CLex: A Lexicon for Exploring Color, Concept and Emotion Associations in Language

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Abstract

Existing concept-color-emotion lexicons limit themselves to small sets of basic emotions and colors, which cannot capture the rich pallet of color terms that humans use in communication. In this paper we begin to address this problem by building a novel, color-emotion-concept association lexicon via crowdsourcing. This lexicon, which we call CLEX, has over 2,300 color terms, over 3,000 affect terms and almost 2,000 concepts. We investigate the relation between color and concept, and color and emotion, reinforcing results from previous studies, as well as discovering new associations. We also investigate cross-cultural differences in color-emotion associations between US and India-based annotators.

1 Introduction

People typically use color terms to describe the visual characteristics of objects, and certain colors often have strong associations with particular objects, *e.g., blue - sky, white - snow*. However, people also take advantage of color terms to strengthen their messages and convey emotions in natural interactions (Jacobson and Bender, 1996; Hardin and Maffi, 1997). Colors are both indicative of and have an effect on our feelings and emotions. Some colors are associated with positive emotions, *e.g., joy, trust* and *admiration* and some with negative emotions, *e.g., aggressiveness, fear, boredom* and *sadness* (Ortony et al., 1988).

Given the importance of color and visual descriptions in conveying emotion, obtaining a deeper understanding of the associations between colors, concepts and emotions may be helpful for many tasks in language understanding and generation. A detailed set of color-concept-emotion associations (*e.g., brown - darkness - boredom; red - blood - anger*) could be quite useful for sentiment analysis, for example, in helping to understand what emotion a newspaper article, a fairy tale, or a tweet is trying to evoke (Alm et al., 2005; Mohammad, 2011b; Kouloumpis et al., 2011). Color-concept-emotion associations may also be useful for textual entailment, and for machine translation as a source of paraphrasing.

Color-concept-emotion associations also have the potential to enhance human-computer interactions in many real- and virtual-world domains, *e.g.,* online shopping, and avatar construction in gaming environments. Such knowledge may allow for clearer and hopefully more natural descriptions by users, for example searching for *a sky-blue shirt* rather than *blue* or *light blue shirt*. Our long term goal is to use color-emotion-concept associations to enrich dialog systems with information that will help them generate more appropriate responses to users' different emotional states.

This work introduces a new lexicon of color-concept-emotion associations, created through crowdsourcing. We call this lexicon CLEX[1]. It is comparable in size to only two known lexicons: WORDNET-AFFECT (Strapparava and Valitutti, 2004) and EMOLEX (Mohammad and Turney, 2010). In contrast to the development of these lexicons, we do not restrict our annotators to a particular set of emotions. This allows us to

[1] Available for download at: http://research.microsoft.com/en-us/downloads/
Questions about the data and the access process may be sent to svitlana@jhu.edu

collect more linguistically rich color-concept annotations associated with mood, cognitive state, behavior and attitude. We also do not have any restrictions on color naming, which helps us to discover a rich lexicon of color terms and collocations that represent various hues, darkness, saturation and other natural language collocations.

We also perform a comprehensive analysis of the data by investigating several questions including: What affect terms are evoked by a certain color, *e.g.,* positive *vs.* negative? What concepts are frequently associated with a particular color? What is the distribution of part-of-speech tags over concepts and affect terms in the data collected without any preselected set of affect terms and concepts? What affect terms are strongly associated with a certain concept or a category of concepts and is there any correlation with a semantic orientation of a concept?

Finally, we share our experience collecting the data using crowdsourcing, describe advantages and disadvantages as well as the strategies we used to ensure high quality annotations.

2 Related Work

Interestingly, some color-concept associations vary by culture and are influenced by the traditions and beliefs of a society. As shown in (Sable and Akcay, 2010) *green* represents *danger* in Malaysia, *envy* in Belgium, *love* and *happiness* in Japan; *red* is associated with *luck* in China and Denmark, but with *bad luck* in Nigeria and Germany and reflects *ambition* and *desire* in India.

