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RED ONIONS ARE CLEARLY PURPLE: COGNITIVE CONVENIENCE IN COLOR NAMING

The purpose of this paper is to describe the use of cognitive convenience in color naming and to find possible cognitive, physical, pragmatic, and logical reasons for such a phenomenon. By the term *cognitive convenience*, we mean the naming of or referring to objects of a certain color, for which their hue is not as important as their brightness, in which case, they might fall under another focal color. For example, in various languages, grapes are "white" and "black", even though their real hue is usually a certain shade of green or purple. Along with a brief typological comparison of examples of cognitive convenience in unrelated languages, we report the results of a survey demonstrating that vagueness and brightness context influenced color naming, thus confirming our main hypotheses. We concluded that in conversation, the main criterion for choosing and identifying a referent of an NP with a color adjective—when the choice is based on color—is the proximity of its shade to the prototypical shade of the named color. In this process, contextual factors may affect the speaker's and hearer's preciseness. We claim that this phenomenon can be explained not only from a philosophical and pragmatic standpoint, but from an information-entropy standpoint as well. For an overall unifying theory, we will connect the informational entropy to the pragmatic notion of semantic vagueness and then inspect the overall choice of a fuzzy predicate logic that is able to incorporate such references.

Key words: *color naming, linguistics, cognitive linguistics, pragmatics, categorization, prototype theory, vagueness.*

1. Color recognition and cognitive convenience

Human beings are able to differentiate between 7,500,000 color shades (Brown & Lenneberg 1954: 457). The *red-green-blue* model was modeled based on the physiology of the human eye, where photoreceptor cone cells respond most to yellow, green, and violet, giving rise to such additive usage in digital devices (Rhyne 2016). According to an alternate model, our perception of a color consists of the following (Payne 2006: 605): *hue* (different wavelengths), *brightness* (reflectivity of a surface), *saturation* (perception

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[*] This article was written as part of the institutional research project *Contemporary South Slavic languages: (socio)pragmatic analyses*, Faculty of Humanities and Social Sciences, University of Zagreb, project manager: Virna Karlić.

of the dominant wavelength). Color and cognition studies have been prominent in both psychology and later in linguistics for almost a century. In a famous seminal study, Berlin and Kay (1969) have proposed that all cultures have color terms for black/dark and white/bright, named *stage I*. If a culture has three color terms, the third one is red; yellow or green follow; then come blue, brown, purple, pink, orange, or gray.[3] Constraints have subsequently been loosened, but the opposition between dark and light still remains a basic binary opposition, usually exemplified by the Dani people (Heider 1970), who divide the color space on the basis of brightness rather than hue. *Mili* is used for cool and dark shades, such as black, green, or blue, while *mola* for light and warm colors like white, yellow, or red.

According to Rosch and Olivier (1972: 338), two semantic measures have received the focus of attention: codability and communication accuracy. Rosch and Oliver (1972: 338) mention that Lantz and Stefflre (1964) showed that *communication accuracy*—the accuracy with which a subject's verbal description of a color allows other native speakers of the language to pick out that particular color—was positively correlated with recognition. Brown and Lenneberg (1945) have concluded that different linguistic communities differ in codability of colors, where *codability* is a measure of length of the name, agreement in naming, and response latency of the naming process. In English speakers, differences in codability were correlated with differences in recognition of such colors. The basic procedure was to expose 4 of the 24 colors, remove them, and ask the test subject to point to the colors just seen, using a large chart of 120 shades (Brown & Lenneberg 1945: 460). A study of the Zuni Indians demonstrated that the Zuni code orange and yellow with a single term and often confused the two in the stimulus set, while English speakers never made that error. Second, Lantz and Stefflre (1964) concluded that communication accuracy was closely related to recognition. Communication accuracy is considered a superior predictor of memory for colors than naming agreement or brevity of description, since it correlates highly with recognition results and predicts different stimulus arrays, while naming agreement and brevity of description do not.

[3] In his paper on the evolution of English color terms and their use, Casson (1997) shows how a gradual semantic shift occurred from largely brightness color concepts to almost exclusively hue concepts.

We will argue that Berlin and Kay's *stage I* is present in languages as a cognitive convenience. By the new term *cognitive convenience*, we will consider the naming process of certain extralinguistic objects for which the color differentiation is not that important. The only thing that matters is that there is an object with a different color as a contrast. Consider ***white*** *grapes* (French *raisin* ***blanc***, Croatian ***bijelo*** *grožđe*) and ***black*** *grapes* (French *raisin* ***noir***, Croatian ***crno*** *grožđe*). White grapes are actually of a yellowish green shade, while black grapes are more of a dark purple to indigo shade. However, the hue does not matter here; the only important process is the ability to differentiate between the two. Similarly, in various languages, there is an opposition between "white" wine (cf. French *vin* ***blanc***, Croatian *bijelo* ***vino***, German ***Weiß****wein*) and "black" (Croatian ***crno*** *vino*) or "red" wine (German ***Rot****wein*, French *vin* ***rouge***). Even though red wine is, in fact, of a reddish tint, white wine is more of a yellowish shade, but taken in contrast to its pair, their hue does not matter as such. The same goes for the frequent opposition of white versus black tea. Recent investigations have pointed out the polysemy for specific colors, especially *white* (Zayniev 2019; Lai & Chung 2018) and *black* (Lai & Chung 2018), such that the basic naming process starts with the literal color and then expands to lighter shades, hair colors, different foods, etc.[4] We argue that such oppositions are examples of cognitive convenience in naming patterns and that the reason for such naming lies in contrasting examples of the same species. We will trace such usage to the human perception of hue, saturation, and value, along with pragmatic context which yields an adequate amount of information by respecting conversational maxims.

2. Sommelier's fallacy

Cognitive convenience is a mechanism for general language use. A regular speaker will differentiate between *white wine* and *red/black wine*, even though wine charts for

[4] This phenomenon in the English language is discussed, for example, by Palmer (1977), and along the same lines, M. Ivić analyzes it in the Serbian language in the book *On the Green Horse* (1995): "'White is brown when it refers to coffee, yellow when it refers to wine, and pink when it is applied to people,' observes the semanticist F. R. Palmer (1977), with this remark pointing to the existence of (intentionally) adopted terms like our *bela kafa* ['white coffee'] and *belo vino* ['white wine'], as well as to the fact that not every *belo lice* ['white face'] is literally white [...]. Those hearing for the first time that Russians have claimed many of their fellow citizens have not only white faces and white hair, but also *white eyes* are usually astonished—how can eyes be white?"

professional users consist of dozens of shades (cf. Boulton 2001). The same goes for all categories in which precision matters; for example, a layman might see just *light beer* and *dark beer*, while a professional taster or a craft beer aficionado will differentiate between IPAs, lagers, stouts, porters, etc. Just as specific color terms matter in a professional setting, cognitive convenience means that these distinctions are not important to an average speaker for the regular usage of the term. In cases where no specific differentiation is needed, it is enough to pinpoint to a light/dark or white/black difference.

