Automatic Color Palette Creation from Words

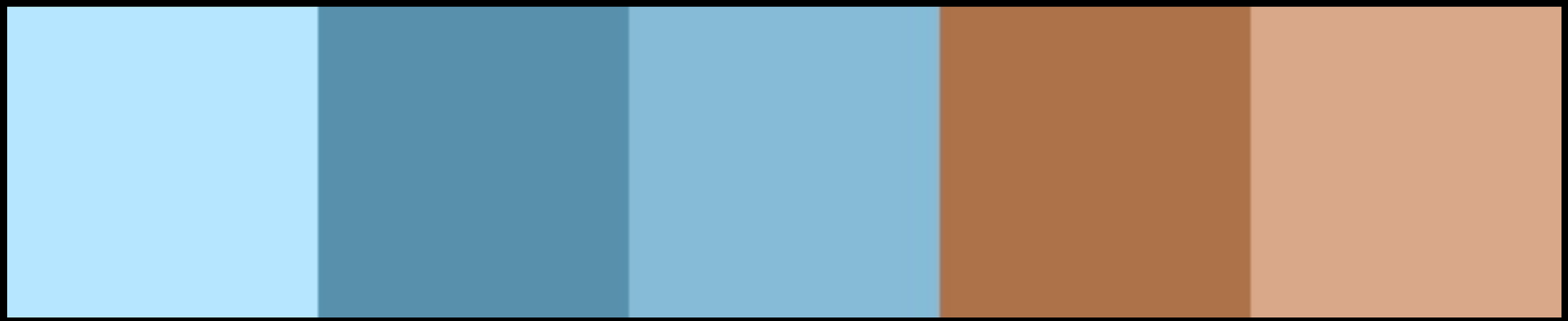
Albrecht Lindner[1,2] and Sabine Süsstrunk[2]

1: Qualcomm Inc, San Diego, USA
2: Ecole Polytechnique Fédérale de Lausanne, Switzerland