Some expressions involving colors share the same meaning across many languages. For instance, *white heat or red heat* (the state of high physical and mental tension), *blue-blood* (an aristocrat, royalty), *white-collar or blue collar* (office clerks). However, there are some expressions where color associations differ across languages, *e.g.,* British or Italian *black eye* becomes *blue* in Germany, *purple* in Spain and *black-butter* in France; your French, Italian and English neighbors are *green with envy* while Germans are *yellow with envy* (Bortoli and Maroto, 2001).

There has been little academic work on constructing color-concept and color-emotion lexicons. The work most closely related to ours collects concept-color (Mohammad, 2011c) and concept-emotion (EMOLEX) associations, both relying on crowdsourcing. His project involved collecting color and emotion annotations for 10,170 word-sense pairs from Macquarie Thesaurus[2]. They analyzed their annotations, looking for associations with the 11 basic color terms from Berlin and Key (1988). The set of emotion labels used in their annotations was restricted to the set of 8 basic emotions proposed by Plutchik (1980). Their annotators were restricted to the US, and produced 4.45 annotations per word-sense pair on average.

There is also a commercial project from Cymbolism[3] to collect concept-color associations. It has 561,261 annotations for a restricted set of 256 concepts, mainly nouns, adjectives and adverbs.

Other work on collecting emotional aspect of concepts includes WordNet-Affect (WNA) (Strapparava and Valitutti, 2004), the General Enquirer (GI) (Stone et al., 1966), Affective Forms of English Words (Bradley and Lang, 1999) and Elliott's Affective Reasoner (Elliott, 1992).

The WNA lexicon is a set of affect terms from WordNet (Miller, 1995). It contains emotions, cognitive states, personality traits, behavior, attitude and feelings, *e.g., joy, doubt, competitive, cry, indifference, pain*. Total of 289 affect terms were manually extracted, but later the lexicon was extended using WordNet semantic relationships. WNA covers 1903 affect terms - 539 nouns, 517 adjectives, 238 verbs and 15 adverbs.

The General Enquirer covers 11,788 concepts labeled with 182 category labels including certain affect categories (*e.g., pleasure, arousal, feeling, pain*) in addition to positive/negative semantic orientation for concepts[4].

Affective Forms of English Words is a work which describes a manually collected set of normative emotional ratings for 1K English words that are rated in terms of emotional arousal (ranging from *calm* to *excited*), affective valence (ranging from *pleasant* to *unpleasant*) and dominance (ranging from *in control* to *dominated*).

Elliott's Affective Reasoner is a collection of programs that is able to reason about human emotions. The system covers a set of 26 emotion categories from Ortony et al (1988).

Kaya (2004) and Strapparava and Ozbal (2010) both have worked on inferring emotions associated with colors using semantic similarity. Their

[2] http://www.macquarieonline.com.au

[3] http://www.cymbolism.com/

[4] http://www.wjh.harvard.edu/~inquirer/

research found that Americans perceive *red* as excitement, *yellow* as cheer, *purple* as dignity and associate *blue* with comfort and security. Other research includes that geared toward discovering culture-specific color-concept associations (Gage, 1993) and color preference, for example, in children *vs.* adults (Ou et al., 2011).

3 Data Collection

In order to collect color-concept and color-emotion associations, we use Amazon Mechanical Turk[5]. It is a fast and relatively inexpensive way to get a large amount of data from many cultures all over the world.

3.1 MTurk and Data Quality

Amazon Mechanical Turk is a crowdsourcing platform that has been extensively used for obtaining low-cost human annotations for various linguistic tasks over the last few years (Callison-Burch, 2009). The quality of the data obtained from non-expert annotators, also referred to as workers or turkers, was investigated by Snow et al (2008). Their empirical results show that the quality of non-expert annotations is comparable to the quality of expert annotations on a variety of natural language tasks, but the cost of the annotation is much lower.