Berlin and Kay (1969: 13) have demonstrated the universality of color categorization. In their research, they have shown that people focus on certain focal points in the color continuum as a kind of orientation. Such foci are common to the speakers of a certain language, and color categorization is rooted in focal colors, which are named and become basic color terms. Rosch's (1973) concluded that focal colors are perceptually salient since, in her experiment, three-year-old children picked out focal chips more than non-focal ones. When the Dugum Dani speakers— who have a two-term color system—were asked to remember certain shades, they were more successful in pointing out the focal colors and acquiring arbitrary names for such foci. We would like to build upon this intuition and strengthen it by stating that not only do foci seem to have perceptual salience, but that black and white have the strongest prominence when only the light and dark opposition matters, guided by certain pragmatic contexts.

Such practical situations may also be seen as manifestations of a prototypical relation. Departing from the standard Aristotelian notion of categories, Rosch (1973) has stated that natural prototypes, as the most typical examples of a certain category, are more *perceptually salient*, more easily learned, and become the basis of categories when category names/labels are learned. For example, a sparrow or a pigeon is more prototypical than an emu or a penguin, having the most features or the most prototypical features in the bird category. In the category of colors, some colors are more focal than others, but in various color shades, the same situation applies: If the notion of *brown* is a category by itself, various shades from basically white to basically black will be parts of such a classification, with the middle brown hue as the prototype.[5]

[5] We will observe this notion from a hue-saturation-value perspective in the section 5. *Fuzzification.*

In cases of "black" and "white" wine or grapes in certain languages, when the pragmatic context requires general classification or differentiation, the strongest foci are those for light and dark differentiation. If specificity is needed, then the rest of the color terms apply. You could have just white/light and dark/black wine, but then you could be more specific and describe it as gray, yellow, rose, tawny, or orange. Your bread might be "black" (cf. Russian ***черный*** *хлеб*, Croatian ***crni*** *kruh*, German ***Schwarz****brot*), even though it is of a brown shade. There seem to be two necessary criteria for such naming: (1) There is another type of the same extralinguistic object that is darker or lighter than the source object; (2) The specific and detailed differentiation between the two is not important for the pragmatic context.

Before we see how the pragmatic context influences cognitive convenience in color usage, we must first detail some pragmatic principles. In information theory, the *entropy* of a random variable is the amount of uncertainty inherent to the variable's possible outcomes. For Shannon (1948), data communication consists of the source, the channel, and the receiver, and the receiver needs to be able to identify the data generated at the source. An event that will always happen has zero self-entropy, while an event that will never happen has infinite self-entropy. The following formula measures the average amount of self-entropies that all events contribute to a certain system. Given a discrete random variable X, possible outcomes $x_1 \ldots x_n$ occurring with probability $P(x_1) \ldots P(x_n)$, entropy H is defined as the sum of average contributions:

$$H = \sum_{i=1}^{n} p_i log_2 \frac{i}{p_i}$$.[6]

The informational value of a communicated message depends on the added novelty, in other words, how surprising the content of the message is. For example, for rare events, we would expect more informative messages. Shannon uses the logarithmic measure because of its practical and mathematical applications and because of its closeness to our intuitive feeling as the proper measure, since we intuitively measure entities by linear

[6] Shannon's entropy is basically the measurement of the amount of information needed to specify a single element (or multiple elements) from a set. The rates of occurrences of each element of a certain set are determined by their probability. Like in pragmatic contexts, taking a single element out of isolation and calculating its entropy would not make much sense since the context is what matters, so the probability distribution over the whole set is required.

comparison with common standards (Shannon 1948). For example, one intuitive deduction is that two books have more information than a single book, the same way a certain outcome of a probability P has the information content of about $1/P$. The entropy is then the average over all outcomes. It is important to note, from a linguistic perspective, that in such a formal view, the meaning itself is irrelevant. That is, we are only dealing with probabilities in such a measure. However, by determining the probability, we can see how much information is actually acquired for differentiation.

Applied to pragmatic contexts, there is a cost for *information overload*. Too much information leads to a chaotic mess. Imagine a language in which you had to be extremely specific for all utterances. Such a language would not be applicable for everyday purposes, for which pragmatics allows us to be vague when the information content might be high, but it is not relevant to the situation. In various cases of conversational maxims[7] in pragmatics, and hence in cognitive convenience in color naming, there is a strong tendency of minimizing the surprising content of the message if the use is not a rare event. However, in specific contexts requiring details, such a message would be too vague and not successful. For example, talking about ***black*** and ***white*** *grapes* or *beans* makes sense in your kitchen, but not in a botanical symposium, the same way sommeliers are not going to talk just about "red"/black" and "white" wine.

Such notions of informational entropy and load lead us to the closely tied concept of semantic vagueness.

3. Semantic and pragmatic vagueness

Semantic vagueness is a fundamental feature of language and an integral part of verbal communication: "In fact, outside of statements of mathematical truths and the like, it is hard to find an expression (or perhaps a use of an expression) in which it is completely lacking" (Solt 2015: 108). Even though nearly all linguistic expressions are vague to some extent, people manage to communicate successfully. Viewed from a pragmatic perspective, vagueness in language use is not (only) an obstacle to be overcome, it is "one of the most commonly used [communication] strategies, whose

[7] See more in the next section *Semantic and pragmatic vagueness*.

forms are rich and variant" (Shi 2015: 227). Moreover, some linguists argue that "vague expressions may be more effective than precise ones in conveying the intended meaning of an utterance" (Jucker, Smith & Lüdge 2003: 1737).

The concept of semantic vagueness is often interpreted as a form of obscurity and lack of precision in language (Jucker, Smith & Lüdge 2003: 1737), and it is usually associated with an absence of "sharply defined [denotation] boundaries" (Ullmann 1974: 3) of linguistic expressions. In other words, vague predicates have a "fuzzy border zone" and have borderline cases (Pinkal 1995: 89). Semantic vagueness manifests in different ways and at different language levels—it can arise from (vague) word choice, vague implicit meanings, use of vague lexis (such as vague quantifiers and qualifiers), and syntactic constructions that introduce vagueness (Cheng & O'Keeffe 2014: 360). Considering the language level of its manifestation, linguists usually classify it into phonological, lexical, structural, and scope vagueness (e.g., Kennedy 2009).

