

BubbleView: an interface for crowdsourcing image importance maps and tracking visual attention



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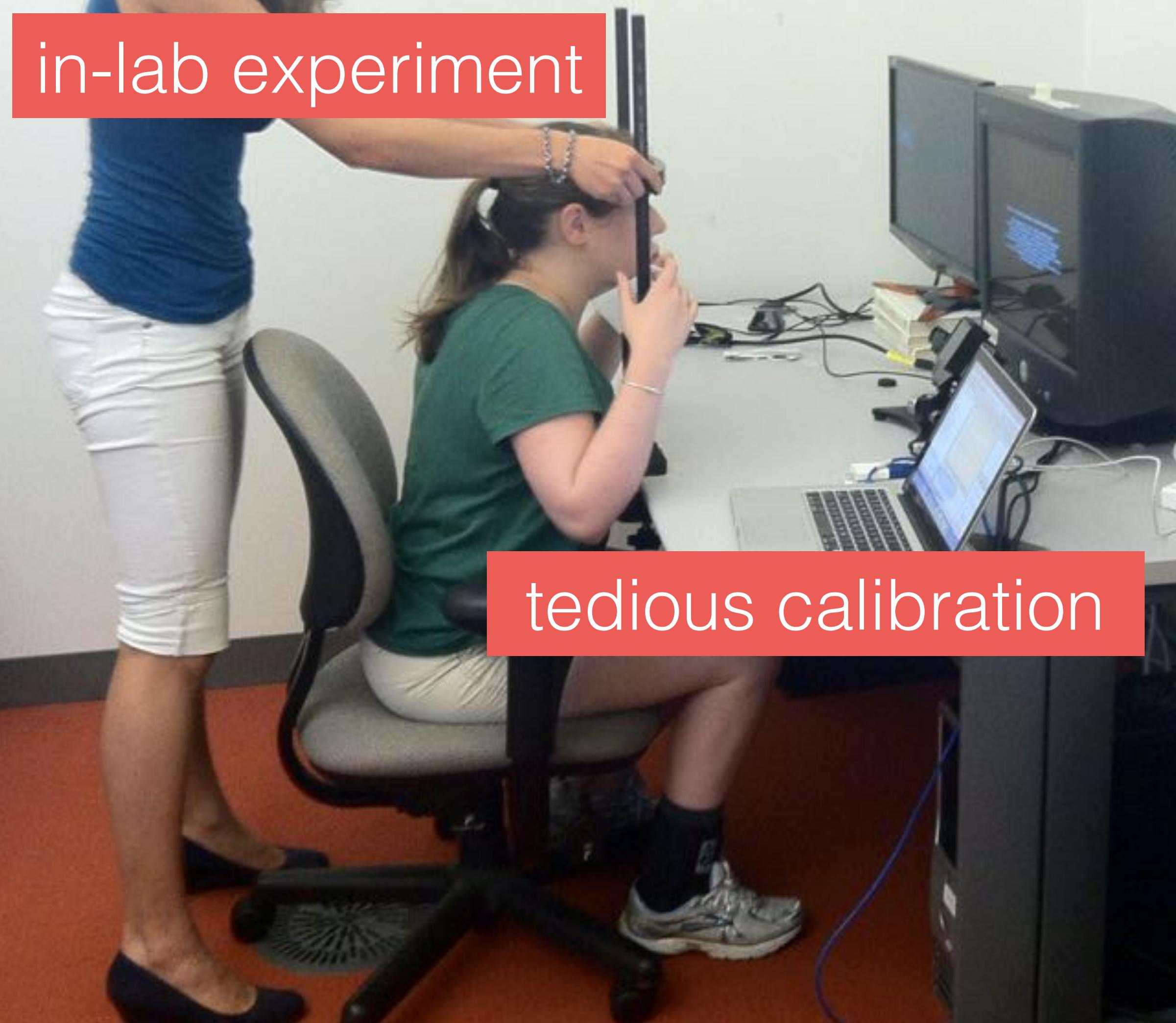
Northeastern University
College of Computer and Information Science

Eye-tracking for capturing human visual attention



Eye-tracking for capturing human visual attention

in-lab experiment



tedious calibration

specialized hardware





Eye-tracking for capturing human visual attention

in-lab experiment

*Difficult to scale up data collection
to more than a few participants*

tedious calibration

specialized hardware

0 clicks 0 characters



Describe the image in as much detail as possible...