There are various quality control strategies that can be used to ensure annotation quality. For instance, one can restrict a "crowd" by creating a pilot task that allows only workers who passed the task to proceed with annotations (Chen and Dolan, 2011). In addition, new quality control mechanisms have been recently introduced *e.g., Masters*. They are groups of workers who are trusted for their consistent high quality annotations, but to employ them costs more.

Our task required direct natural language input from workers and did not include any multiple choice questions (which tend to attract more cheating). Thus, we limited our quality control efforts to (1) checking for empty input fields and (2) blocking copy/paste functionality on a form. We did not ask workers to complete any qualification tasks because it is impossible to have gold standard answers for color-emotion and color-concept associations. In addition, we limited our crowd to a set of trusted workers who had been consistently working on similar tasks for us.

3.2 Task Design

Our task was designed to collect a linguistically rich set of color terms, emotions, and concepts that were associated with a large set of colors, specifically the 152 RGB values corresponding to facial features of cartoon human avatars. In total we had 36 colors for hair/eyebrows, 18 for eyes, 27 for lips, 26 for eye shadows, 27 for facial mask and 18 for skin. These data is necessary to achieve our long-term goal which is to model natural human-computer interactions in a virtual world domain such as the avatar editor.

We designed two MTurk tasks. For Task 1, we showed a swatch for one RGB value and asked 50 workers to name the color, describe emotions this color evokes and define a set of concepts associated with that color. For Task 2, we showed a particular facial feature and a swatch in a particular color, and asked 50 workers to name the color and describe the concepts and emotions associated with that color. Figure 1 shows what would be presented to worker for Task 2.

Q1. How would you name this color?
Q2. What emotion does this color evoke?
Q3. What concepts do you associate with it?

Figure 1: Example of MTurk Task 2. Task 1 is the same except that only a swatch is given.

The design that we suggested has a minor limitation in that a color swatch may display differently on different monitors. However, we hope to overcome this issue by collecting 50 annotations per RGB value. The example color $\xrightarrow{e}$ emotion $\xrightarrow{c}$ concept associations produced by different annotators a_i are shown below:

- [R=222, G=207, B=186] (a_1) light golden yellow $\xrightarrow{e}$ purity, happiness $\xrightarrow{c}$ butter cookie, vanilla; (a_2) gold $\xrightarrow{e}$ cheerful, happy $\xrightarrow{c}$ sun, corn; (a_3) golden $\xrightarrow{e}$ sexy $\xrightarrow{c}$ beach, jewelery.

- [R=218, G=97, B=212] (a_4) pinkish purple $\xrightarrow{e}$ peace, tranquility, stressless $\xrightarrow{c}$ justin

[5] http://www.mturk.com

bieber's headphones, someday perfume; (a_5) pink $\xrightarrow{e}$ happiness $\xrightarrow{c}$ rose, bougainvillea.

In addition, we collected data about workers' gender, age, native language, number of years of experience with English, and color preferences. This data is useful for investigating variance in annotations for color-emotion-concept associations among workers from different cultural and linguistic backgrounds.

4 Data Analysis

We collected 15,200 annotations evenly divided between the two tasks over 12 days. In total, 915 workers (41% male, 51% female and 8% who did not specify), mainly from India and United States, completed our tasks as shown in Table 1. 18% workers produced 20 or more annotations. They spent 78 seconds on average per annotation with an average salary rate \$2.3 per hour (\$0.05 per completed task).

Country	**Annotations**
India	7844
United States	5824
Canada	187
United Kingdom	172
Colombia	100

Table 1: Demographic information about annotators: top 5 countries represented in our dataset.

In total, we collected 2,315 unique color terms, 3,397 unique affect terms, and 1,957 unique concepts for the given 152 RGB values. In the sections below we discuss our findings on color naming, color-emotion and color-concept associations. We also give a comparison of annotated affect terms and concepts from CLEX and other existing lexicons.