Pinkal (1995: 73) points out that color adjectives are typical examples of lexical vagueness due to their lack of a sharp denotation border: "*red* [has] no border at all, but rather a blurry 'grey zone' between the positive and negative domain". What they do have is a category prototype, which means that the main criterion for determining whether a certain shade can be called *red* "depends on its nearness in the color space to the focal shade of true red" (Solt 2015: 110). Although this is the main criterion when choosing a "suitable" color adjective in an utterance, in some situations, contextual factors may affect speaker's preciseness, and thus his/her choice of color adjective.

For example, in Figure 1, we can easily determine which puppy speaker finds cute, although the speaker's choice and use of the color adjective *black* is vague/imprecise (there is no black puppy in the scene—puppy A is beige and puppy B is dark brown).

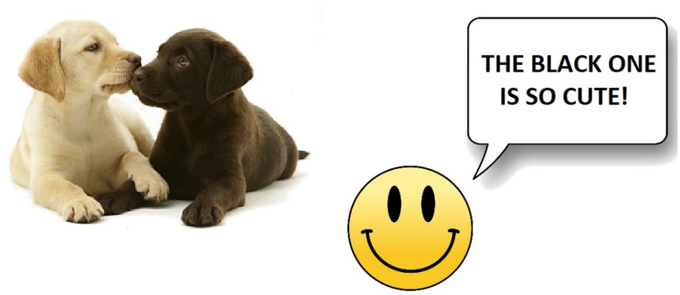


Figure 1. An example of *vague* use of a color adjective in a hypothetical utterance.[8]

[8] Puppy image was incorporated from natureplprints.com.

In this chapter, we will discuss the vagueness of color adjectives and its manifestation in language use. We will raise two questions: (1) Why do speakers sometimes choose to be vague/imprecise when naming the color of a referent in an utterance? (2) What enables a successful transfer of the message to a hearer in such cases?

As Urbanová observes (1999: 99–100), breaching Grice's maxim of manner (according to which a speaker should avoid obscurity and ambiguity)[9] is very common in everyday communication: "Not only a certain amount of vagueness in language [is] allowed, but it is also expected, since its manifestation is in harmony with the requirements of accessibility, acceptability and negotiability of the meaning conveyed". In language production, vagueness that arises from vague content and/or vague structure of an utterance, is called *pragmatic vagueness*. According to He's definition, "pragmatic vagueness is a general term for meaning indeterminacy of language in its production and interpretation" (He 1990 in Shi 2015: 226).

Urbanová (1999) points out that intentional use of vagueness in conversation can be referential or affective, and it can serve many different pragmatic functions (e.g., self-defense, self-protection, expressing negative politeness or informality, persuasion). According to the author's classification, the use of the adjective *black* instead of *dark brown* in Figure 1 falls into the category of *referential vagueness*—the utterance covers the speaker's communicative intention, and the use of more precise modifier such as *dark brown* could be interpreted as redundant or too "strict". Since this kind of intentional vagueness can contribute to an informal atmosphere and "loose manner" between interlocutors, it can also be interpreted as a case of *affective vagueness*, a manifestation of speaker's attitudes and standpoints in the exchange of views (Urbanová 1999: 103).

When it comes to color adjectives, their vague use in speech production belongs to *Type 2 vagueness* or *scalar vagueness* (cf. Solt: 2015), most frequently known as *imprecision.* According to Solt (2015: 112), the main difference between imprecision and

[9] Grice's (1975) cooperative principle specifies the way people achieve effective conversational communication. The maxim of manner deals with how something is said and refers to being perspicuous, i.e., avoiding obscurity and ambiguity, and being brief and providing information in an orderly manner. The maxim of relation or relevance ensures that all the information provided by the speaker is relevant to the current informational exchange. The maxim of quality or truth requires the contribution to be true. The maxim of quantity requires the contributions to be as informative as required and no more than that.

“classical” *Type 1* vagueness is that “the former merely involves looseness in use around some definitive, unique value [e.g., color adjectives, since they have a category prototype], whereas the latter is characterized by the puzzling lack of any non-arbitrary threshold value whatsoever [e.g., relative adjectives such as *tall* or *long*]”.

In their paper on the meaning of scalar adjectives, Hansen and Chemla (2017) discuss the impact of imprecision on qualitative color reading. The results of their experiment demonstrate significant interpersonal and intrapersonal inconsistencies in tasks that determine a drawing’s color. For example, the respondents categorized non-prototype examples of a certain color differently in different context, depending on whether a prototype example of that color was shown next to the drawing. The authors singled out several possible causes of such inconsistencies and concluded that they are most likely due to changes in the degree of respondents’ precision in different tasks:

> The idea of differing levels of precision might help explain the variation that we observed in responses to the qualitative reading of color adjectives. On first observing an object that is borderline blue […], some participants might employ a coarsely-grained measure structure and place it in the positive extension of “blue”. Then, when they encounter a better example of blue […], they might be inclined to adopt a more precise measure structure that excludes the alien in the 1/3 qualitative condition from the positive extension of “blue”. (Hansen & Chemla 2017: 266)

The reason why the respondents were constantly and inconsistently adjusting the levels of precision can be explained by the artificial context and the lack of prototypical anchors for determining the color of the examples—they were “simply unsure what the standards of precision are for what they are being asked to do” (Hansen & Chemla 2017: 266).

4. Experiment

We believe that in language use, the standards of a speaker’s precision are dependent on the speaker's intention and the context in which the conversation takes place. In the next chapter, we present the results of an experiment on qualitative color reading in hypothetical “real-life” conversations. The research was conducted with the aim of determining the relationship between the vague use of color adjectives, the degree of the speaker's or hearer's precision, and the context of language use.

We conducted the experiment with the aim of testing two hypotheses: (1) In conversation, the main criterion for identifying a referent of a definite NP (color adjective + noun) based on its color is the proximity of referent's shade to the focal (prototypical) shade of the named color on the color spectrum (as in Figure 1); (2) Consequently, contextual factors may affect speaker's (and thus hearer's) preciseness when choosing/interpreting a color adjective. For example, if a black dog "walked in" to the scene presented in Figure 1, a vague use of a color adjective "black" would no longer be possible. In the situation presented in Figure 2, the phrase "black dog" from the speaker's utterance can only refer to the black dog, not to the dark brown dog.

