Affective Colour Palettes in Visualization

Abhisekh Patra *
School of Interactive Arts & Technology,
Simon Fraser University

Lyn Bartram †
School of Interactive Arts & Technology,
Simon Fraser University

Maureen Stone ‡
Tableau Software, USA

ABSTRACT

The communication of affect, a feeling or emotion, is central to creating engaging visual experiences. We report research into how different colour properties (lightness, chroma and hue) contribute to different affective impressions in information visualization applications. Our results provide initial evidence for how colour properties can be manipulated to achieve affective expressiveness in information visualization.

Index Terms: K.6.1 [Management of Computing and Information Systems]: Project and People Management—Life Cycle; K.7.m [The Computing Profession]: Miscellaneous—Ethics

1 INTRODUCTION

We react affectively as well as cognitively to visual imagery [8]: this is important in visualization for supporting communicative intent [1], engagement, and problem solving [5]. While it is often considered as emotion, other experiential responses such as those used in marketing and journalism are important for visualization designers: notably those to do with trust [2]and data storytelling [1]. We selected eight affects to explore for colour association: **Positive, Negative, Calm, Exciting, Serious, Playful, Trustworthy** and **Disturbing**. The first four are drawn from common models of emotion [11]; the latter four chosen as feasibly useful in visualization applications. Designers are skilled in using colour to communicate affect but this is largely rooted in professional craft and qualitatively rather than empirically validated. There are few computationally tractable models that define how to use colour in information visualization to enhance affect. We are interested in whether we can capture affect as properties of a colour palette in simple visualizations, and to what degree we can characterize palettes of colours for affective impact. We studied how different palette properties influenced affective impressions. Our results show that perceptual colour properties (hue, chroma and lightness) and palette composition (hue clusters, hue dispersion) differ by affect. These results contribute to operational guidelines for affective colour palette design.

2 BACKGROUND

Research has established consistent colour naming and semantic associations [7, 9, 10]. These algorithms explore the rich associations grounded in concept-colour relations, but have not been applied to more nuanced terms of affect. There is substantial evidence of the impact of individual colour on affect. For example, warm colours have been shown to be more physiologically stimulating than cool hues of blue and green [3]. Red is considered hot, vibrant and intense across cultures [3] and most likely to induce arousal and anxiety. Blue is considered serious while yellow contributes to impressions of unprofessionalism [2]. However, while there are many designerly approaches to organizing colours into palettes (e.g. ColorBrewer [6]]) there are no rigourously validated models of affective palettes for visualization.

*e-mail:apatra@sfu.ca
†e-mail:lyn@sfu.ca
‡e-mail:mstone@tableau.com

3 STUDIES: AFFECTIVE PALETTES

In an initial image analysis of 12,000 images from Flickr and deviantArt.com, mostly abstract, we found distinct differences across our affective tags. We had two objectives first to determine if there were consistent color properties associated with affective tags, and second if there were consistent pattern of colours use and then apply these to development of colour palettes for further studies. **Calm, Playful** and **Exciting** images were lighter than **Disturbing** and **Negative**. **Negative** and **Calm** were less colourful than **Playful** and **Exciting**. We considered hue distribution using [9] algorithm to remove the effects of background. **Calm** and **Trustworthy** images had higher concentrations of blues and greens; **Playful** and **Exciting** had more highly saturated colours - reds, vibrant greens and blues. **Disturbing** had a larger distribution of dark browns, blues, reds and black. **Negative** used more grey and muted browns. We generated 8 sets of 40 distinct hues each using k-means clustering. For each of this set of hues we calculate the conditional probability of a candidate color c from the set given an affect value and corresponding image histogram T by applying kernel density estimation (KDE) to the histogram [9] to find the probability of a given color for affect across images. Each hue was measured against the set of different images that were categorized by affect. We then select the most weighted and distinct colors to fit across affects. An expert in visualization colour design refined colors by clustering to optimize saliency and distinctiveness to build a set of candidate colours that captured the range

We wanted to know whether these results would transfer to visualization contexts, so we ran two experiments in which users created affective palettes for simple visualizations using the set of colours derived from this analysis. Participants selected five colours for two categorical visualizations (bar chart or map). The goal was to see whether users would consistently assign different colour palettes for each of our 8 affective categories. Our respondents included people with design experience (49) and non designers (172). There were 37 available colours in the first experiment; based on its initial results we added 4 additional dark colours to the second study to increase the expressivity of the palettes. After selecting the palette, participants rated their satisfaction with how well the colours expressed the affect on a sliding scale from 1 to10.