Bubble View

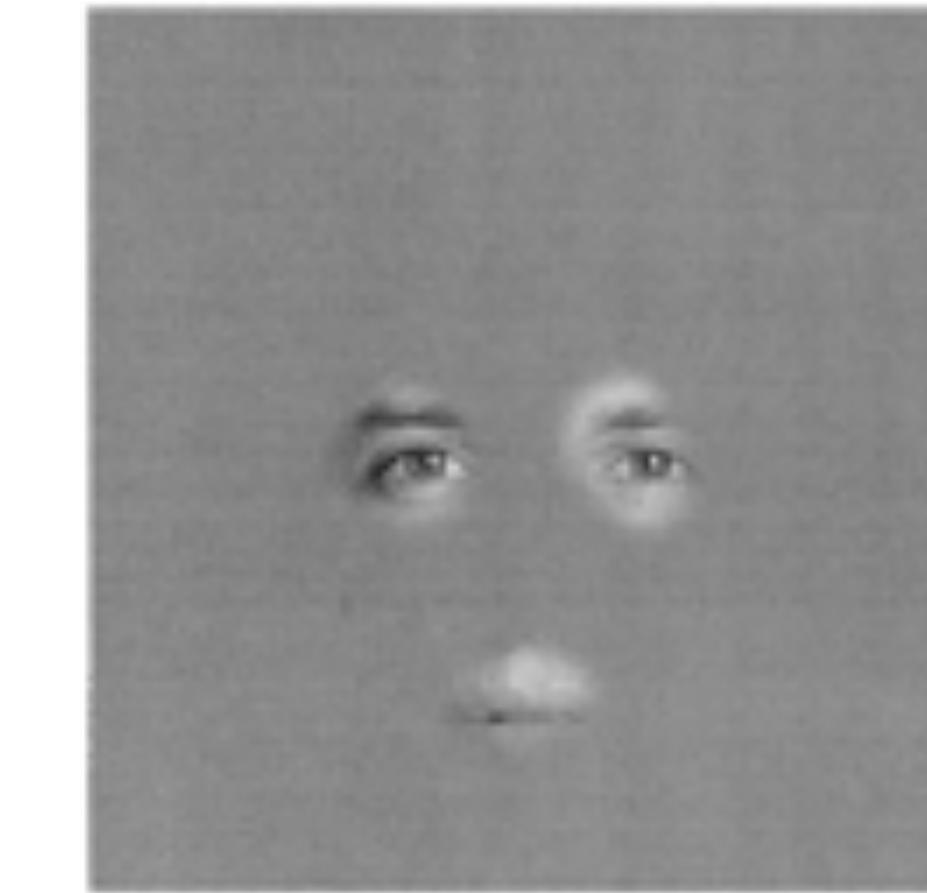
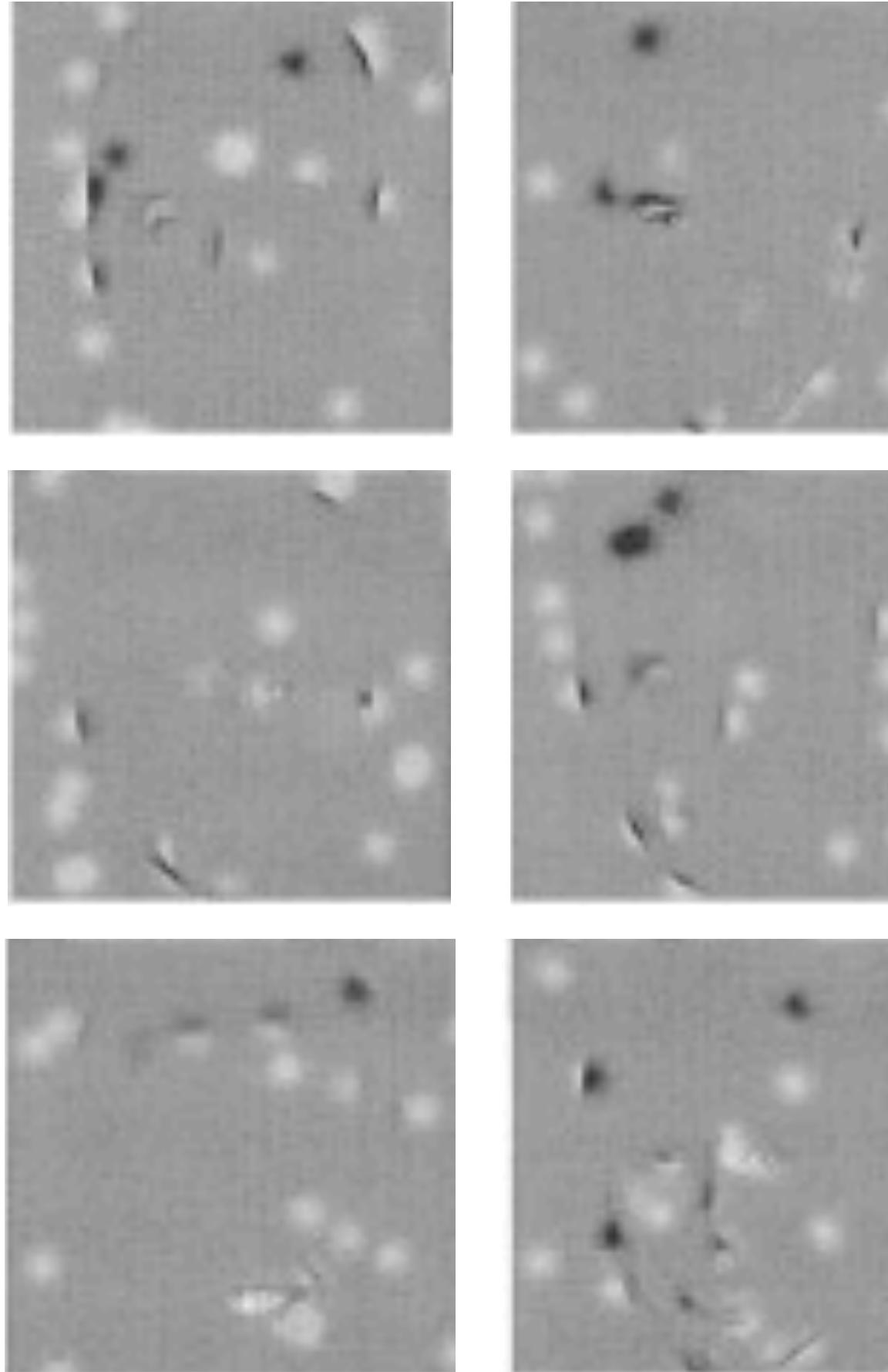
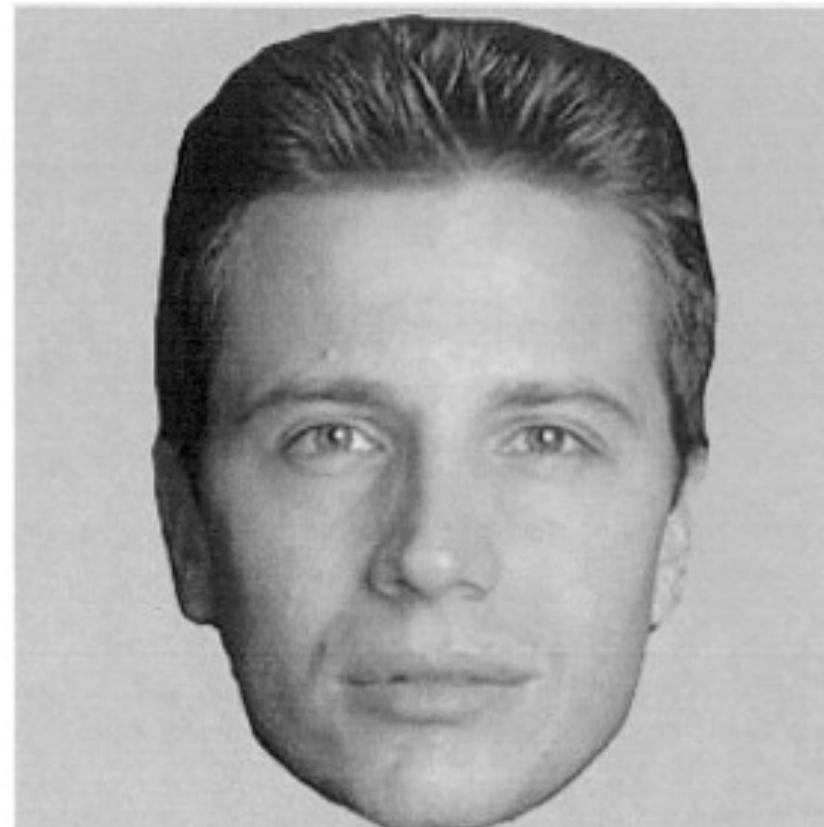
An alternative for eye tracking using **discrete mouse clicks** to measure which information people **consciously** choose to examine.