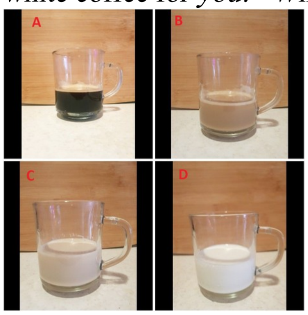
Figure 2. An example of *non-vague* use of a color adjective in a hypothetical utterance.

The experiment involved 85 participants. The participants were undergraduate (61%) and graduate (39%) students of the Faculty of Humanities and Social Sciences, University of Zagreb (Croatia). Ages ranged from 18 to 29. 76.5% of participants were female, and 23.5% were male. All of the participants were native speakers of the Croatian language.

The experiment was conducted through an online questionnaire consisting of 20 tasks, six of which were used as fillers. In each task, participants were presented with: (1) pictures of two, three, or four items (objects or animals) of a different color; (2) a description of a hypothetical conversation in which participants take part. In each hypothetical conversation, the participant's interlocutor makes an utterance and refers to a certain item using a referring expression (NP) consisting of a color adjective and a noun (i.e., *crna kava* 'black coffee', *crvene cipele* 'red shoes'). The participants' task was to pick the item from the picture they believe the locutor is referring to (Example 1).

Example 1

You're in a cafe with three friends. You ordered white coffee, and others ordered something else. The waiter brings a tray with four cups of different drinks to the table and says to you: "One white coffee for you!" Which cup will you take from the tray? (See picture)



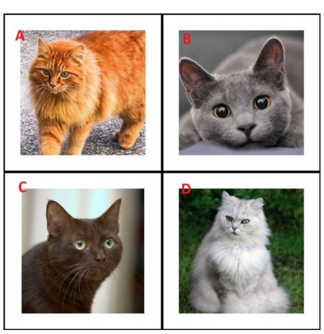
A) Cup A
B) Cup B
C) Cup C
D) Cup D
E) I am not sure.

To determine how context affects the naming of colors and their recognition, some objects were presented in different surroundings, as part of different tasks. Thus, in Example 2, a participant needs to determine to which cat in the picture the NP *crna mačka* [black cat] is referring. In Example 2a, the picture shows a white, orange, gray, and dark brown cat. In Example 2b, the picture shows a dark brown, dark gray, and black cat.

Example 2

Task A[10]

You are visiting a friend who has four cats (see picture). A friend tells you not to pet the black cat if you don't want to be scratched. Which of the four cats is not friendly?

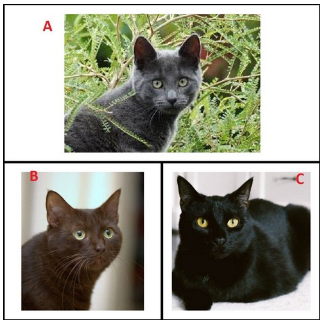


A) Cat A
B) Cat B
C) Cat C
D) Cat D
E) I am not sure.

[10] Task A photograph sources: pixabay.com, metro.co.uk, Wikimedia commons, and flickrhivemind.net.

Task B[11]

A friend told you that he decided to adopt a black cat from the picture (see picture). Which of the three cats will your friend adopt?



A) Cat A
B) Cat B
C) Cat C
D) Cat D
E) I am not sure.

Table 1 shows the content and the structure of the questionnaire. The first column (Gr.) shows groups of tasks according to the item marked with the referring expression: (I) animals (color of their fur), (II) shoes, (III) hair, (IV) bread, (V) coffee. The second column (No.) shows the ordinal number of tasks.[12] The third column (RE) shows a referring expression used in a task. Columns A, B, C, D and UNDECIDED show the answers offered in each task. Columns A to D indicate the color of potential referents (items shown in the picture). In cases where participants could not identify the referent, they were instructed to mark the UNDECIDED answer.

Table 1. Questionnaire structure and results.

Gr.	No.	RE	A	B	C	D	Undecided
Ia	1.	Black bear	0%	100%	X	X	0%
	2.	Black bear	0%	0%	100%	X	0%
Ib	3.	White dog	X	100%	0%	X	0%
	4	White dog	99%	0%	0%	X	1%
IIa	5.	White shoes	0%	99%	0%	0%	1%
	6.	White shoes	92%	0%	0%	0%	8%
IIb	7.	Red shoes	0%	88%	0%	0%	12%
	8.	Red shoes	0%	1%	98%	0%	1%

[11] Task B photograph sources: pixabay.com, Wikimedia commons, and gettyimages.com.
[12] The order of the tasks shown in the table is not the same as the order of the tasks in the questionnaire.

III	9.	Red hair	0%	94%	5%	0%	1%
	10.	Red hair	78%	9%	0%	0%	13%
IV	11.	White bread	4%	94%	0%	0%	2%
	12.	Black bread	0%	1%	86%	6%	7%
V	13.	White coffee	2%	64%	27%	1%	6%
	14.	Black coffee	0%	0%	0%	100%	0%

In addition to the content of the questionnaire, Table 1 shows the research results. Cells in columns A-D indicate the color of items (potential referents) shown in the picture in each task. Thus, cells represent the answers offered in each task. In each cell, the percentage of the participants who chose the answer they represent is listed. For example, in Task 1 from **Group 1**, the participants were asked to determine which bear in the picture was black. There were two bears in the picture – one was beige, and the other was dark brown. 100% of participants marked the dark brown bear as black. In Task 2, participants were asked to do the same, but with three bears in the picture: beige, dark brown, and black. The table shows that in this task 0% of participants marked a dark brown bear as black (everyone marked the black bear). The results of Tasks 3 and 4 indicate the same pattern. In these two tasks, the participants were asked to determine which dog in the picture was white. In Task 3, two dogs were in the picture: one was beige and the other one was dark brown. All the participants marked the beige dog as white. In Task 4, the situation changed, and the picture showed a white dog as well, which is why none of the participants marked the beige dog as white (99% of the participants marked the white dog, and 1% were undecided).

The same pattern is observed in the results of the tasks from **Group 2**. In Task 5, 99% of the participants marked the beige shoes as white (they had to choose between beige, pink, brown and green shoes), while 1% were undecided. In Task 6, none of the participants marked the beige shoes as white (they had to choose between beige, white, light grey, and light-yellow shoes). 92% marked the white shoes and 8% were undecided). Similar results are observed in Tasks 7 and 8. In Task 7, 88% of the participants marked the dirty pink shoes as red (they had to choose between pink, beige, brown and green shoes), while 12% were undecided. In Task 8, in which the participants had to choose between pink, red, orange, and purple shoes, only 1% marked the dirty pink shoes as red. 98% of the participants marked the red shoes, and 1% were undecided. In tasks 9 and 10 from **Group 3**, the participants were asked to identify a red-haired girl in the picture. In Task 9, participants had to choose between girls with copper, brown, black, and blonde hair. 94% of the participants marked the copper-haired girl as having red hair, 4% marked the brown-haired girl, and 1% were undecided. In Task 10, the participants had to choose between girls with copper, bright red, brown, and purple hair. Only 9% of the participants identified the copper-haired girl as having red hair. 78% marked the girl with bright red hair, while 13% were undecided.