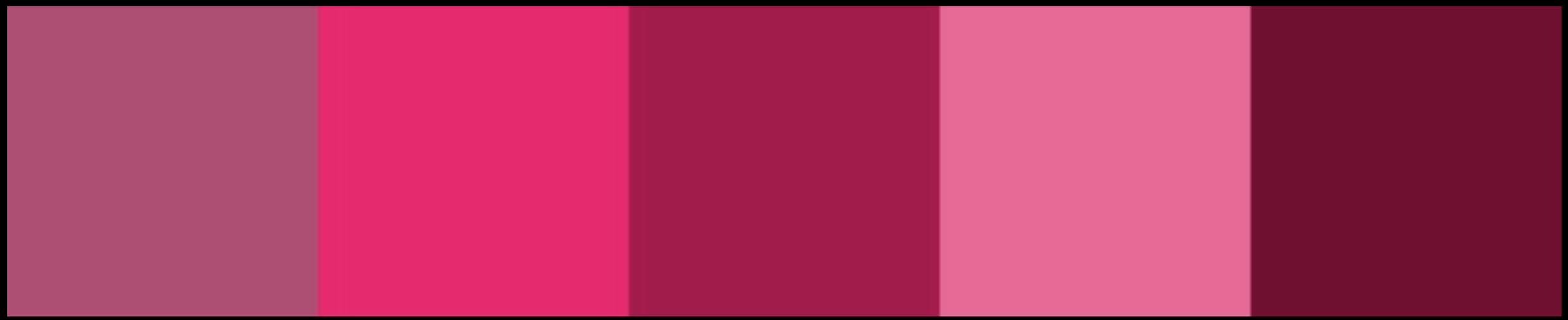
CIC 2013 Nov 7, 2013

ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

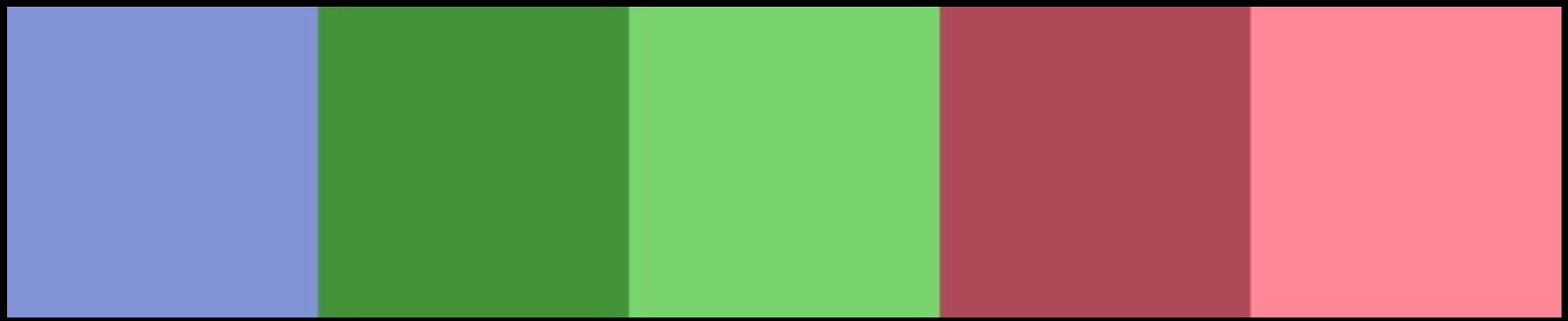
beach



love



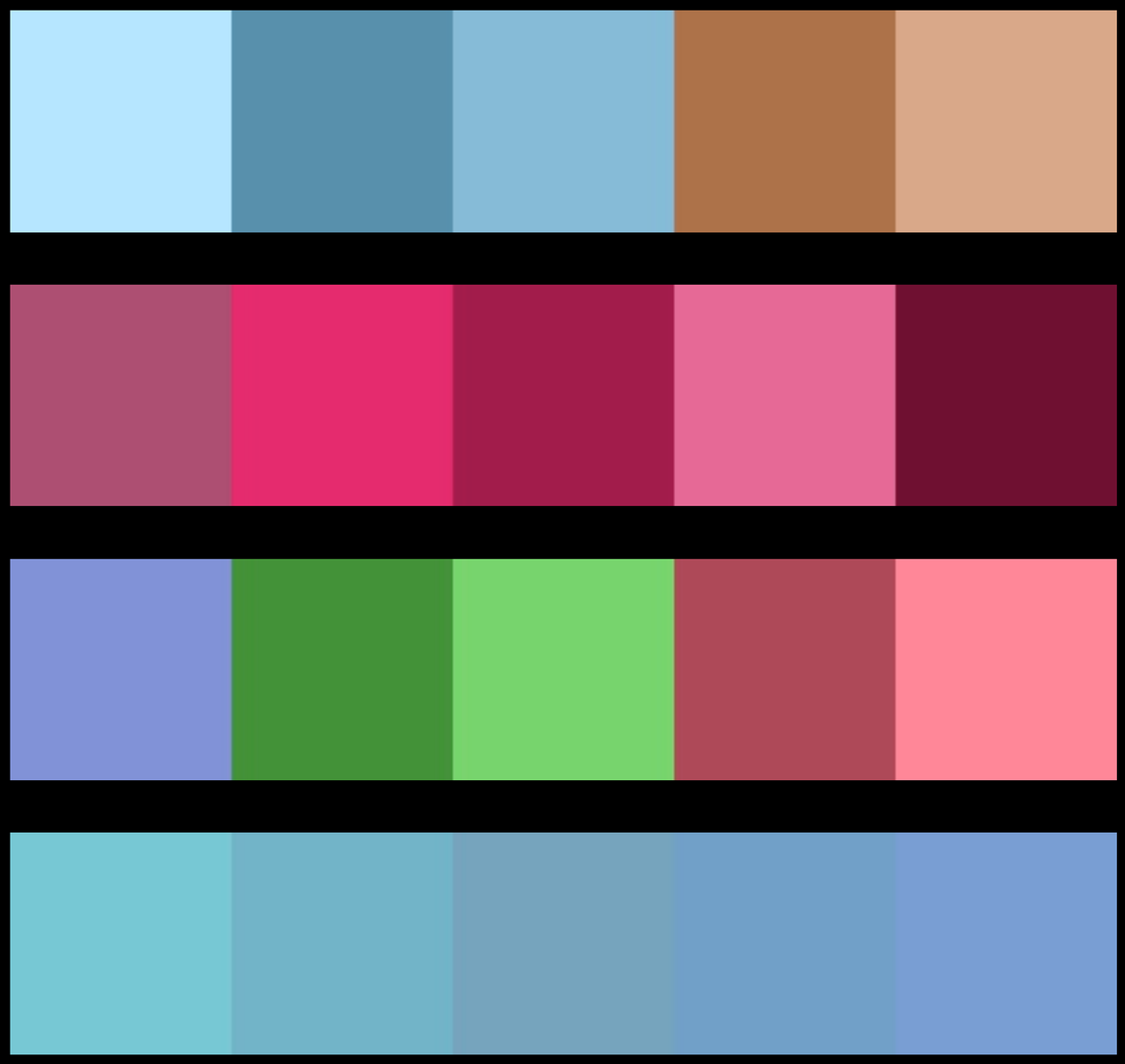
cherry

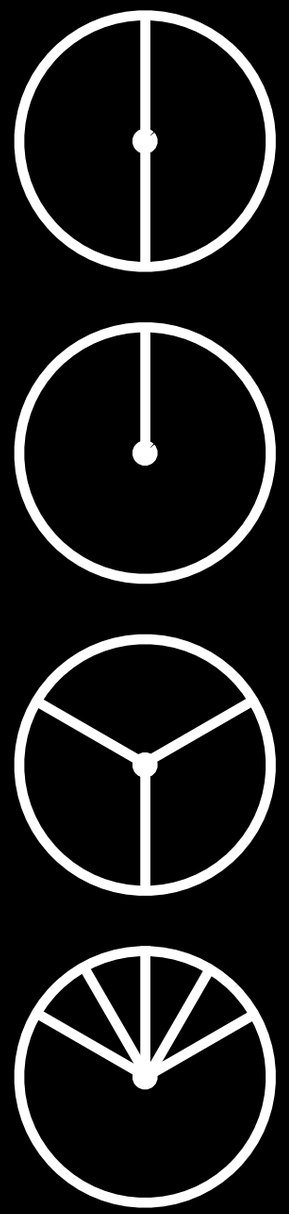


cold

Color Harmony

Color Harmony



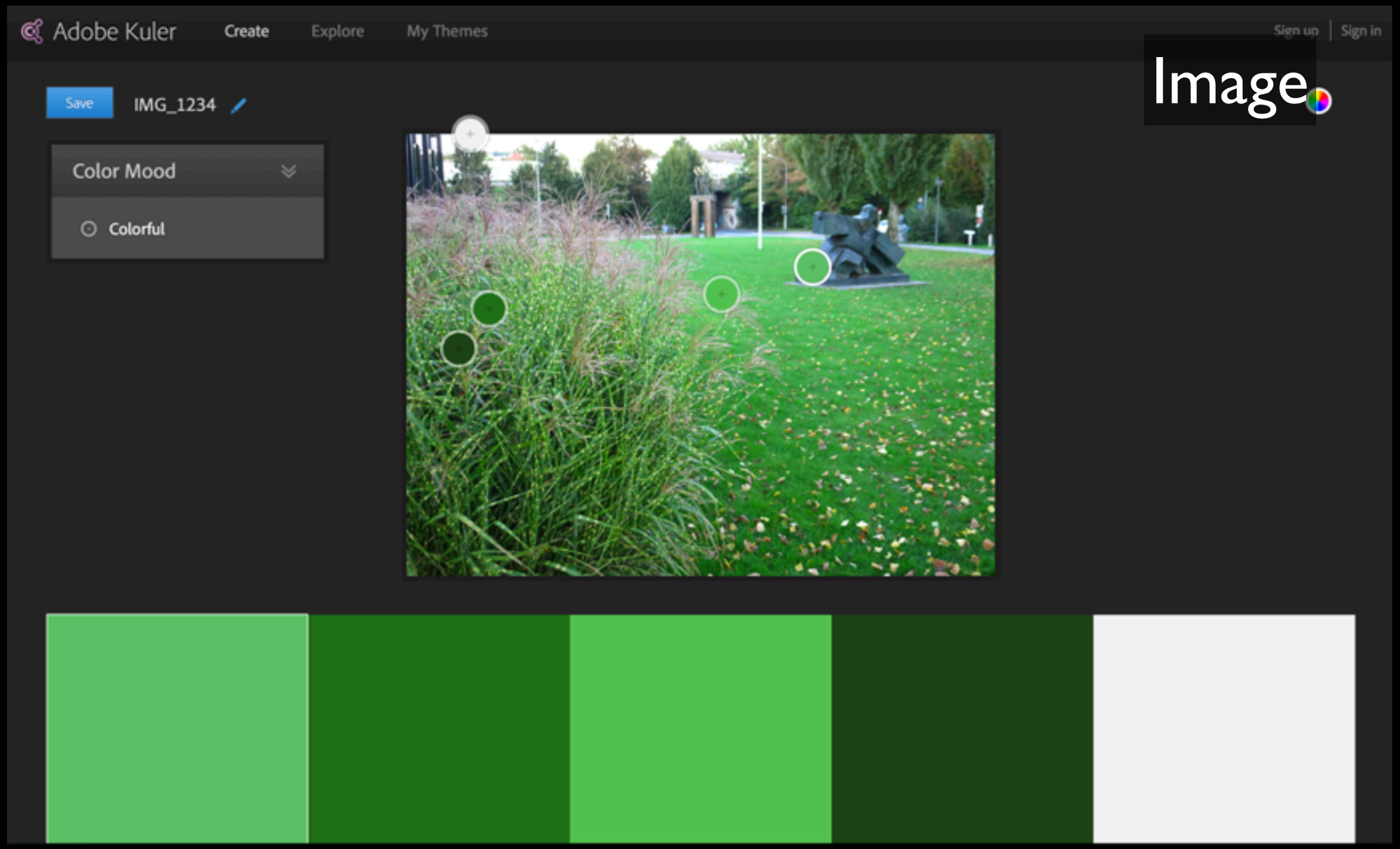


Templates

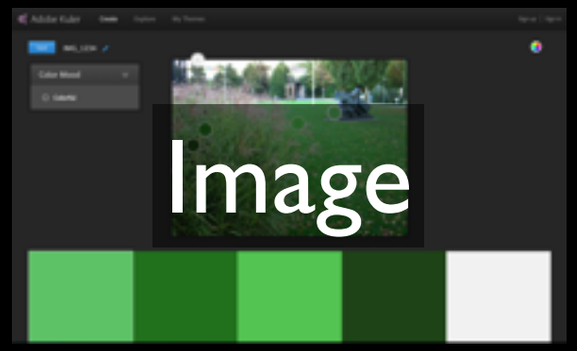
Hue

[Matsuda 95]

Existing Solutions



Existing Solutions

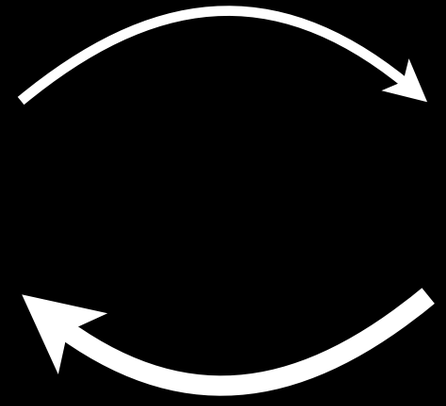


Manual		Image
X	Adobe Kuler	X
	cssdrive.com	X
	pictaculous.com	X
X	IPT, [Meier et al, 04]	

Palettes and Keywords

State of the art:

manual tagging



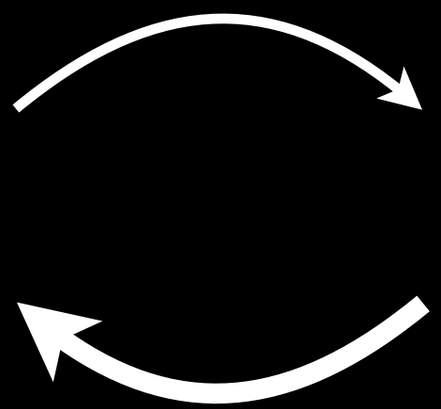
love

database query

Palettes and Keywords

State of the art:

manual tagging



love

Our proposition:

database query

semantic framework

love

- No vocabulary restrictions, including foreign languages.
- Keywords, sentences, paragraphs, books, etc.

Outline

1. Vocabulary
2. Semantic Framework
3. Psychophysical Evaluation