4.1 Color Terms

Berlin and Kay (1988) state that as languages evolve they acquire new color terms in a strict chronological order. When a language has only two colors they are white (light, warm) and black (dark, cold). English is considered to have 11 basic colors: *white, black, red, green, yellow, blue, brown, pink, purple, orange and gray*, which is known as the B&K order.

In addition, colors can be distinguished along at most three independent dimensions of hue (*olive, orange)*, darkness (*dark, light, medium)*, saturation (*grayish, vivid)*, and brightness (*deep, pale)* (Mojsilovic, 2002). Interestingly, we observe these dimensions in CLEX by looking for B&K color terms and their frequent collocations. We present the top 10 color collocations for the B&K colors in Table 2. As can be seen, color terms truly are distinguished by darkness, saturation and brightness terms *e.g., light, dark, greenish, deep*. In addition, we find that color terms are also associated with color-specific collocations, *e.g., sky blue, chocolate brown, pea green, salmon pink, carrot orange*. These collocations were produced by annotators to describe the color of particular RGB values. We investigate these color-concept associations in more details in Section 4.3.

In total, the CLEX has 2,315 unique color

Color	**Co-occurrences**	$\sum$
white	off, antique, half, dark, black, bone, milky, pale, pure, silver	0.62
black	light, blackish brown, brownish, brown, jet, dark, green, off, ash, blackish grey	0.43
red	dark, light, dish brown, brick, orange, brown, indian, dish, crimson, bright	0.59
green	dark, light, olive, yellow, lime, forest, sea, dark olive, pea, dirty	0.54
yellow	light, dark, green, pale, golden, brown, mustard, orange, deep, bright	0.63
blue	light, sky, dark, royal, navy, baby, grey, purple, cornflower, violet	0.55
brown	dark, light, chocolate, saddle, reddish, coffee, pale, deep, red, medium	0.67
pink	dark, light, hot, pale, salmon, baby, deep, rose, coral, bright	0.55
purple	light, dark, deep, blue, bright, medium, pink, pinkish, bluish, pretty	0.69
orange	light, burnt, red, dark, yellow, brown, brownish, pale, bright, carrot	0.68
gray	dark, light, blue, brown, charcoal, leaden, greenish, grayish blue, pale, grayish brown	0.62

Table 2: Top 10 color term collocations for the 11 B&K colors; co-occurrences are sorted by frequency from left to right in a decreasing order; $\sum_1^{10} p(\bullet \mid color)$ is a total estimated probability of the top 10 co-occurrences.

Agreement	Color Term	
% of overall agreement	Exact match	0.492
	Substring match	0.461
Free-marginal Kappa	Exact match	0.458
	Substring match	0.424

Table 3: Inter-annotator agreement on assigning names to RGB values: 100 annotators, 152 RGB values and 16 color categories including 11 B&K colors, 4 additional colors and none of the above.

names for the set of 152 RGB values. The inter-annotator agreement rate on color naming is shown in Table 3. We report free-marginal Kappa (Randolph, 2005) because we did not force annotators to assign certain number of RGB values to a certain number of color terms. Additionally, we report inter-annotator agreement for an exact string match *e.g., purple, green* and a substring match *e.g., pale yellow = yellow = golden yellow*.

4.2 Color-Emotion Associations

In total, the CLEX lexicon has 3,397 unique affect terms representing feelings *(calm, pleasure)*, emotions *(joy, love, anxiety)*, attitudes *(indifference, caution)*, and mood *(anger, amusement)*. The affect terms in CLEX include the 8 basic emotions from (Plutchik, 1980): *joy, sadness, anger, fear, disgust, surprise, trust and anticipation*[6]

CLEX is a very rich lexicon because we did not restrict our annotators to any specific set of affect terms. A wide range of parts-of-speech are represented, as shown in the first column in Table 4. For instance, the term *love* is represented by other semantically related terms such as: *lovely, loved, loveliness, loveless, love-able* and the term *joy* is represented as *enjoy, enjoyable, enjoyment, joyful, joyfulness, overjoyed*.