4 METRICS

We characterized palettes with two kinds of metrics. Aggregate perceptual properties were mean L* and chroma. For colour distribution we used an aggregate measure of saturation-weighted hue distribution [4] to capture hue in the a*b* projection of the CIELAB space. The actual collections of hues were more difficult to algorithmically define. We simply weighted the use of each colour for each affect.

5 RESULTS

We see differences in both the particular hues chosen for affect and how dispersed the colours are in the resulting palettes. Figures 1

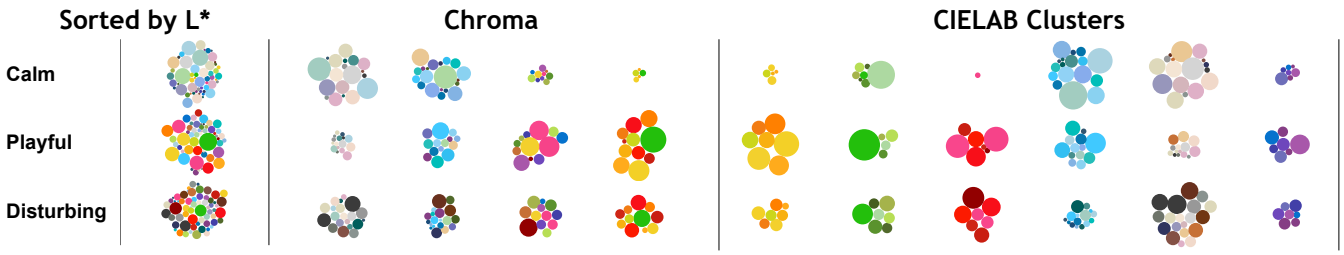

Figure 1: Palettes by L*, chroma and hue distribution.

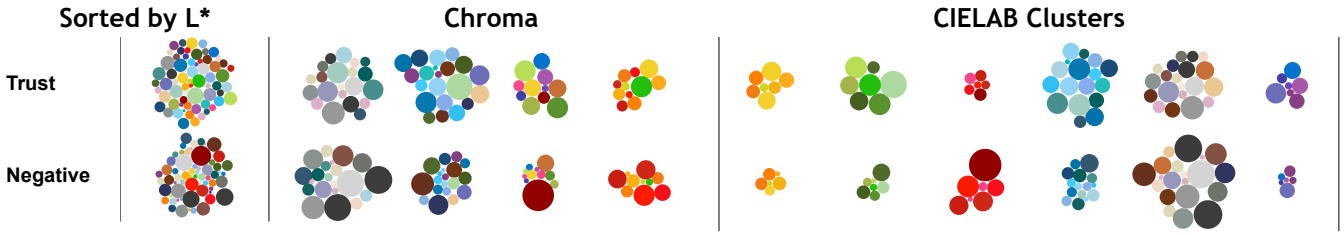

Figure 2: Hue dispersion highlights differences in affect.