Vocabulary

- Need: Long list of frequently used words.
- Solution: Google N-grams

  butterfly 1997 24,903

  butterfly 1998 24,030

  ...

- Count all words from last 20 years.
- Keep 100,000 most frequent words.
- Last three: *bayswater*, *turbidite*, *trabalho*.

Image Database

- Download 60 images per word using Google: 6 million images.
- Assume sRGB encoding.
- Convert to HSV (hue templates).

Semantic Framework

Erdinger

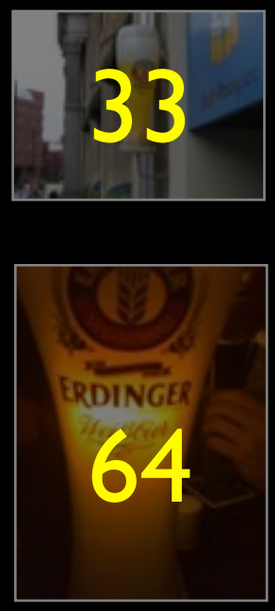



Guinness

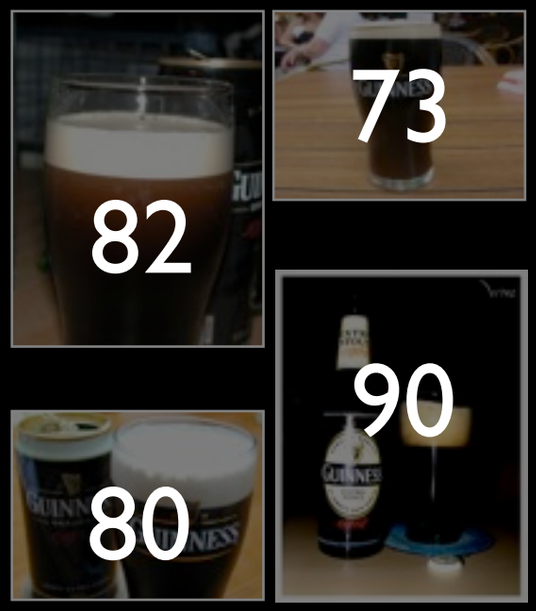

Leffe

Semantic Framework

Erdinger



Guinness



Leffe

percentage of pixels with $v<0.1$

Statistical Test

sorted list	33	47	50	51	62	64	72	73	75	80	82	90
rank index	1	2	3	4	5	6	7	8	9	10	11	12

ranksum $T = 8+10+11+12 = 41$

Statistical Test

sorted list	33	47	50	51	62	64	72	73	75	80	82	90
rank index	1	2	3	4	5	6	7	8	9	10	11	12

ranksum $T = 8+10+11+12 = 41$

Mann-Whitney-Wilcoxon ranksum test

$$\mu_T = \frac{n_1(n_1+n_2+1)}{2} \qquad \sigma_T^2 = \frac{n_1 n_2(n_1+n_2+1)}{12}$$