In the tasks from **Group 4**, the participants were asked to identify white and black bread in the picture. In Task 11, 94% of the participants marked the bread with a light brown crust as white bread, 4% marked the bread with a white crust, and 2% were undecided. In Task 12, 86% of the participants marked the bread with dark brown crust as black bread, 6% marked the bread with black crust (with charcoal), 1% marked the bread with light brown crust, and 7% were undecided. In the tasks from **Group 5**, the participants were asked to identify white and black coffee in the picture. In Task 13, 64% of the participants marked the light brown beverage as white coffee, 27% marked the darker brown beverage, 2% marked the white beverage, and 6% were undecided. In Task 14, 100% of participants marked a black beverage as black coffee.

Based on the results, we have drawn the following conclusions:

(1) Low percentages of UNDECIDED answers (0-13%) and significant interpersonal consistency in tasks suggest that vague use of color adjectives was not an obstacle in communication.

(2) The results of the tasks from Groups I-III confirmed both of our hypotheses. The results show that in these tasks the participants identified referents of NPs with a color adjective based on the principle described in the first hypothesis: **the potential referent whose shade is closest to the prototype shade of a color named in a referring expression "wins"**. This principle has been consistently applied in all situations described in the tasks from Groups I-III—both in cases of vague and precise use of the color adjectives. When interpreting the color adjectives, participants adjusted the degree of precision to the context, although this meant (seemingly) inconsistent color reading

through the questionnaire (e.g., in Task 1 all the participants marked the dark brown bear as black, while in Task 2, none of them did). These results confirm the second hypothesis —**contextual factors may affect speaker's and hearer's preciseness when using/interpreting a color adjective.**

(3) The results of the tasks from Groups IV-V did not confirm our hypotheses. These tasks included the referential expressions "white/black bread" and "white/black coffee", which are, unlike the expressions from the previous tasks, conventionalized. In such cases, **a referent that most closely resembles the prototype concept of a referring expression "wins" over a referent whose shade is closest to the prototype shade of a color named in a referring expression.** For example, as a referent of the referring expression "white bread", 94% of the participants marked the bread with a light brown crust. Only 4% of the participants marked the bread with a white crust. In other words, when identifying a referent of such conventionalized expressions, the key criterion was its similarity with their prototypical concept and not with the prototypical shade of a named color. Thus, almost all participants thought that white bread should have a brown crust, not white, although its name suggests otherwise. This result leads to the conclusion that the vague use of color adjectives in expressions like "black/white bread" and "black/white coffee" is fixed. Therefore, color adjectives within such expressions are not subject to change due to contextual factors. Their interpretation is permanently based on the light/dark contrast among the prototype concepts of "white bread/coffee" and "black bread/coffee".

5. Fuzzification

In logic, vague predicates include examples like (*being*) *tall*, *red*, *bald*, *heap*, *tadpole*, and *child*, which share three interrelated features: 1) they admit borderline cases 2) they lack sharp boundaries 3) they are susceptible to sorites paradoxes (Keefe 2000: 6). One of the motivations for the development of fuzzy logic was to model reasoning with vague or imprecise statements, and the truth values would be interpreted as degrees of truth (Cintula, Fermüller & Noguera 2021). Borderline cases refer to situations in which it is unclear whether the predicate applies or not, for example certain reddish-orange patches are borderline red (Keefe 2000: 6). Also, vague predicates lack well-defined extensions since these borders, unlike in classical logic, are blurred (Keefe 2000: 7). Vague predicates are susceptible to sorites paradoxes, in which we might consider a vast number of cases and see whether the predicate still applies. As in the paradox of the heap, asking whether the rest of a heap of sand grains, when a single grain of sand is removed, is still a heap, the question becomes whether a certain lighter or darker shade of red is still red.

In fuzzy logic, the truth of variables can be any real number between 0 and 1. The process of assigning the numerical input to fuzzy sets with some degree of membership is known as the fuzzification. If we wanted to describe the temperature range of ["cold", "warm", "hot"], then a point which would have the `TEMP(x) = 0.2` value would be slightly warm, while a `TEMP(x) = 0.8` would be slightly hot. In order to describe the whole color space, each color is usually described using a combination of red, green and blue, which can be seen as a function. For white, `RGB(0, 0, 0)`, for black `RGB(255,255,255)`, and for gray, the middle `RGB(128,128,128)`will apply. There have been various research projects on fuzzy color spaces, especially for use in computer vision. Soto-Hidalgo et al. (2010) have investigated the degree of correspondence of each color with the proposed fuzzy colors. For example, membership degrees for both *yellow* and *green* fuzzy colors are obtained when the color is a kind of a combination of both, but they have also proposed extended calculations to describe shades like *yellow-green* or *greenish yellow* as `0.7/yellow - green + 0.34/greenish yellow` for the first, and `0.19/vivid yellow - green + 0.81/strong greenish yellow` for the second.

However, such values only matter outside a semantically vague context. For example, if we were to take two prototypical colors black and white and a certain function `BW(x)`, defined as a mapping from a certain shade to a certain interval between [0, 1], where 0 stands for white or `RGB(0, 0, 0)` (hexadecimal `#000000`) and 1 stands for black or `RGB(256,256,256)` (hexadecimal code `#ffffff`). A middle shade of gray (hexadecimal code `#808080`, `RGB(128, 128, 128)`) would have a `BW(x) = 0.5`. However, in different languages and different contexts, a red shade could function as a white shade or a black shade, i.e., light or dark, depending whether the second pair of the opposition is darker or not. In such cases, RGB composition does not matter, as it is the human perception of it that does. The mentioned HSV (hue/saturation/value) differentiation is an alternative to the RGB model, connected to the way humans perceive color-making attributes. *Hue* stands for the perceived color, *saturation* for the colorfulness relative to its own brightness, and *value* corresponds to a visual sensation to which an area emits more or less light (Fairchild, 2005). Consider red, `RGB(255, 0, 0, HSL(0, 100%, 50%)`, its darker or lighter shade can create a completely different color, for example `HSL(0, 100%, 95%)` for the "color" space RED would be a pink shade, `HSL(0, 100%, 0%)`for RED would be completely black, while `HSL(0, 100%, 30%)`would be almost brown (cf. Figure 3).