>> 2x

NEXT

Inspiration: Bubbles

[Gosselin & Schyns, 2001]



The **eyes** and **mouth**

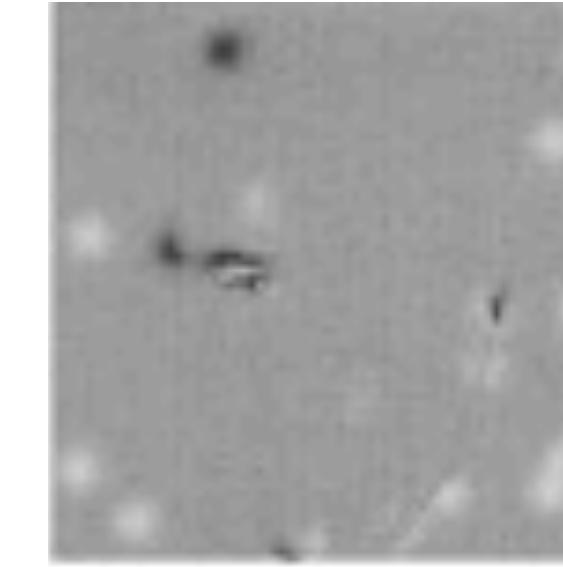
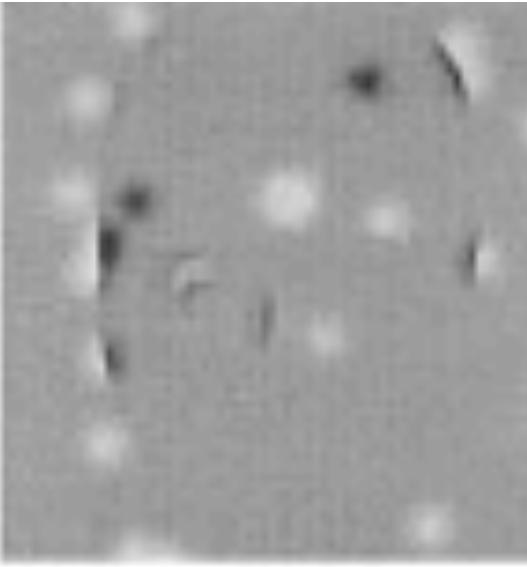
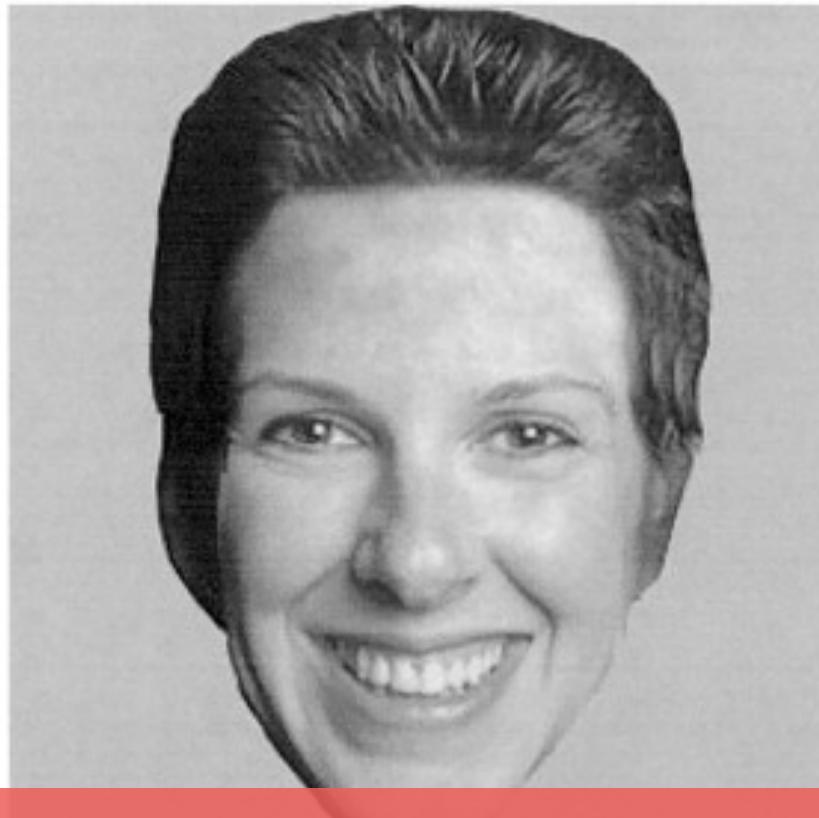
Face stimuli

Punctured by bubbles

Gender categorization

Inspiration: Bubbles

[Gosselin & Schyns, 2001]



BubbleView generalizes this idea to allow users to control where they want to look.