POS	Affect Terms, %	Concepts, %
Nouns	79	52
Adjectives	12	29
Adverbs	3	5
Verbs	6	12

Table 4: Main syntactic categories for affect terms and concepts in CLEX.

The manually constructed portion of WORDNET-AFFECT includes 101 positive and 188 negative affect terms (Strapparava and Valitutti, 2004). Of this set, 41% appeared at least once in CLEX. We also looked specifically at the set of terms labeled as emotions in the WORDNET-AFFECT hierarchy. Of these, 12 are positive emotions and 10 are negative emotions.

We found that 9 out of 12 positive emotion terms (except *self-pride*, *levity* and *fearlessness*) and 9 out of 10 negative emotion terms (except *ingratitude*) also appear in CLEX as shown in Table 5. Thus, we can conclude that annotators do not associate any colors with *self-pride, levity, fearlessness* and *ingratitude*. In addition, some emotions were associated more frequently with colors than others. For instance, positive emotions like *calmness, joy, love* are more frequent in CLEX than *expectation* and *ingratitude*; negative emotions like *sadness, fear* are more frequent than *shame, humility* and *daze*.

Positive	Freq.	Negative	Freq.
calmness	1045	sadness	356
joy	527	fear	250
love	482	anxiety	55
hope	147	despair	19
affection	86	compassion	10
enthusiasm	33	dislike	8
liking	5	shame	5
expectation	3	humility	3
gratitude	3	daze	1

Table 5: WORDNET-AFFECT positive and negative emotion terms from CLEX. Emotions are sorted by frequency in decreasing order from the total 27,802 annotations.

Next, we analyze the color-emotion associations in CLEX in more detail and compare them with the only other publicly-available color-emotion lexicon, EMOLEX. Recall that EMOLEX (Mohammad, 2011a) has 11 B&K colors associated with 8 basic positive and negative emotions from (Plutchik, 1980). Affect terms in CLEX are not labeled as conveying positive or negative emotions. Instead, we use the overlapping 289 affect terms between WORDNET-AFFECT and CLEX and propagate labels from WORDNET-AFFECT to the corresponding affect terms in CLEX. As a result we discover positive and negative affect term associations with the 11 B&K colors. Table 6 shows the percentage of positive and negative affect term associations with colors for both CLEX and EMOLEX.

[6]The set of 8 Plutchik's emotions is a superset of emotions from (Ekman, 1992).

	Positive		Negative	
	CLEX	EL	CLEX	EL
white	**2.5**	**20.1**	0.3	2.9
black	0.6	3.9	**9.3**	**28.3**
red	1.7	8.0	**8.2**	**21.6**
green	**3.3**	**15.5**	2.7	4.7
yellow	**3.0**	**10.8**	0.7	6.9
blue	**5.9**	**12.0**	1.6	4.1
brown	6.5	4.8	**7.6**	**9.4**
pink	**5.6**	**7.8**	1.1	1.2
purple	**3.1**	**5.7**	1.8	2.5
orange	1.6	**5.4**	**1.7**	3.8
gray	1.0	5.7	**3.6**	**14.1**

Table 6: The percentage of affect terms associated with B&K colors in CLEX and EMOLEX (similar color-emotion associations are shown in bold).

The percentage of color-emotion associations in CLEX and EMOLEX differs because the set of affect terms in CLEX consists of 289 positive and negative affect terms compared to 8 affect terms in EMOLEX. Nevertheless, we observe the same pattern as (Mohammad, 2011a) for negative emotions. They are associated with *black, red* and *gray* colors, except *yellow* becomes a color of positive emotions in CLEX. Moreover, we found the associations with the color *brown* to be ambiguous as it was associated with both positive and negative emotions. In addition, we did not observe strong associations between *white* and positive emotions. This may be because *white* is the color of *grief* in India. The rest of the positive emotions follow the EMOLEX pattern and are associated with *green, pink, blue* and *purple* colors.