$n_1 = 4$ cardinalities
$n_2 = 8$ of both sets

$$z = \frac{T-\mu_T}{\sigma_T} = \frac{41-26}{5.88} \approx 2.55$$

[F. Wilcoxon, Individual comparisons by ranking methods, Biometrics Bulletin, 1(6):80–83, 1945]

Statistical Test

sorted list	33	47	50	51	62	64	72	73	75	80	82	90
rank index	1	2	3	4	5	6	7	8	9	10	11	12

ranksum $T = 8+10+11+12 = 41$

Mann-Whitney-Wilcoxon ranksum test

$$\mu_T = \frac{n_1(n_1+n_2+1)}{2} \qquad \sigma_T^2 = \frac{n_1 n_2(n_1+n_2+1)}{12}$$

$n_1 = 4$ cardinalities
$n_2 = 8$ of both sets

$$z = \frac{T-\mu_T}{\sigma_T} = \frac{41-26}{5.88} \approx 2.55$$

$z > 0$ ➔ *Guinness* images have significantly more dark pixels.

Statistical Test

sorted list	33	47	50	51	62	64	72	73	75	80	82	90
rank index	1	2	3	4	5	6	7	8	9	10	11	12

ranksum $T = 8+10+11+12 = 41$

$T = 1+2+4+6 = 13$

Mann-Whitney-Wilcoxon ranksum test

Guinness $z = \frac{T - \mu_T}{\sigma_T} = \frac{41 - 26}{5.88} \approx 2.55$

Erdinger $z = \frac{T - \mu_T}{\sigma_T} = \frac{13 - 26}{5.88} \approx -2.21$

Statistical Test

sorted list	33	47	50	51	62	64	72	73	75	80	82	90
rank index	1	2	3	4	5	6	7	8	9	10	11	12
ranksum	$T = 8+10+11+12 = 41$											

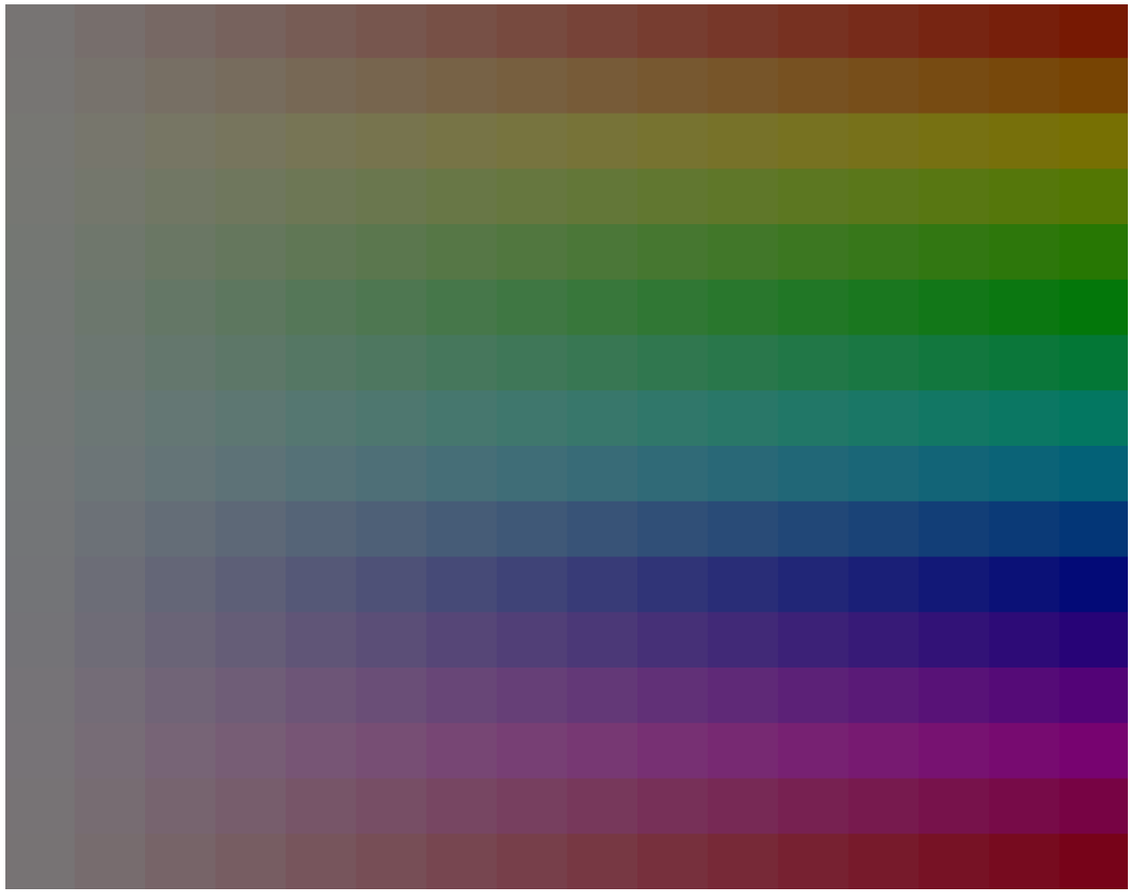
$T = 1+2+4+6 = 13$

- Only **one sort** operation.
- An additional keyword is just **one sum**.
- Scalability to large vocabularies.