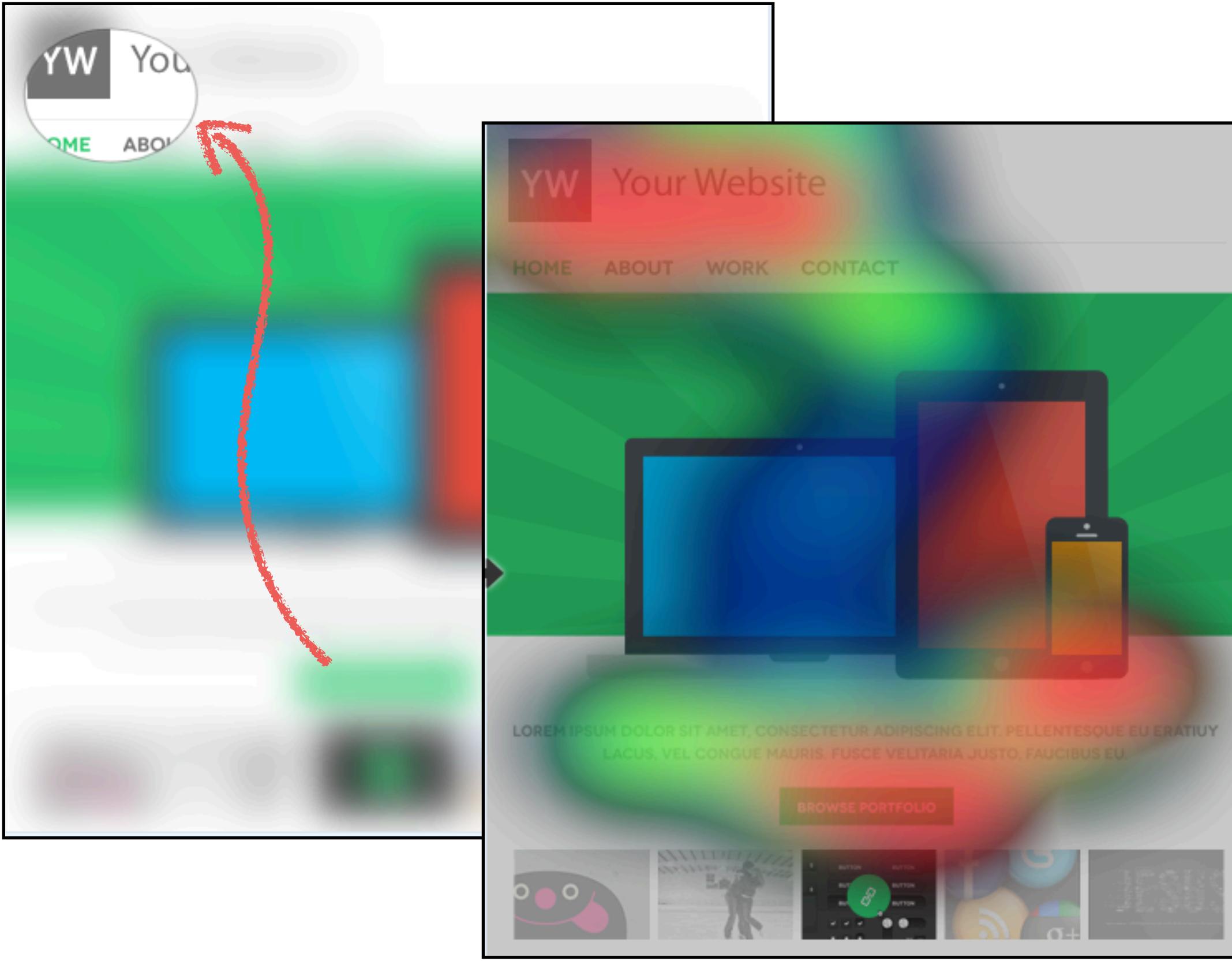
The eyes and mouth

Face stimuli

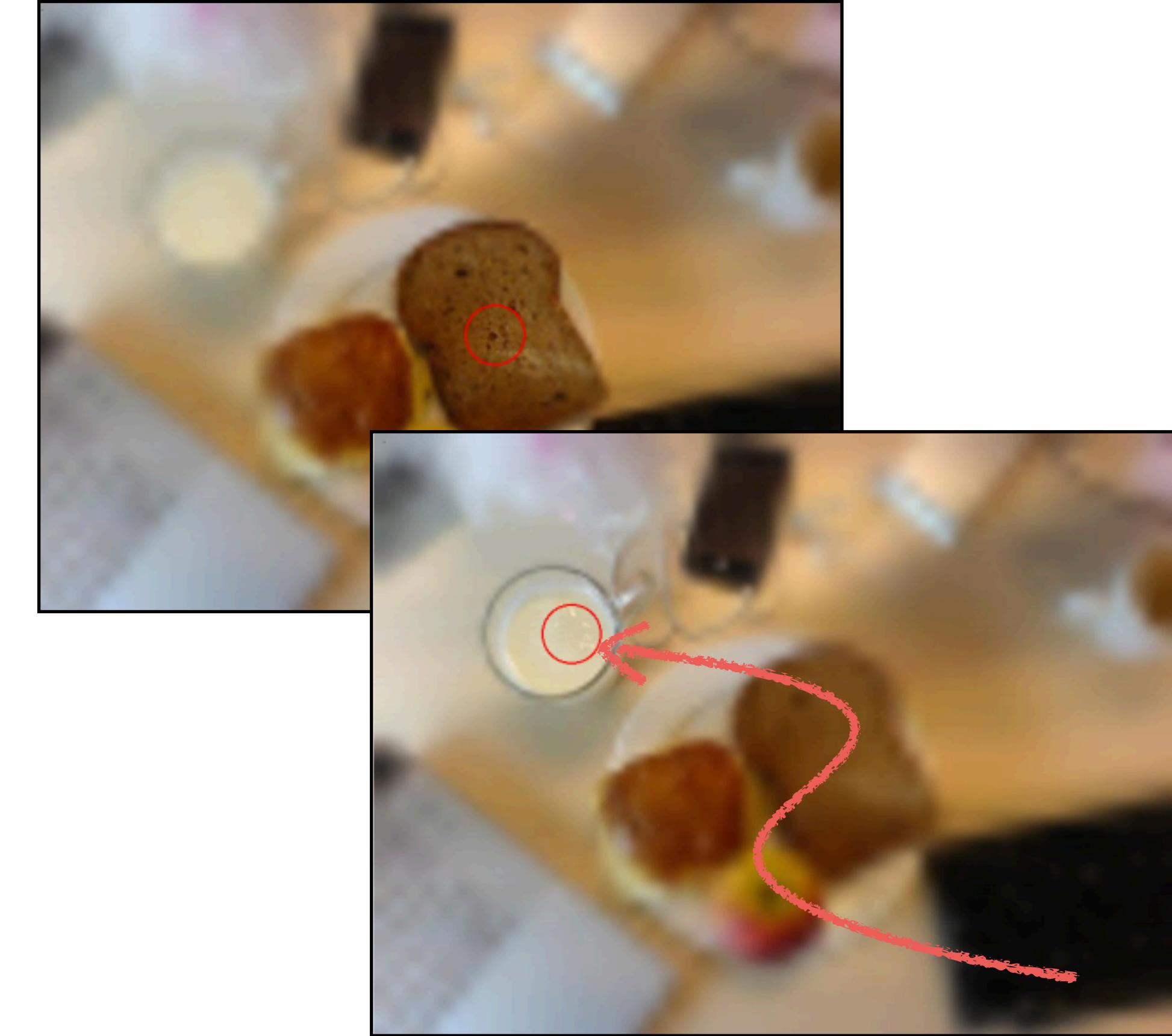
Punctured by bubbles

