and consensus among them. The above-mentioned notion that *basicness* is a gradual, not a dichotomous property, opens up new directions for future work, in order to identify whether only the six monolexemic terms should be considered basic in Georgian.

There have been further peculiarities observed. The relative ease of the Georgian language to produce color terms and the high number of synonyms also led to the lower inter-observer consistency. The Georgian equivalents to 11 basic color terms were used less frequently than they are reported to be used in English [8] and native Georgian speakers seem to be trying to either use a synonymous term, or invent a word themselves. Whether this is their natural behavior, or it was the experimental task that motivated them to use the unusually broad range of vocabulary is a topic for future study. However, objective factors, like existence of concurrent terms, lead to higher degree of individual interpretation. For instance, words *stapilosperi* (color of carrot), *narinjisperi* (color of bitter orange), and *portokhlisperi* (color of orange) are used interchangeably by some, while others use them either for different shades of orange, or in different contexts (e.g. one of the authors of this paper, a native Georgian speaker, uses two different terms for orange - *narinjisperi* in formal, and *stapilosperi* in informal situations). Thus, they fulfill *context independence* criterion of *basicness* for some subjects, while fail for others - making *context independence* itself a questionable criterion for *basicness*. This inter-subject variation led to lower overall dominance of the orange terms. In the future, interviewing the subjects and putting the colors in particular contexts might be needed. These qualitative and quantitative findings provide an interesting perspective on the peculiarities of the Georgian language. With the future validation in controlled conditions it can also contribute to the understanding the general anthropological development of color communication across the languages and communities.

5 Conclusion

We have conducted an experimental study to investigate color term usage among Georgian speakers. The study has revealed interesting trends: the six monolexemic terms, the equivalents of red, green, yellow, white, black and blue have been the most salient, indicating that Georgian might have six basic color terms. However, unconstrained nature of the experiment and re-definition of *basicness* from a dichotomous to a more gradual concept, leave much room for future research about the basicness of the other terms. While the listing task provided results more consistent with English, the naming task revealed interesting differences due to flexibility of color term formation and high number of loosely defined synonyms. The future study should be conducted in controlled conditions for quantitative modeling of the categorical boundaries. Besides, colors are rarely observed in abstract context like this. Studying them as object properties could reveal whether e.g. usage of *stapilosperi* increases when images of carrot are shown, or whether gloss is correlated with the usage of *okrosperi* (gold) color.

References

1. Color-aid corporation. Standard set (Accessed on 15/05/2020), https://coloraid.com/standardset220colors.aspx
2. The World Color Survey (Accessed on 15/05/2020), http://www1.icsi.berkeley.edu/wcs/
3. Andrews, D.R.: The Russian color categories sinij and goluboj: An experimental analysis of their interpretation in the standard and émigré languages. Journal of Slavic Linguistics pp. 9–28 (1994)
4. Berlin, B., Kay, P.: Basic color terms: their universality and evolution (1969)
5. Biggam, C., Biggam, C.P.: The Semantics of Colour: A Historical Approach. Cambridge University Press (2012)
6. Crawford, T.: Defining "basic color term". Anthropological Linguistics pp. 338–343 (1982)
7. Davies, I.R., Corbett, G.G.: A cross-cultural study of colour grouping: Evidence for weak linguistic relativity. British Journal of Psychology **88**(3), 493–517 (1997)
8. Davies, I., Corbett, G.G., et al.: A practical field method for identifying probable basic colour terms. Languages of the World **9**(1), 25–36 (1995)
9. Gigilashvili, D., Thomas, J.B., Hardeberg, J.Y., Pedersen, M.: Behavioral investigation of visual appearance assessment. In: Color and Imaging Conference. pp. 294–299. No. 1, Society for Imaging Science and Technology (2018)
10. Gigilashvili, D., Thomas, J.B., Pedersen, M., Hardeberg, J.Y.: Material appearance: ordering and clustering. In: Material Appearance 2019, IS&T International Symposium on Electronic Imaging. pp. 202:1–202:6. Society for Imaging Science and Technology (2019)
11. Hunter, R.S., Harold, R.W.: The measurement of appearance. John Wiley & Sons (1987)
12. Jameson, K.: Culture and cognition: What is universal about the representation of color experience? Journal of Cognition and Culture **5**(3-4), 293–348 (2005)
13. Kay, P., McDaniel, C.K.: The linguistic significance of the meanings of basic color terms. Language pp. 610–646 (1978)