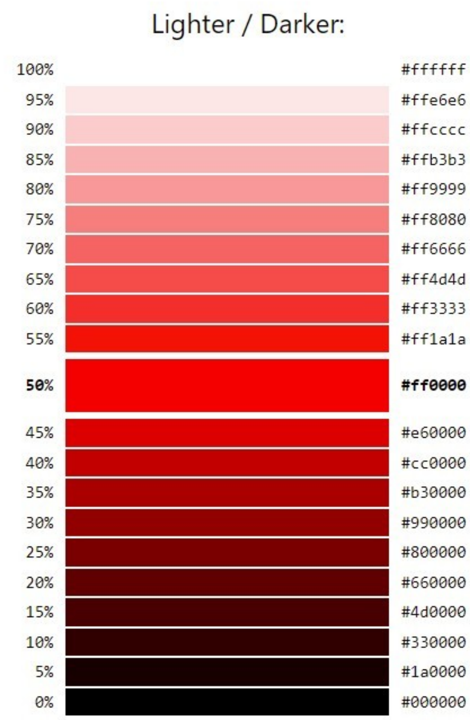


Figure 3. Hue-saturation-value differences for the color space RED

The HSV context ignores color differentiation. Even though by increasing the value/brightness percentage, the starting perceived color may become another perceived color, (i.e., being described by another basic color term as is the case when red might become *brown*, *black*, or *pink),* we argue that a switch from RGB to HSV importance changes with the pragmatic context. If the context is semantically vague, then only the *brightness* matters, i.e., connection to black or white. We also argue that in various naming patterns, the only thing that matters is the brightness and connection to the more prominent focus. For example, in English, Croatian and Russian, ***white*** *clover* (Cr. ***bijela*** *djetelina*, Rus. *клевер* ***белый***) is white, even though it might have pink shades, while ***red*** *clover* (Cr. ***crvena*** *djetelina*, Rus. *клевер* ***красный***) usually points to a pink shade.

6. In the beginning, there was light

In English, ***red*** *wine* is still red, but for Croatian speakers, its brightness is more important since it is seemingly closer to black, so it is called "black" wine (Cr. ***crno*** *vino*). In Croatian, "red" onion refers to the regular *yellow* onion in English, where we can see the cultural difference in emphasizing shade or brightness level depending on whether cognitive convenience is wanted. In such cases, the interval is not ["white", "black"] but ["black", "red"] and ["white", "red"] respectively. The "red" in *red* wine takes up the role of darkness and differentiation, and the same applies to "red" onion in Croatian, in order to differentiate it from white cultivars or garlic. In English, ***yellow*** *onion* takes up the given role. With the introduction of new cultivars, i.e., new extralinguistic objects, the interval may be broadened, for example, in Croatian ["white", "purple", "red"] for the "purple" onion, known as ***red*** *onion* in English.

In the case of currants, ***black****currant* is really close to black, and ***red****currant* is red, but the appearance of a new pink or green cultivar required only a vague differentiation. The ***white****currant* exists as white because of its difference between the black and the red one, similar to the way that *white grapes* are differentiated from black ones, which may be of reddish shades. Along with *whitecurrants* in the plant and vegetable world, there are various examples of cognitive convenience in which a greenish tint becomes *white*, in contrast to some darker color. We have already mentioned ***white*** *grapes* and ***black*** *grapes*, but the same goes for ***white*** *figs* and ***black*** *figs* and ***white*** *mulberry* contrasted to ***black*** *mulberry*. However, one of the best examples of cognitive convenience is the opposition between a ***white*** *rhinoceros* and a ***black*** *rhinoceros*. Both are of a gray shade, and some theories presume that the naming took place because of a different type of soil. Linguistically, we do not consider this highly likely and argue that the naming was used to emphasize the opposition. The new black rhinoceros had to be differentiated from the white one, and since its skin is of a dark gray shade, the cognitive convenience in naming was used for the opposition. A similar example is the opposition of ***black*** and ***white*** *truffles*, in which the black truffle can be black, but the white one is brown to yellow, with only brightness as the main criterion of differentiation. A similar example is the opposition of "white" and "dark"/"black" chocolate. For example, compare Cr. ***crna****/tamna čokolada* meaning "black/dark chocolate", French *chocolat* ***noir*** using "black", and the cases of ***white*** *chocolate* in English, French (*chocolat* ***blanc***), German (***weiße*** *Schokolade*), Croatian *(****bijela*** *čokolada*) or Russian (***белый*** *шоколад*).

A clear example can be seen both in the figures and check patterns of various chessboards, as illustrated in Figure 4. Even though the figures do not have to be exactly black and white and are most often in the ivory/yellowish/brown-black opposition, they are referred to as playing "white" or "black" respectively.

Figure 4. Chessboard with brightness contrast for black and white squares and an example of "white" figures.[13]

In various languages (English ***white*** *meat*, Croatian ***bijelo*** *meso*, French *viande* ***blanche***, Russian ***белое*** *мясо*), meat is considered white, even though it is actually of a pink shade when raw or grayish pink shade when cooked. From the HSV perspective, such a shade still belongs to the red spectrum, but in this case, red is considered white. In such languages, the opposition is between white and red (***red*** *meat,* ***crveno*** *meso, viande* ***rouge****,* ***красное*** *мясо*), since the redder shade is now more prominent, mimicking the relationship between white and red wine (cf. English, German, and French). In the case of wine, *the red hue, with small brightness value, takes the value of being "black"* in certain languages, since the opposition is lighter, of a yellowish shade, and described as "white". However, in the case of meat, *the red hue, now with a large brightness value, takes up the role of being "white*", because the opposition has larger brightness, even though it is the same original color: a shade of red.

[13] Chessboard source: chess.com match. Figures source: Wikimedia Commons, copyrighted free use.

Figure 5. A social media post evoking semantic vagueness.[14]

Cognitive convenience, manifested by the examples provided so far, seems to be culturally anchored. For illustrative purposes, consider how wine derived from *black* grapes is named in various languages. In Table 2, it is clear that *black/white* opposition is not as common as the *red/white* one. However, in the case of *white*, we already have cognitive convenience in action, since neither of the analyzed languages have lexemes such as “yellow wine” or “golden wine”.

Table 2. Wine naming in different languages: cases of cognitive convenience.