and 2 show examples from our results that highlight some of the significant differences in The clusters in the left are sorted by lightness. The middle group shows levels of chroma. The right columns shows hue clusters calculated by the distance in the CIELAB a*b* projection. **Calm** is lighter than **Playful**, while **Disturbing** uses more dark colours. Conversely, both **Playful** and **Disturbing** are significantly more saturated than **Calm**. **Calm** palettes use more blues. High arousal affects (**Playful**, and **Disturbing**) use more reds and yellows. Green was more pronounced in Positive palettes (**Playful**). Yellow also figured more strongly in **Playful**, reinforcing [2]. **Disturbing** palettes contained more dark reds, browns, black and dark blues. **Negative** and **Disturbing** palettes used more reds, browns and while **Disturbing** include one or two light colours we presume for contrast. While some affects were similar in chroma and lightness, we see differences in hue distance and dispersion. **Negative** and **Trustworthy** show trends related to hue. Like **Calm, Trustworthy** uses more blues, reflecting evidence that these hues relate to peace, competence and trust [2]. The palette is darker overall. At the same time, hue dispersion is greater in these palettes, meaning that there was wider spread (a broader selection of other hues), compared to **Exciting** and **Playful** that have a larger concentration of warmer hues (closer to each other in the colour space). **Negative**, on the other hand, is similar to **Disturbing** in lightness; both use browns and dark reds. The difference in saturation between the more exciting affects of **Playful** and **Disturbing** and the less aroused of **Calm** and **Trustworthy** indicate that chroma relates strongly to these impressions. The strong difference in lightness between **Calm** and **Disturbing** shows that lightness also influences the impression of intensity. This suggests that palettes with predefined hues (such as used in branding) for affects can vary these properties to tune affect. Hue dispersion, and the types of predominant colour family, on the other hand, relate more strongly to valence: the more negative affects used proportionally more browns, dark reds and dark greys, and less yellows and greens. Finally, ratings were uniformly high, except for one case in the first experiment where designers were less satisfied with Trustworthy.

6 Conclusion

These studies introduce the concept of affect as a component of visual design and provide a basis for extending semantically resonant palette design to affective concepts. While these results are not in themselves surprising, given research in colour psychology and design practice, they do introduce new dimensions of expressivity to visualization. Our results show, at least in the limited conditions we studied, the relations between perceptual colour properties (hue, chroma and lightness), palette composition (hue clusters, colour dispersion) and affective communicative intent for the eight categories we measured. This extends findings in colour psychology and design practice to the context of simple information visualization forms and palette composition. While preliminary, we suggest this can inform operational features for automatic recommendations of colour combinations for affective communicative intent, and algorithmic manipulations of perceptual properties to enhance affect.

References

[1] A. Cairo. U.s. gun deaths and the challenge of uncertainty, peachpit, - http://www.peachpit.com/articles/article.aspx?p=2036558, 2013.

[2] D. Cyr, M. Head, and H. Larios. Colour appeal in website design within and across cultures: A multi-method evaluation. *International journal of human-computer studies*, 68(1):1–21, 2010.

[3] A. J. Elliot and M. A. Maier. Color psychology: Effects of perceiving color on psychological functioning in humans. *Annual review of psychology*, 65:95–120, 2014.

[4] A. Hanbury. Circular statistics applied to colour images. In *8th Computer Vision Winter Workshop*, volume 91, pages 53–71. Citeseer, 2003.

[5] L. Harrison, R. Chang, and A. Lu. Exploring the impact of emotion on visual judgement. In *Visual Analytics Science and Technology (VAST), 2012 IEEE Conference on*, pages 227–228. IEEE, 2012.

[6] M. Harrower and C. A. Brewer. Colorbrewer. org: an online tool for selecting colour schemes for maps. *The Cartographic Journal*, 2013.

[7] J. Heer and M. Stone. Color naming models for color selection, image editing and palette design. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 1007–1016. ACM, 2012.

[8] A. M. Isen. The influence of positive affect on decision making and cognitive organization. *NA-Advances in Consumer Research Volume 11*, 1984.

[9] S. Lin, J. Fortuna, C. Kulkarni, M. Stone, and J. Heer. Selecting semantically-resonant colors for data visualization. In *Computer Graphics Forum*, volume 32, pages 401–410. Wiley Online Library, 2013.

[10] V. Setlur and M. C. Stone. A linguistic approach to categorical color assignment for data visualization. *IEEE transactions on visualization and computer graphics*, 22(1):698–707, 2016.

[11] M. Yik, J. A. Russell, and J. H. Steiger. A 12-point circumplex structure of core affect. *Emotion*, 11(4):705, 2011.