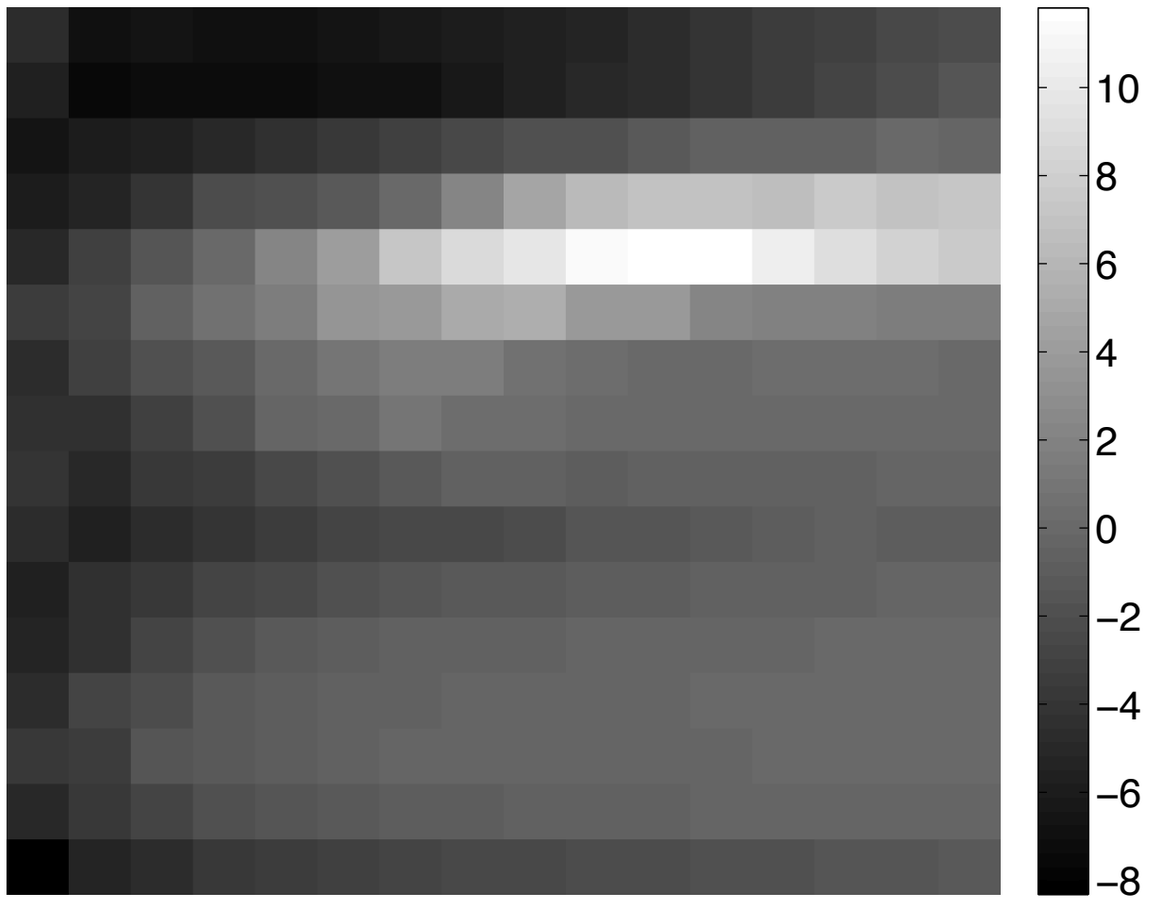
Significance Distribution

HSV histogram with 16^3 bins.

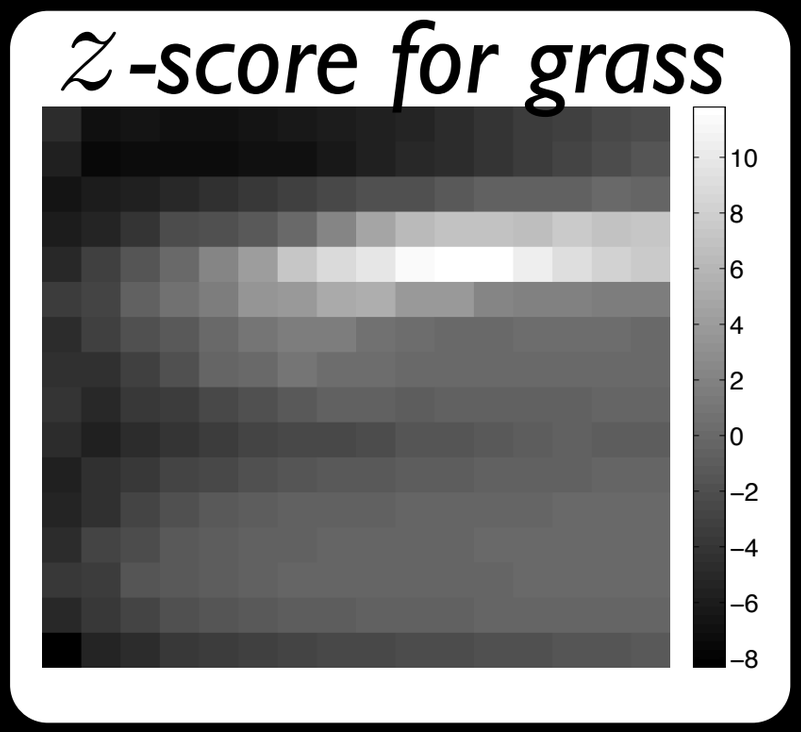
histogram slice, *v*=const



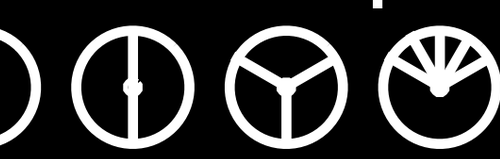
z-score for grass



Palette Optimization



Place 5 colors $\mathbf{c_n}, \mathbf{n} = 1 \ldots 5$ that maximize a palette's significance score $s(\mathbf{c_n})$ and satisfy a hue template:

$\mathbf{c_n} \in P =$ 

$$s(\mathbf{c_n}) = \sum_{\mathbf{c} \in \mathrm{HSV}} z(\mathbf{c}) \cdot \max_{n=1\ldots5} \left[\exp\{(\mathbf{c} - \mathbf{c_n})^2 / \sigma^2\} \right]$$

Hue Templates

h	*s*-0.3	*v*+0.05
h	*s*	*v*+0.3
h	*s*	*v*
h	*s*-0.3	*v*+0.3
h	*s*	*v*-0.2

h	*s*-0.1	*v*+0.3
h	*s*+0.1	*v*-0.2
h	*s*	*v*
h+0.5	*s*+0.2	*v*-0.2
h+0.5	*s*	*v*

h-2α	*s*+0.05	*v*+0.1
h-α	*s*+0.05	*v*+0.05
h	*s*	*v*
h+α	*s*+0.05	*v*+0.05
h+2α	*s*+0.05	*v*+0.1

h+0.33	*s*-0.1	*v*
h	*s*+0.1	*v*-0.3
h	*s*	*v*
h+0.66	*s*+0.2	*v*-0.2
h+0.66	*s*	*v*+0.3