Red wine	**Black wine**	**White wine**
Albanian (verë e kuqe) Arabic (نَبِيذ أَحْمَر) Chinese (Mandarin) (紅葡萄酒) Czech (červené víno) Dutch (rode wijn) English (red wine)	Basque (ardo beltz) Catalan (vi negre) Croatian (crno vino) Georgian (შავი ღვინო)	Albanian (verë e bardhë) Arabic (نَبِيذ أَبْيَض) Catalan (vi blanc) Chinese (Mandarin) (白葡萄酒) Croatian (bijelo vino) Czech (bílé víno)

[14] Source: Instagram, @dudewithsign.

Finnish (punaviini) French (vin rouge) German (Rotwein) Greek (κόκκινο κρασί) Hungarian (vörösbor) Indonesian (anggur merah) Italian (vino rosso) Irish (fíon dearg) Japanese (赤ワイン) Korean (적포도주) Mongolian (улаан дарс) Russian (кра́сное вино́) Turkish (kırmızı şarap)		Dutch (witte wijn) English (white wine) Finnish (valkoviini) French (vin blanc) Georgian (თეთრი ღვინო) Greek (λευκό κρασί) Hungarian (fehérbor) Indonesian (anggur putih) Italian (vino bianco) Irish (fíon geal) Japanese (白ワイン) Korean (백포도주) Mongolian (цагаан дарс) Russian (бе́лое вино́) Turkish (beyaz şarap)

As Table 3 notes, eastern cultures tend to emphasize the focal red in the opposition with white, while the rest of the examples follow the black/white opposition.

Table 3. Black and white tea naming in different languages.

Red tea	**Black tea**	**White tea**
Cantonese (紅茶, 红茶) Mandarin (紅茶, 红茶) Japanese (紅茶) Korean (홍차)	Albanian (çaji i zi) Arabic (شَاي أَسْوَد) Czech (černý čaj) Dutch (zwarte thee) English (black tea) Finnish (musta tee) French (thé noir) German (schwarzer Tee) Greek (μαύρο τσάι) Hungarian (fekete) Indonesian (teh hitam) Italian (tè nero)	Albanian (çaji i bardhë) Arabic (شَاي أَبْيَض) Cantonese (白茶) Dutch (witte thee) English (white tea) Finnish (valkoinen tee) French (thé blanc) German (weißer Tee) Greek (λευκό τσάι) Hungarian (fehér tea) Indonesian (teh putih) Italian (tè bianco)

	Irish (tae dubh) Mongolian (хар цай) Russian (чёрный чай) Turkish (siyah çay)	Irish (tae geal) Japanese (白茶) Korean (백차) Mandarin (白茶) Mongolian (цагаан цай) Russian (бе́лый чай) Turkish (beyaz çay)

It is interesting to note that the third color that emerges in these descriptions is actually red, following Berlin and Kay (1969). Sometimes the white color is prototypical because the variety is more common or first observed, and sometimes it is the other way around. Let us now talk about the elephant in the room from a linguistic point of view. Human skin color ranges from the darkest brown to lightest hues. Since the HSV differentiation is akin to human perception, we believe that cognitive convenience was involved in naming various skin colors as well. Instead of talking about skin that is pinkish, reddish, yellowish, brownish or using other shades, the emergence of light-skinned people led to the differentiation between the prototypical "black", i.e., dark shade and the new lighter, "white" shade. In dermatological contexts, one might use the Fitzpatrick (1986) skin typing scale, where Type I is the palest, and Type VI is deeply pigmented dark or darkest brown, but for ordinary pragmatic contexts, such a detailed classification was not deemed necessary. Such categorization is, of course, subjective and arbitrary, but might show that color-based labels follow a familiar pattern found in other pragmatic contexts. Again, the appearance of "red" and "yellow" people follows the Berlin and Kay (1969) hierarchy as well, as a choice of connecting various shades to the existing foci.

One could argue that all of the mentioned cases of cognitive convenience illustrate just metaphorical usages of black and white as referring to dark and light. That is certainly the case, but it is not the only reason. We argue that this is an expected consequence of pragmatic context, cognitive convenience, and semantic vagueness, rather than its underlying cause. The extension of meaning to include dark and light extralinguistic objects is a type of cognitive convenience as well, contributing to the overall entropic stability of the system. If only such light/dark differentiation was in play, then we would not have examples in which other colors become “hue bearers” outside the *white* and *black* colors. For example, the mentioned *red* in *red meat* and *white meat*, along with *red clove*r and *white clover*, where, in the first case, it is the dark shade, and in the second case, we have the pink, bright shade taking up the role of the given hue. We would only expect examples of “white” and “black” clovers, or “white” and “pink” ones and not generalizations to the saturated middle of the hue, i.e., red. Even some generalizations like *black and white movies*, which are clearly most of the shades between *black* and *white*, show that brightness levels tend to be generalized, even in terms without the opposition of two kinds.

In such cases, speakers have a certain degree of belief about a proposition, i.e., being sure about the “correctness” of the color term in a given context, i.e. *epistemic modality* (Palmer 1981). Calling a red onion “red” reflects epistemic certainty in some contexts, but vagueness or flexibility in others (for example, if a speaker knows it’s purple but still calls it red for convenience). Another influence is the deontic norm (Palmer 1981: 153) where socially accepted terms such as “red onion” or “white wine” override hue precision.

7. Resolving vagueness and machine learning

In natural language processing, Meo, McMahan and Stone (2014) have shown how in labeled datasets people differ in vague distinctions. At the heart of their algorithm is the measure of the confidence with which one can use a color term to describe a color *Y* and to exclude a second color *Z*. For example, in a Flicker 30 dataset provided by Young et al. (2014), one user distinguished two dogs as *tan* and *white*, while the other used *brown* and *tan*. Meo, McMahan and Stone state that when we categorize a dog of lighter hair, we must have a color category to fit this dog, but not the darker one. We agree with such a notion and emphasize the HSV model choice in such a categorization. Namely, *tan* and *white* or *tan* and *brown* do not belong to different RGB categories, in which tan would be a synonym for light brown or dark brown, but to the same category, in which only the brightness level matters. In that case *white* does not refer to the color white, nor does *brown* to brown, but to different hues in the range ["white", "brown", "black"].

Figure 6. Tan/white or brown/tan dog (Meo, McMahan & Stone, 2014)[15]

It is interesting to note that training machine-learning models would require similar resolution of relevancy maxims. In order to apply the category of *black* or *white* to, for example, dogs in Figure 6, the supervised learning model[16] would have to be trained on key-value pairs of [+/-black] and [+/- white] features with different HSV values. For example, if basic pattern or color recognition relies on selecting a shade from hexadecimal or RGB values, in order to better emulate the human information relevance, it would have to switch to a brightness/darkness resolution in order to incorporate the pragmatic context. In the case of unsupervised learning,[17] similar objects of various shades might be clustered around the same focal black or white color.