Next, we perform a detailed comparison between CLEX and EMOLEX color-emotion associations for the 11 B&K colors and the 8 basic emotions from (Plutchik, 1980) in Table 7. Recall that annotations in EMOLEX are done by workers from the USA only. Thus, we report two numbers for CLEX - annotations from workers from the USA (C_A) and all annotations (C). We take EMOLEX results from (Mohammad, 2011c). We observe a strong correlation between CLEX and EMOLEX affect lexicons for some color-emotion associations. For instance, *anger* has a strong association with *red* and *brown*, *anticipation* with *green*, *fear* with *black*, *joy* with *pink*, *sadness* with *black, brown* and *gray*, *surprise* with *yellow* and *orange*, and finally, *trust* is associated with *blue* and *brown*. Nonetheless, we also found a disagreement in color-emotion associations between CLEX and EMOLEX. For instance *anticipation* is associated with *orange* in CLEX compared to *white, red* or *yellow* in EMOLEX. We also found quite a few inconsistent associations with the *disgust* emotion. This inconsistency may be explained by several reasons: (a) EMOLEX associates emotions with colors through concepts, but CLEX has color-emotion associations obtained directly from annotators; (b) CLEX has 3,397 affect terms compared to 8 basic emotions in EMOLEX. Therefore, it may be introducing some ambiguous color-emotion associations.

Finally, we investigate cross-cultural differences in color-emotion associations between the two most representative groups of our annotators: US-based and India-based. We consider the 8 Plutchik's emotions and allow associations with all possible color terms (rather than only 11 B&K colors). We show top 5 colors associated with emotions for two groups of annotators in Figure 2. For example, we found that US-based annotators associate *pink* with *joy*, *dark brown* with *trust vs.* India-based annotators who associate *yellow* with *joy* and *blue* with *trust*.

4.3 Color-Concept Associations

In total, workers annotated the 152 RGB values with 37,693 concepts which is on average 2.47 concepts compared to 1.82 affect term per annotation. CLEX contains 1,957 unique concepts including 1,667 nouns, 23 verbs, 28 adjectives, and 12 adverbs. We investigate an overlap of concepts by part-of-speech tag between CLEX and other lexicons including EMOLEX (EL), Affective Norms of English Words (AN), General Inquirer (GI). The results are shown in Table 8.

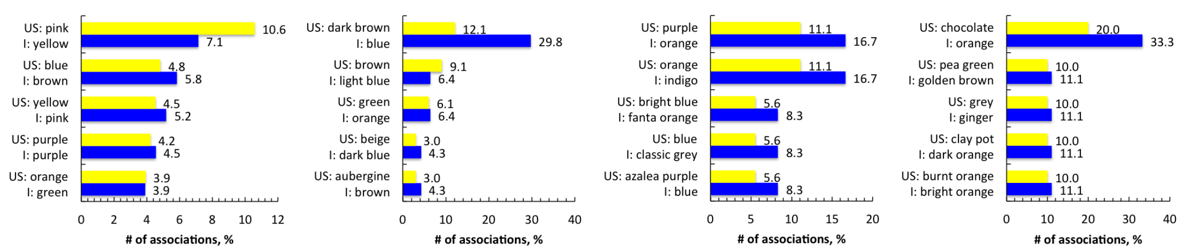
Finally, we generate concept clusters associated with *yellow, white* and *brown* colors in Figure 3. From the clusters, we observe the most frequent k concepts associated with these colors have a correlation with either positive or negative emotion. For example, *white* is frequently associated with *snow, milk, cloud* and all of these concepts evolve positive emotions. This observation helps resolve the ambiguity in color-emotion associations we found in Table 7.