inspired from Adobe Kuler

grass 9.49

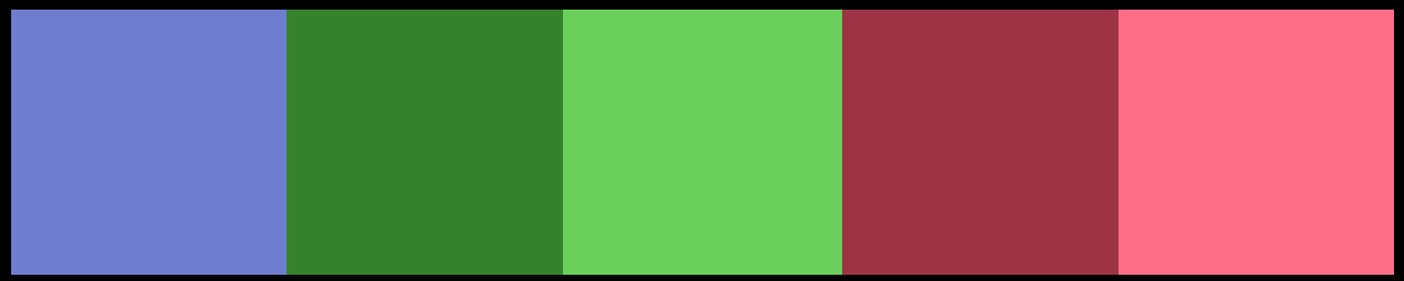
cherry

palette ranking

15.03

9.66

8.08

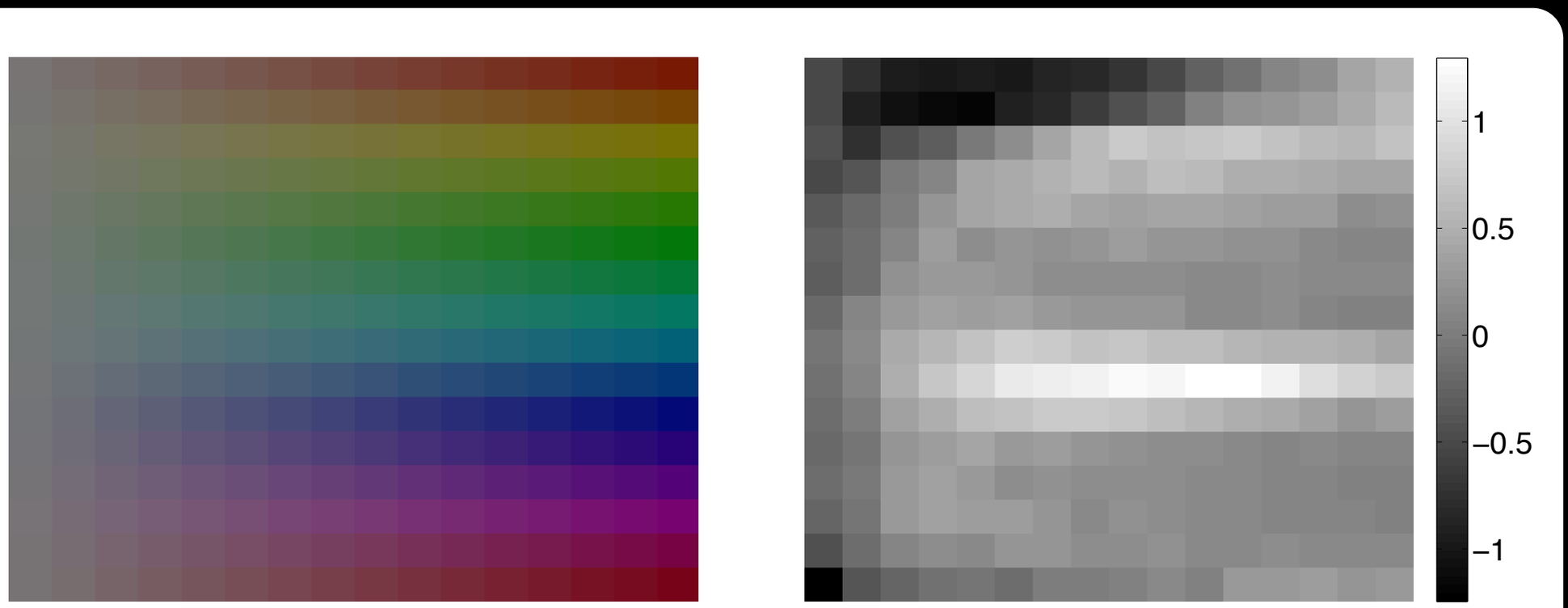


7.23

Palettes from Text

Winter (/ˈwɪntər/ win-tər) is the coldest season of the year in temperate climates, between autumn and spring. It is caused [...]