8. Vagueness as an interdisciplinary phenomenon

The purpose of this paper was to pinpoint the notion of vagueness in color naming. We have connected the color space gradient to psychological perceptions of a human agent, to predicate vagueness in fuzzy logic, and to semantic and pragmatic vagueness.

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[15] Publicly available Flickr 30 dataset, University of Illinois at Urbana-Champaign.

[16] *Supervised learning* is a type of machine learning in which the model is trained on labeled data and then tested on previously unseen data. Such learning can be either *classification* (for example, this is a bird or not, this is black or not) or *regression* (using real values, for example, the price of this house is going to be $1,000,000). See more in Skansi (2018).

[17] *Unsupervised learning* is a type of machine learning where the users do not supervise the model by labeling the data: the model learns the patterns and forms various connected clusters by observing regularities and irregularities in the data set (cf. Skansi 2018).

However, we must point out that this case is a subset of the overall category of vagueness, akin to human experience in general.

Sorensen (2018) states that when a vague term is applied to one of its absolute borderline cases, the result is a statement that resists all attempts to settle whether it is true or false, and no amount of conceptual analysis or empirical investigation could settle whether a man of 180 cm height is tall or not. This notion of inquiry resistance seems to be one of the major properties of borderline cases. However, in the case of color terms and possibly as a universal occurrence, we believe that inquiry resistance is culturally specific. For example, the predicate *tall* would be interpreted differently in Mbuti, the shortest group of Pygmies in Africa, averaging 137 cm in height (The Editors of *Encyclopaedia Britannica* 2022), or in Tutsi, whose young adult males average 183 cm (*Guinness World Records* 2022).

In this case, contextualism seems most aligned with our linguistic, and especially pragmatic, intuitions. Philosophical *contextualism* focuses on the context of the statement, where the set of items to which the term applies shifts with the context (Sorensen 2018). For example, dandelions might be desired by farmers for food, wine, and for medical uses, but perceived as undesirable by lawn caretakers (ibid.). This example is comparable to the mentioned red/black and white wine distinction that does not matter for non-professional communication but is employed in a professional context. For these two situations, vagueness needs to be resolved using different terms.

According to *supervaluationism*,[18] borderline statements lack a truth-value, and the reason why there are borderline cases seems to be our ignorance towards making up our minds (Sorensen 2018; cf. Shapiro 2003). The origin of such a stance in the modern era can be attributed to Russell's (1932) seminal paper on vagueness. Russell (1932) mentions that words such as *red* are vague, and since colors form a continuum, there are shades of color "concerning which we shall be in doubt whether to call them red or not, not because we are ignorant of the meaning of the word 'red', but because it is a word the extent of whose application is essentially doubtful". Russell's (2013) point is that all the words denoting sensible qualities have a similar kind of vagueness that is ascribed to

[18] See Dummett (1975) for more information.

colors, but such a phenomenon exists, to a lesser degree, in quantitative words as well, such as *metre* or *second*. For him, vagueness is "applicable to every kind of representation" (ibid.). We agree that all words might seem, to a certain degree, vague inside a pragmatic-context shift, but we would also like to emphasize, as Russell does, that some qualities are often deemed less accurate than others, which was the focus of this paper.

Barnes and Williams (2011) see vagueness as a subset of a theory of *metaphysical indeterminacy*, in which indefiniteness is metaphysically primitive: "it is metaphysically indeterminate whether *p* iff (1) it is indefinite whether *p*, and (2) the source of this indefiniteness is the non-representational world." Sorensen (2018) compares such theories to a phenomenon of indeterminacy in other disciplines, for example in quantum mechanics,[19] or various examples from other disciplines, such as vagueness in geographical maps or music (Sorensen 2001), which, we presume, could be considered part of semiotics as well. One intriguing point raised by Sorensen (2018) is that *mental imagery* is a vague phenomenon. If I see stars before my eyes, I cannot perhaps tell how many, and such indeterminacy might be seen as presupposing that language is an outgrowth of human psychology, and thus an "accessible intermediate bearer of vagueness" (ibid.). This point seems important for our thesis since the HSV-differentiation is closer to human perception and psychology, rather than other arbitrary categorizations of color. Color is, in fact, an essential part of pictorial representations, and it is no wonder that it is itself vague because its superset—mental imagery overall—might already be a vague category.

9. Results and future research

In this paper, we have shown that Berlin and Kay's (1969) seminal study is not just a typological phenomenon regarding color naming in lexicology, but a typological and cognitive phenomenon regarding the usage of surprising color terms in different contexts.

[19] In algebra, we have indeterminate systems of simultaneous equations which has more than one solution or maybe infinitely many solutions, comparable to quantum indeterminacy, characterized by a probability distribution of various outcomes of a certain observable.

We have focused on the terms *black* and *white* as the most extreme cases of color categorization and see it as a case of cognitive convenience, which is employed when we have two objects for which the color distinction is not important, but the brightness difference instead. We have connected such perceptual phenomena reflected in language to a hue-saturation-value scale which tries to model the human perception of colors. In various languages, we have seen how black/white differences or similar color generalizations are employed in different ways, changing from context to context and from language to language, and cognitive convenience can be seen as a pragmatic phenomenon which is culturally or language specific. There is a strong connection to the notion of entropy and information while inspecting the usage of vague color terms, since information load brings cost to the success of the message, employed by the regular use of pragmatic maxims and relevancy principles in conversations.

In the central part of the paper, we have presented the results of an experiment conducted among native speakers of the Croatian language. The experiment was carried out with the aim of determining the principle on which the (vague) use of color adjectives is based in language use. Research has shown that in conversation, the main criterion for choosing and identifying a referent of NP (containing a color adjective) based on its color is the proximity of its shade to the prototypical shade of the named color on the spectrum. The results of the survey also showed that the use of color adjectives is conditioned by contextual factors.

However, seeing cognitive convenience as a part of semantic vagueness and as a part of a general concept of vagueness in various disciplines, we might inspect it either as a universal phenomenon, regarding the overall vague human experience, or as a cognitive specificity related to specific cultures and languages, in which the initial vagueness was settled and then learned by later speakers. For example, English speakers will denote *red* and *white* wine, while Croatian speakers will talk about “black” and “white” wine, even though their perceptual powers are the same. Language thus reflects one of the possible options to which a community has settled in the original naming of objects and kinds and might provide a valuable insight into different conceptualization strategies and the notion of learning—be it human or machine—in general.

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