Gender categorization

Cursor-Based Attention Tracking

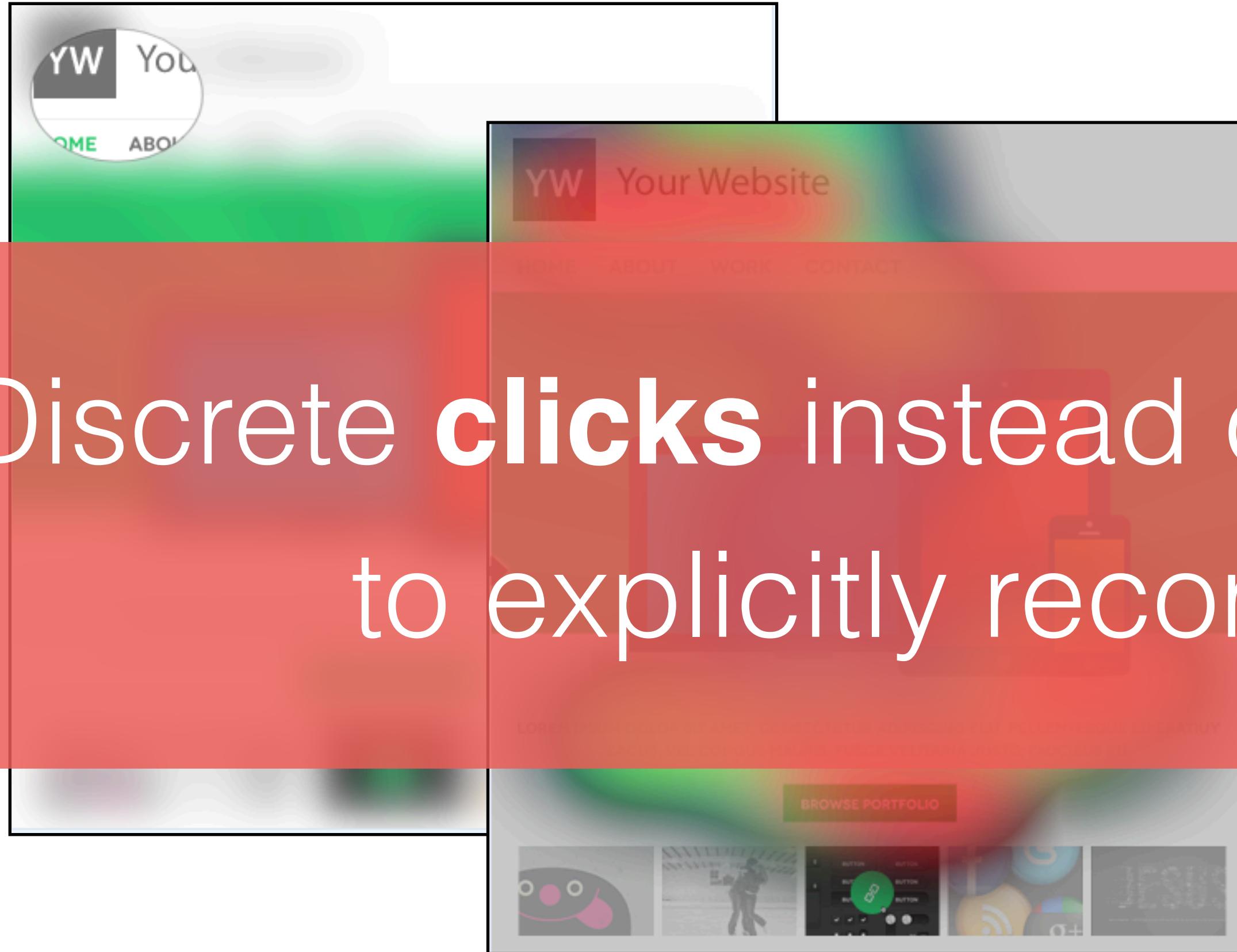


[Schulte- Mecklenbeck et al. 2011]