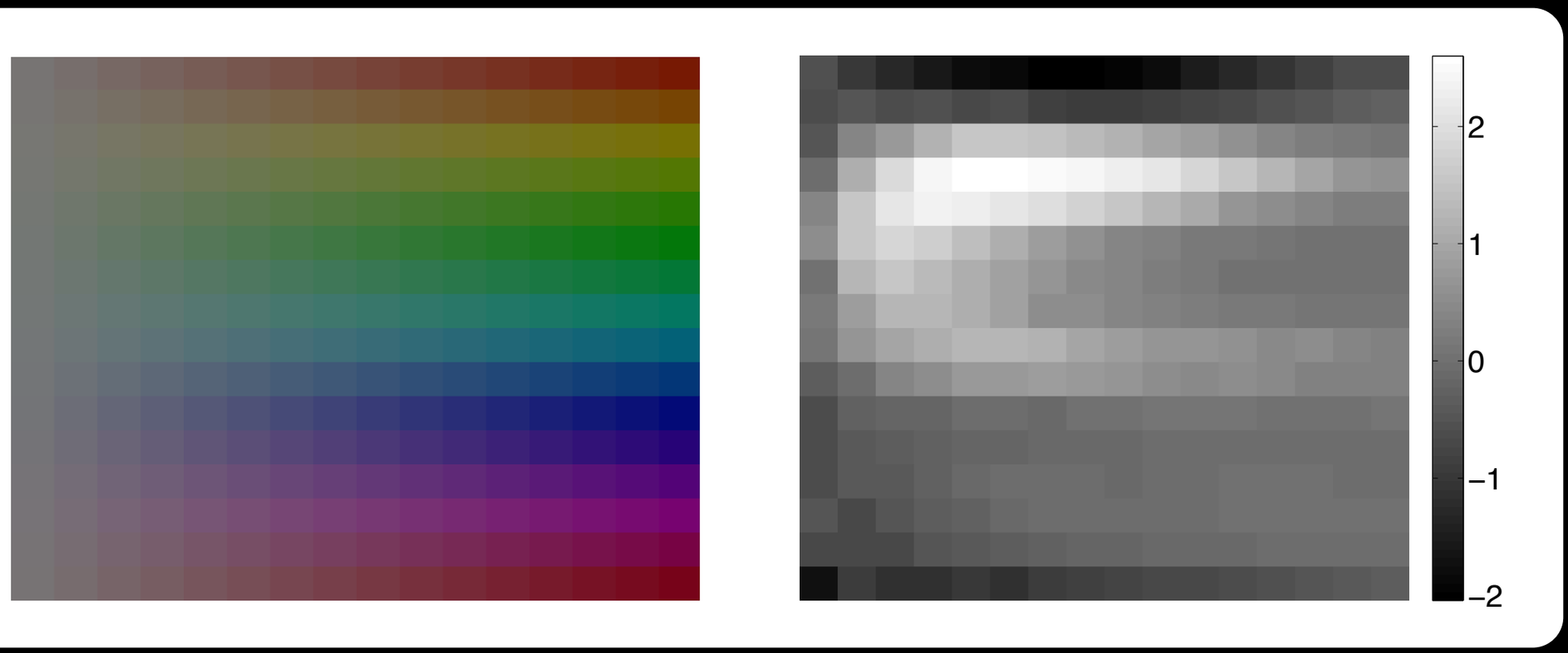
http://en.wikipedia.org/wiki/Winter



Palettes from Text

A swamp is a wetland that is forested.[1] Many swamps occur along large rivers, where they are critically dependent upon natural water [...]

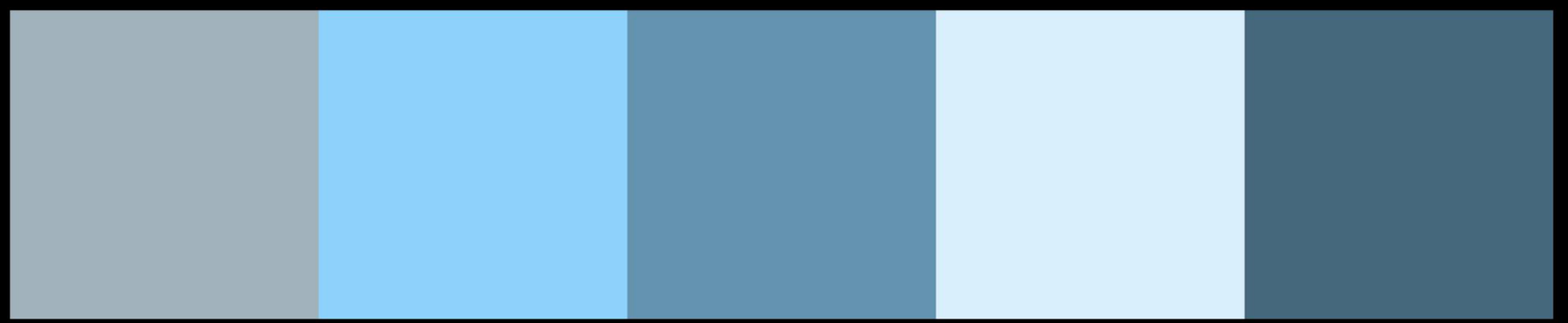
http://en.wikipedia.org/wiki/Swamp



Palettes from Text

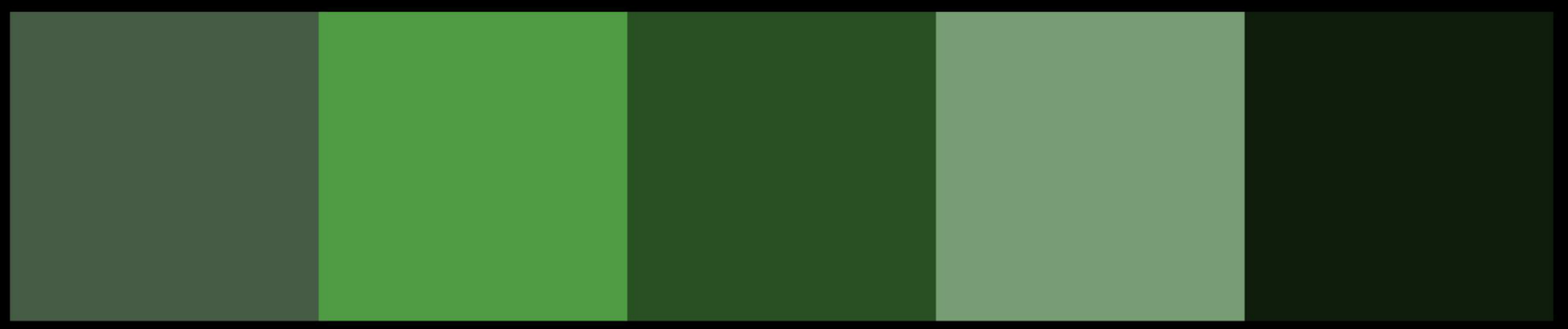
winter

3.85



swamp

5.85



Psychophysical Evaluation

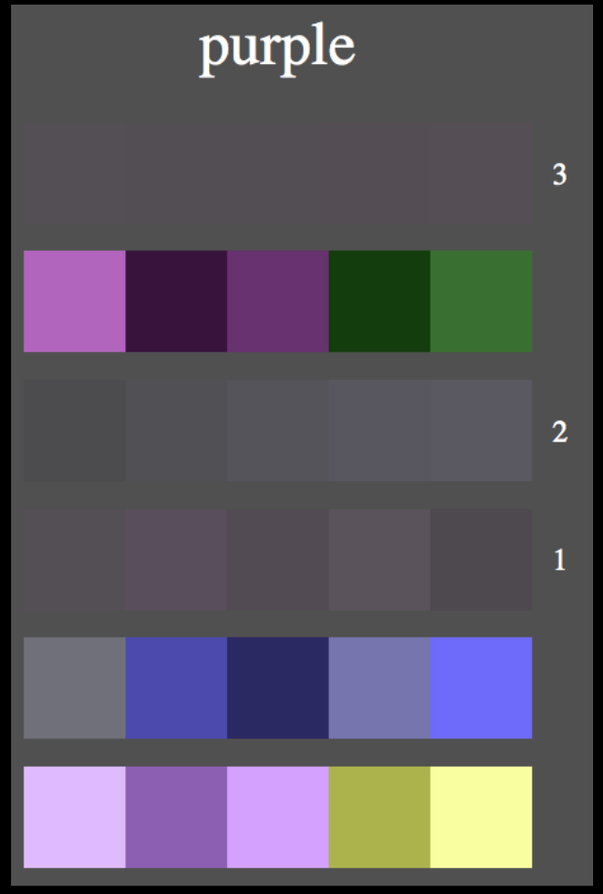
1. How do we compare w.r.t. Adobe Kuler?
2. Is the palette's significance score a reasonable rank order estimate?