5 Conclusions

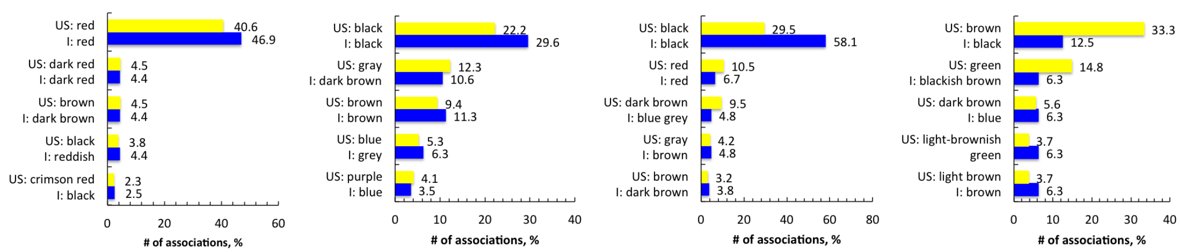
We have described a large-scale crowdsourcing effort aimed at constructing a rich color-emotion-

		white	*black*	*red*	*green*	*yellow*	*blue*	*brown*	*pink*	*purple*	*orange*	*grey*
	C	-	3.6	**43.4**	0.3	0.3	0.3	3.3	0.6	0.3	1.5	2.1
anger	C_A	-	3.8	**40.6**	0.8	-	-	4.5	-	0.8	2.3	0.8
	E_A	2.1	30.7	**32.4**	5.0	5.0	2.4	6.6	0.5	2.3	2.5	9.9
	C	0.3	**24.0**	0.3	0.6	0.3	4.2	**11.4**	0.3	2.2	0.3	**10.3**
sadness	C_A	-	**22.2**	-	0.6	-	5.3	**9.4**	-	4.1	-	**12.3**
	E_A	3.0	**36.0**	**18.6**	3.4	5.4	5.8	7.1	0.5	1.4	2.1	**16.1**
	C	0.8	**43.0**	**8.9**	2.0	1.2	0.4	6.1	0.4	0.8	0.4	2.0
fear	C_A	-	**29.5**	**10.5**	3.2	1.1	-	3.2	-	1.1	1.1	4.2
	E_A	4.5	**31.8**	**25.0**	3.5	6.9	3.0	6.1	1.3	2.3	3.3	11.8
	C	-	2.3	1.1	**11.2**	1.1	1.1	**24.7**	1.1	3.4	1.1	-
disgust	C_A	-	-	-	**14.8**	1.8	-	**33.3**	-	1.8	-	-
	E_A	2.0	**33.7**	**24.9**	4.8	5.5	1.9	9.7	1.1	1.8	3.5	10.5
	C	1.0	0.2	0.2	3.4	5.7	4.2	4.2	**9.1**	4.4	4.0	0.6
joy	C_A	0.9	-	0.3	3.3	4.5	4.8	2.7	**10.6**	4.2	3.9	0.6
	E_A	**21.8**	2.2	7.4	14.1	13.4	11.3	3.1	11.1	6.3	5.8	2.8
	C	-	-	1.2	3.5	1.2	**17.4**	8.1	1.2	1.2	5.8	1.2
trust	C_A	-	-	3.0	**6.1**	3.0	3.0	**9.1**	-	-	3.0	3.0
	E_A	22.0	6.3	8.4	**14.2**	8.3	**14.4**	5.9	5.5	4.9	3.8	5.8
	C	-	-	-	3.3	6.7	6.7	3.3	3.3	6.7	**13.3**	3.3
surprise	C_A	-	-	-	-	5.6	5.6	-	5.6	**11.1**	**11.1**	-
	E_A	11.0	13.4	**21.0**	8.3	13.5	5.2	3.4	5.2	4.1	5.6	8.8
	C	-	-	-	5.3	5.3	-	5.3	5.3	-	**15.8**	5.3
anticipation	C_A	-	-	-	-	-	-	-	10.0	-	10.0	10.0
	E_A	16.2	7.5	11.5	**16.2**	10.7	9.5	5.7	5.9	3.1	4.9	8.4

Table 7: The percentage of the 8 basic emotions associated with 11 B&K colors in CLEX *vs.* EMOLEX, *e.g., sadness* is associated with *black* by 36% of annotators in EMOLEX(E_A), 22.1% in CLEX(C_A) by US-based annotators only and 24% in CLEX(C) by all annotators; we report zero associations by "-".