14. Kay, P., Regier, T.: Resolving the question of color naming universals. Proceedings of the National Academy of Sciences **100**(15), 9085–9089 (2003)
15. Kay, P., Regier, T.: Language, thought and color: recent developments. Trends in Cognitive Sciences **10**(2), 51–54 (2006)
16. Khomeriki, M., Kezeli, A., Lomashvili, N.: The revealing of color categorical boundaries among Georgian speakers. Bulletin of the Georgian National Academy of Sciences **3**(3), 136–140 (2009)
17. Koren, M.: What color is a tennis ball? An investigation into a surprisingly divisive question. The Atlantic Accessed on 23/02/2020 at https://www.theatlantic.com/science/archive/2018/02/what-color-tennis-ball-green-yellow/523521/
18. Levinson, S.C.: Yélî Dnye and the theory of basic color terms. Journal of Linguistic Anthropology **10**(1), 3–55 (2000)
19. Lin, H., Luo, M.R., MacDonald, L.W., Tarrant, A.W.: A cross-cultural colour-naming study. part I: Using an unconstrained method. Color Research & Application **26**(1), 40–60 (2001)
20. Lindsey, D.T., Brown, A.M.: Color naming and the phototoxic effects of sunlight on the eye. Psychological Science **13**(6), 506–512 (2002)
21. Lindsey, D.T., Brown, A.M.: World Color Survey color naming reveals universal motifs and their within-language diversity. Proceedings of the National Academy of Sciences **106**(47), 19785–19790 (2009)
22. Lindsey, D.T., Brown, A.M.: Recent progress in understanding the origins of color universals in language. Current Opinion in Behavioral Sciences **30**, 122–129 (2019)
23. Linhares, J.M.M., Pinto, P.D., Nascimento, S.M.C.: The number of discernible colors in natural scenes. JOSA A **25**(12), 2918–2924 (2008)
24. Manasyan, G.: Artistic approach to the process of color naming and boundaries among color term meanings. [in Georgian]. Spekali, Tbilisi State University (4) (2011)
25. Marín-Franch, I., Foster, D.H.: Number of perceptually distinct surface colors in natural scenes. Journal of Vision **10**(9:9), 1–7 (2010)
26. Moss, A.E.: Basic colour terms: problems and hypotheses. Lingua **78**(4), 313–320 (1989)
27. Paramei, G.V.: Singing the Russian blues: An argument for culturally basic color terms. Cross-cultural Research **39**(1), 10–38 (2005)
28. Ratner, C.: A sociohistorical critique of naturalistic theories of color perception. The Journal of Mind and Behavior pp. 361–372 (1989)
29. Rätsep, K.: Colour terms in Turkish, Estonian and Russian: how many basic blue terms are there? [PhD thesis]. University of Tartu Press (2018)
30. Sutrop, U.: List task and a cognitive salience index. Field methods **13**(3), 263–276 (2001)
31. Thompson, E.C., Juan, Z.: Comparative cultural salience: measures using free-list data. Field methods **18**(4), 398–412 (2006)
32. Whorf, B.L.: Science and linguistics. In Language, Thought and Reality. J. B. Carroll (Ed.). (1956)
33. Winawer, J., Witthoft, N., Frank, M.C., Wu, L., Wade, A.R., Boroditsky, L.: Russian blues reveal effects of language on color discrimination. Proceedings of the national academy of sciences **104**(19), 7780–7785 (2007)
34. Witzel, C.: Misconceptions about colour categories. Review of Philosophy and Psychology **10**(3), 499–540 (2019)
35. Witzel, C., Gegenfurtner, K.R.: Color perception: Objects, constancy, and categories. Annual Review of Vision Science pp. 475–501 (2018)