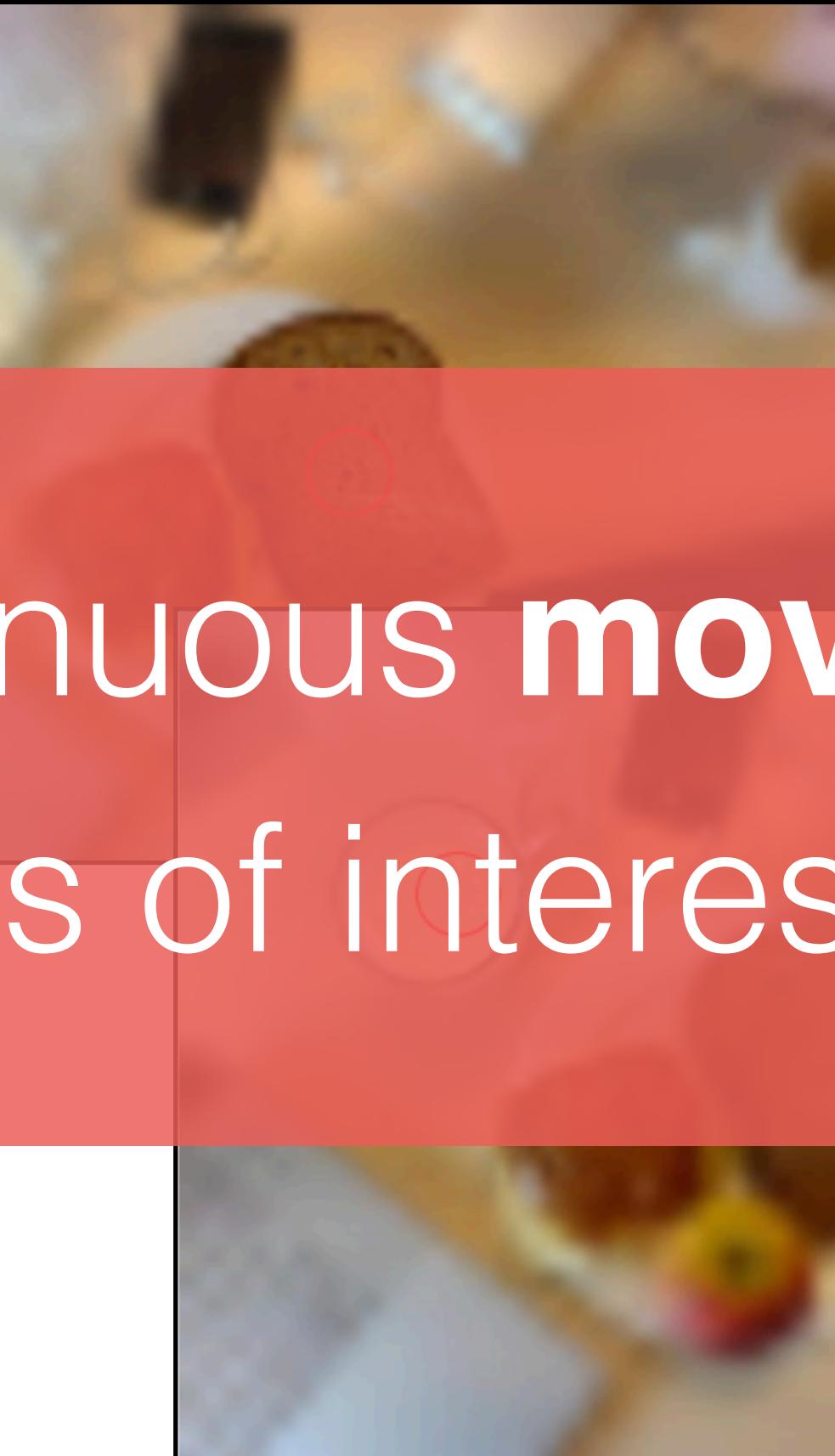


[Jiang et al. 2015]

Cursor-Based Attention Tracking



Discrete **clicks** instead of continuous **movements**
to explicitly record points of interest



[Schulte- Mecklenbeck et al. 2011]

[Jiang et al. 2015]