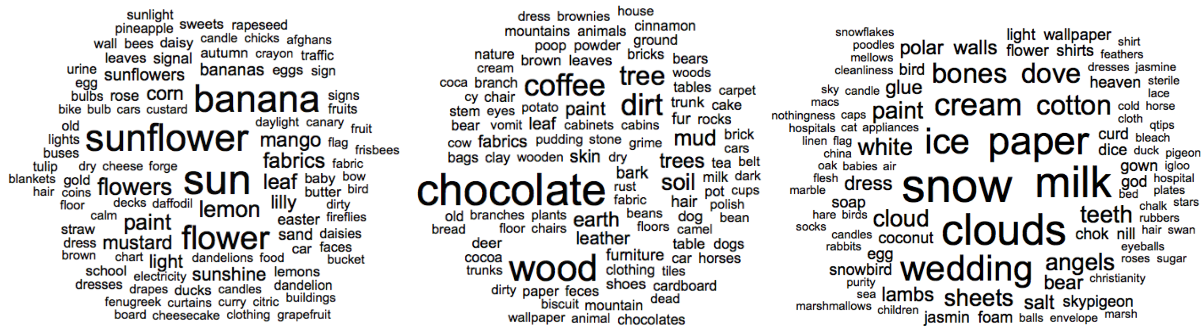


(a) Joy - US: 331, I: 154 (b) Trust - US: 33, I: 47 (c) Surprise - US: 18, I: 12 (d) Anticipation - US: 10, I: 9



(e) Anger - US: 133, I: 160 (f) Sadness - US: 171, I: 142 (g) Fear - US: 95, I: 105 (h) Disgust - US: 54, I: 16

Figure 2: Apparent cross-cultural differences in color-emotion associations between US- and India-based annotators. 10.6% of US workers associated *joy* with *pink*, while 7.1% India-based workers associated *joy* with *yellow* (based on 331 *joy* associations from the US and from 154 India).



(a) Yellow (b) Brown (c) White

Figure 3: Concept clusters of color-concept associations for ambiguous colors: *yellow, white, brown*.

concept association lexicon, CLEX. This lexicon links concepts, color terms and emotions to specific RGB values. This lexicon may help to disambiguate objects when modeling conversational interactions in many domains. We have examined the association between color terms and positive or negative emotions.

Our work also investigated cross-cultural differences in color-emotion associations between India- and US-based annotators. We identified frequent color-concept associations, which suggests that concepts associated with a particular color may express the same sentiment as the color.

Our future work includes applying statistical inference for discovering a hidden structure of concept-emotion associations. Moreover, automatically identifying the strength of association between a particular concept and emotions is another task which is more difficult than just identifying the polarity of the word. We are also interested in using a similar approach to investigate the way that colors are associated with concepts and emotions in languages other than English.

CLEX∩AN		CLEX∩EL		CLEX∩GI	
Noun	287	Noun	574	Noun	708
Verb	4	Verb	13	Verb	17
Adj	28	Adj	53	Adj	66
Adv	1	Adv	2	Adv	3
	320		**642**		**794**
AN\CLEX		EL\CLEX		GI\CLEX	
	712		**7,445**		**11,101**
CLEX\AN		CLEX\EL		CLEX\GI	
	1,637		**1,315**		**1,163**

Table 8: An overlap of concepts by part-of-speech tag between CLEX and existing lexicons. CLEX∩GI stands for the intersection of sets, CLEX\GI denotes the difference of sets.

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