Palette Preparation

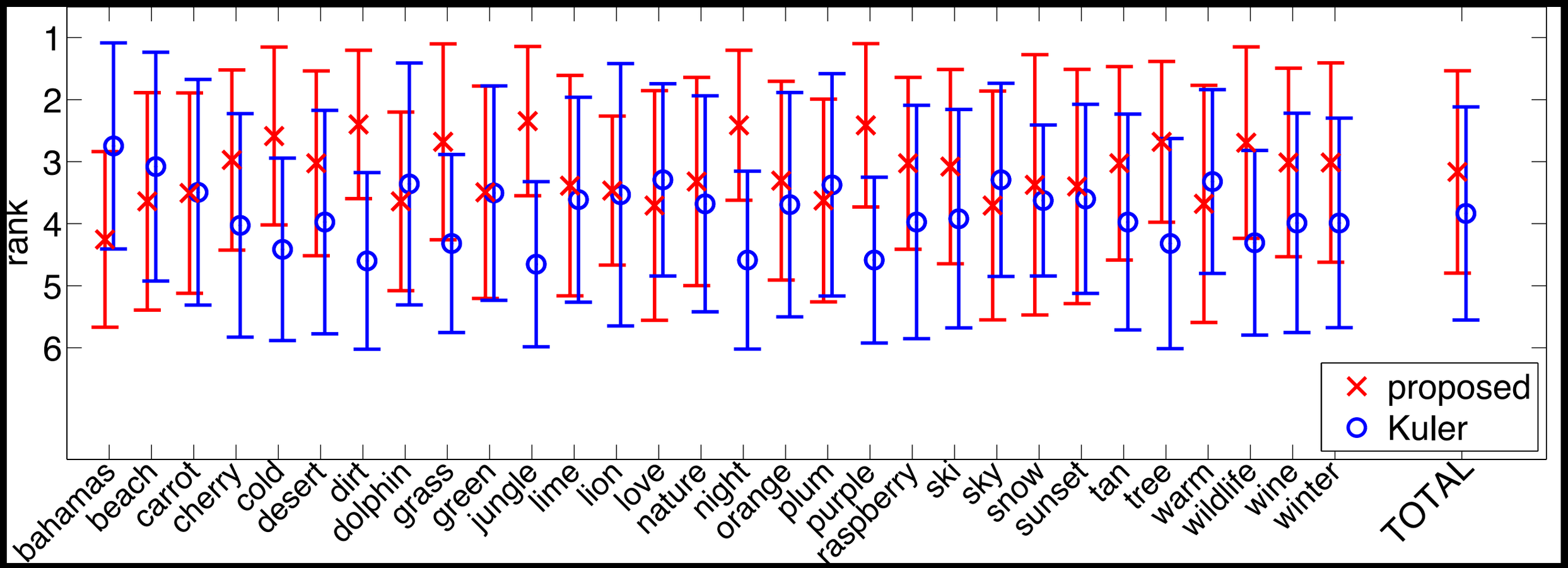
- 30 words: *bahamas, beach, carrot, cherry, cold, desert, dirt, dolphin, grass, green, jungle, lime, lion, love, nature, night, orange, plum, purple, raspberry, ski, sky, snow, sunset, tan, tree, warm, wildlife, wine, and winter.*
  Keywords cover a large gamut.
- 3 palettes per kewyord with highest significance score.
- Query Adobe Kuler with keyword and take palette that best matches each hue template.

Experiment Setup

- Web-based, 25 observers.
- *"Please rank the color palettes according to how well they match the given keyword."*

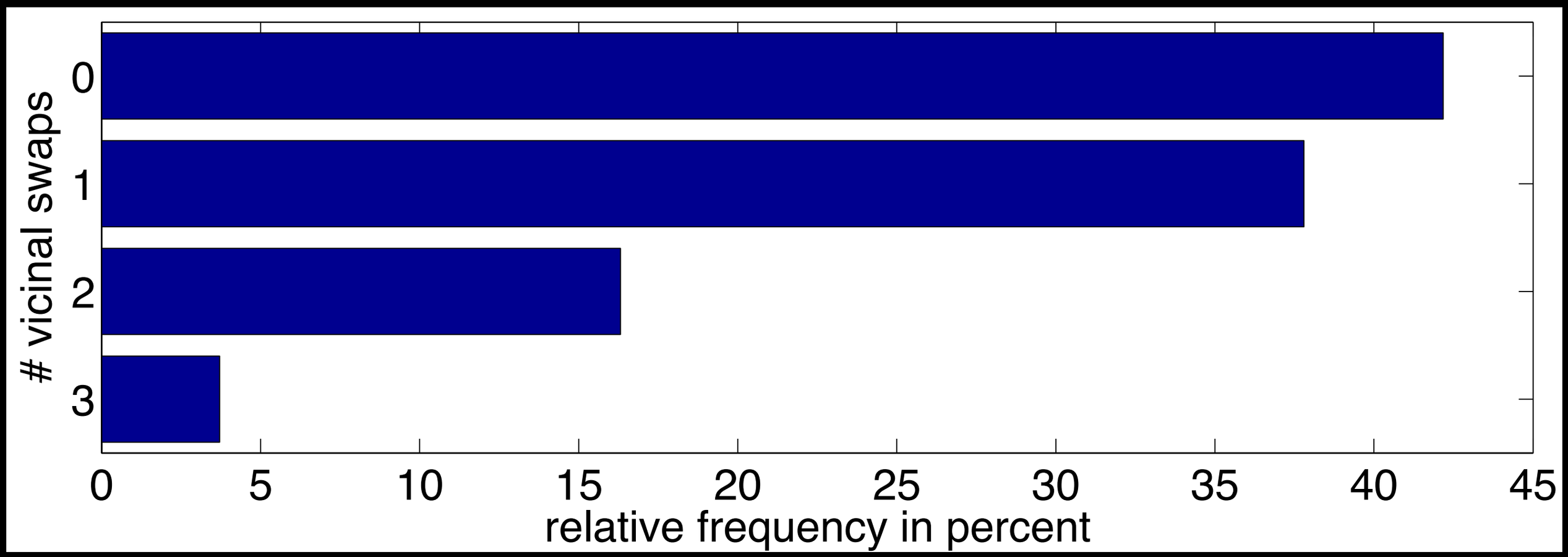


Comparison to Adobe Kuler



- Automatic method is euqally good as Adobe Kuler.

Ranking



- The significance score is a reasonable rank order estimate.

Conclusions

- 100,000 words and 6 Million images.
- Statistical test to link words with colors.
- Automatic creation of palettes from words and text.
- Equally good as Adobe Kuler.
- Significance score as rank order estimate.
- **Fully automatic set-up and operation.**

Q&A