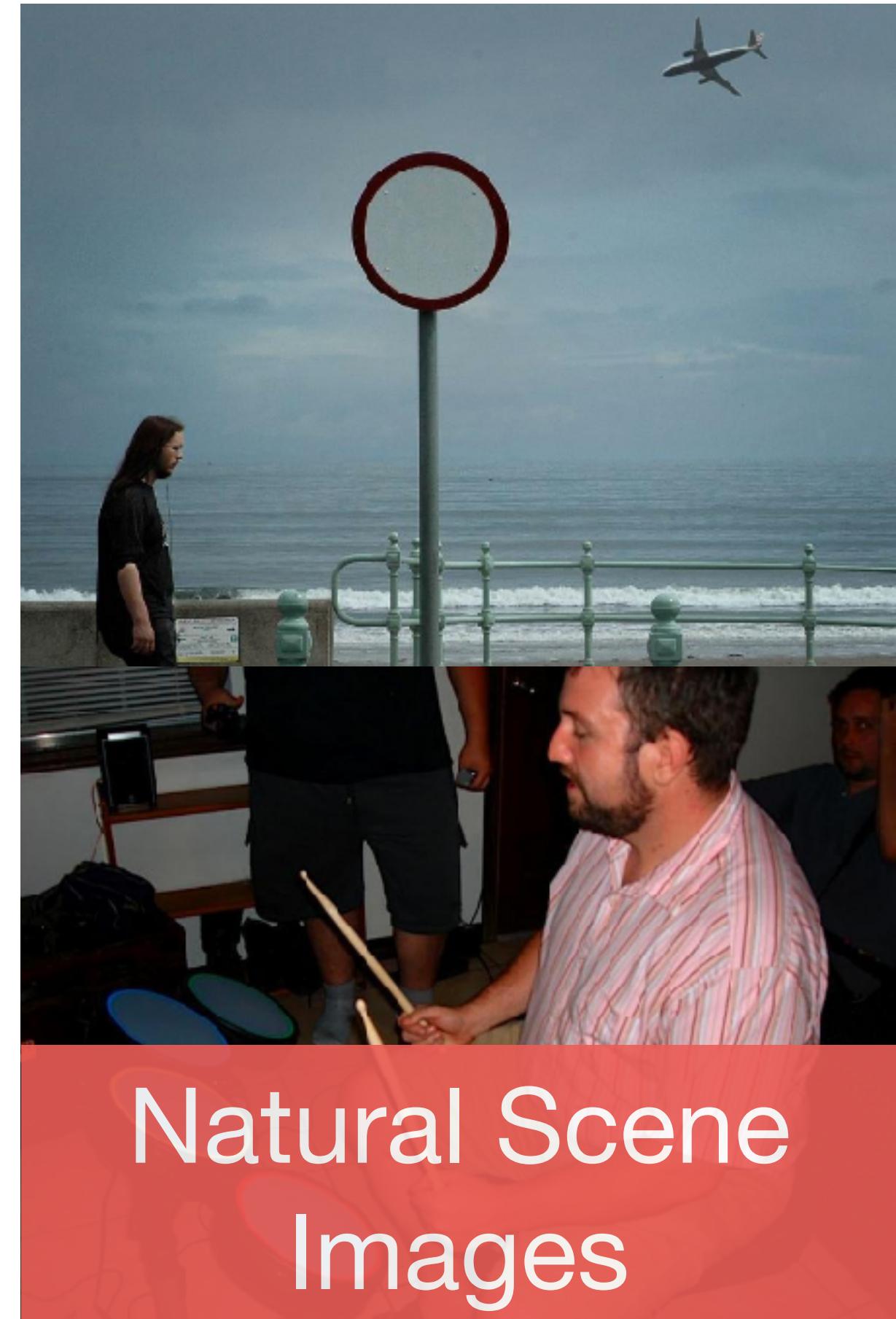
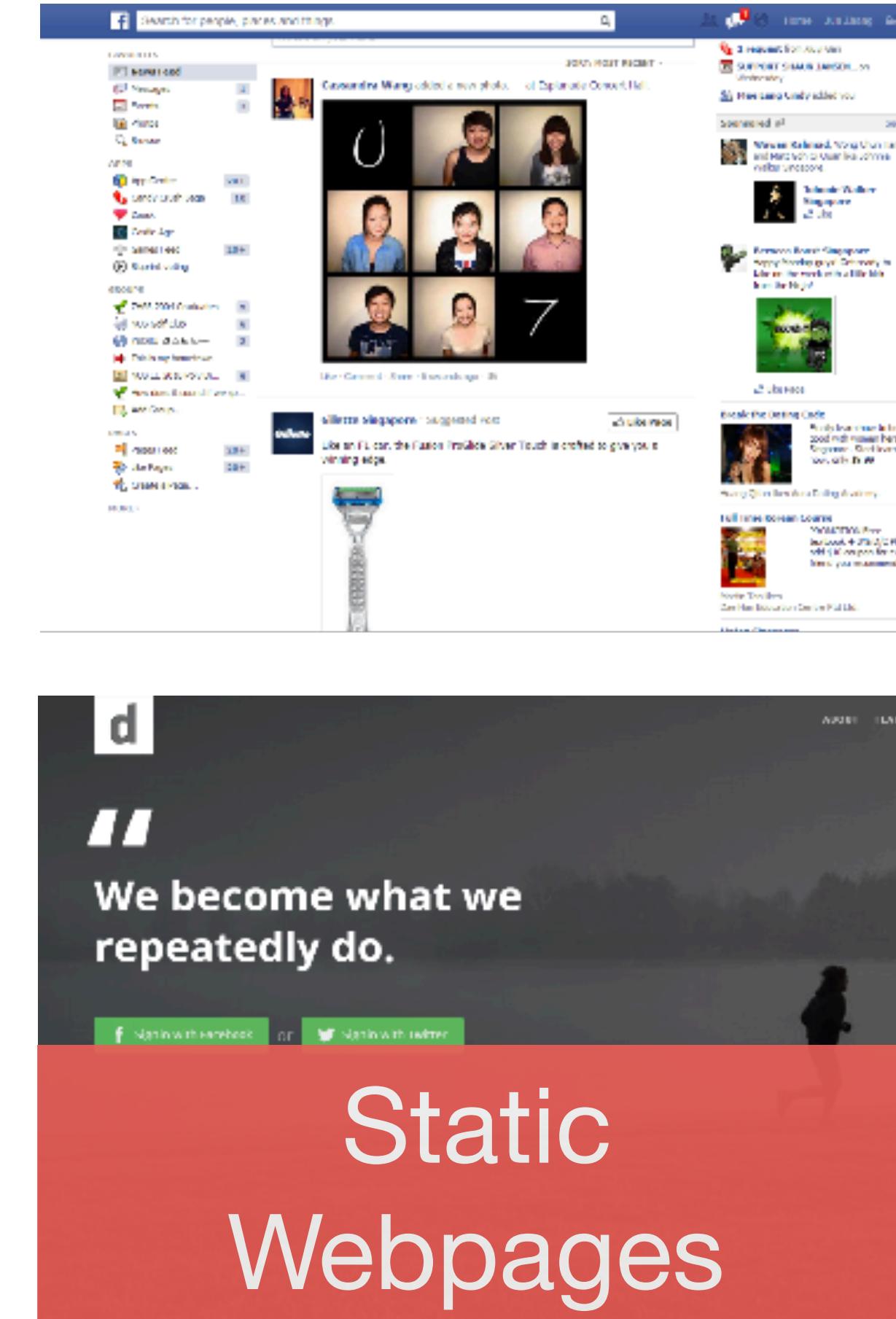
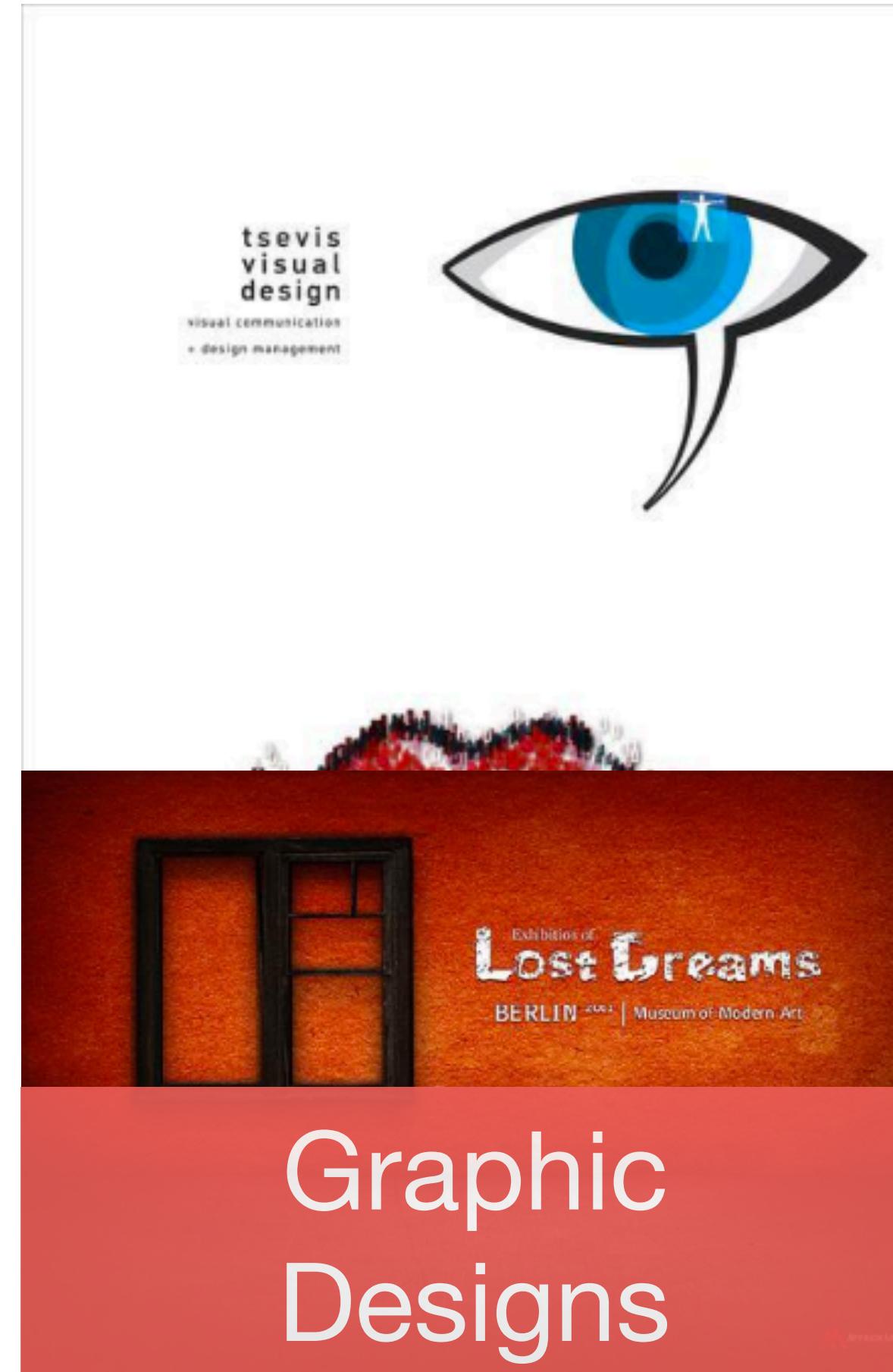
Cursor-Based Attention Tracking

We systematically evaluate cursor-based tracking under different parameters and task settings.

[Schulte- Mecklenbeck et al. 2011]

[Jiang et al. 2015]

Evaluated on Various Image Types



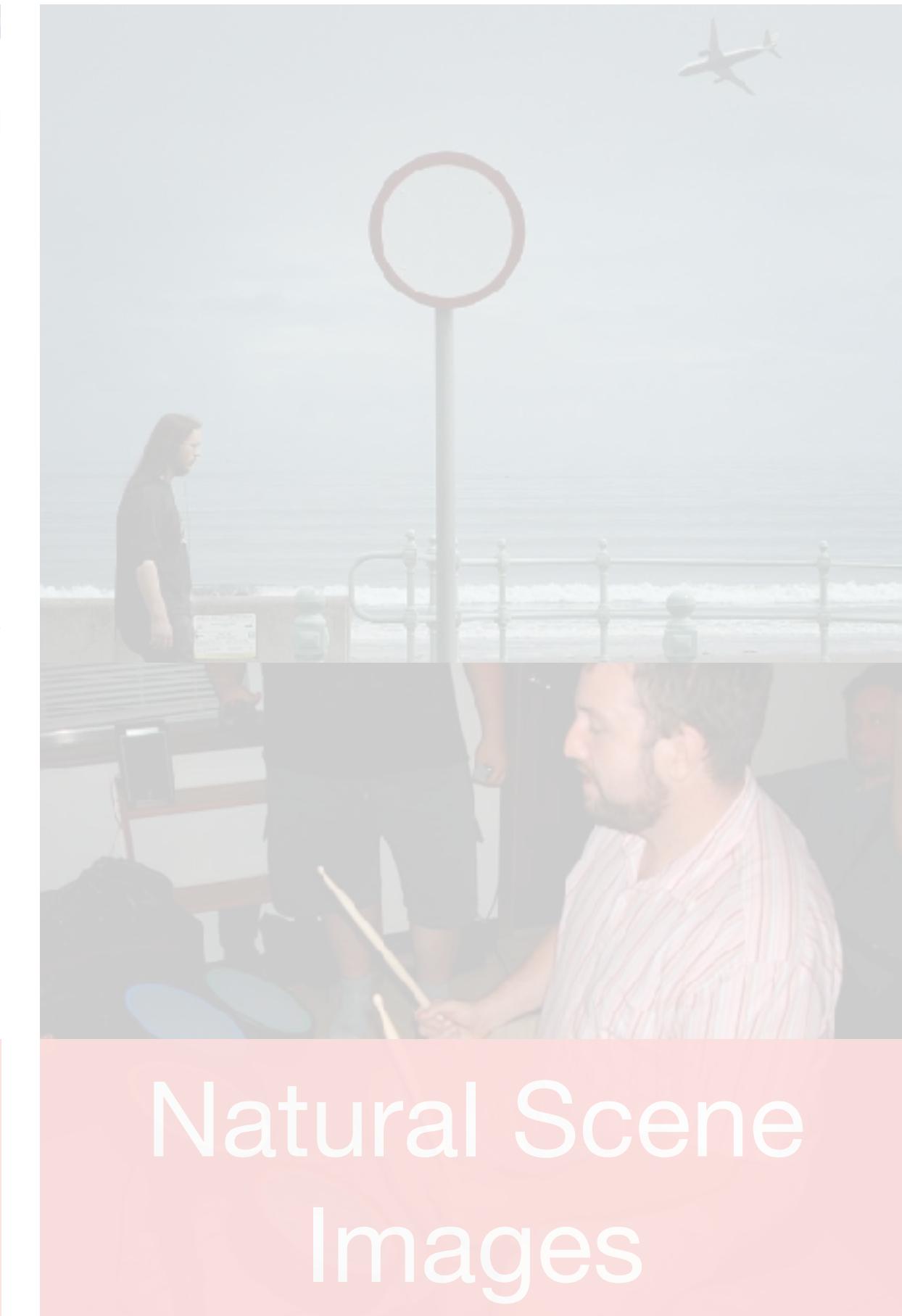
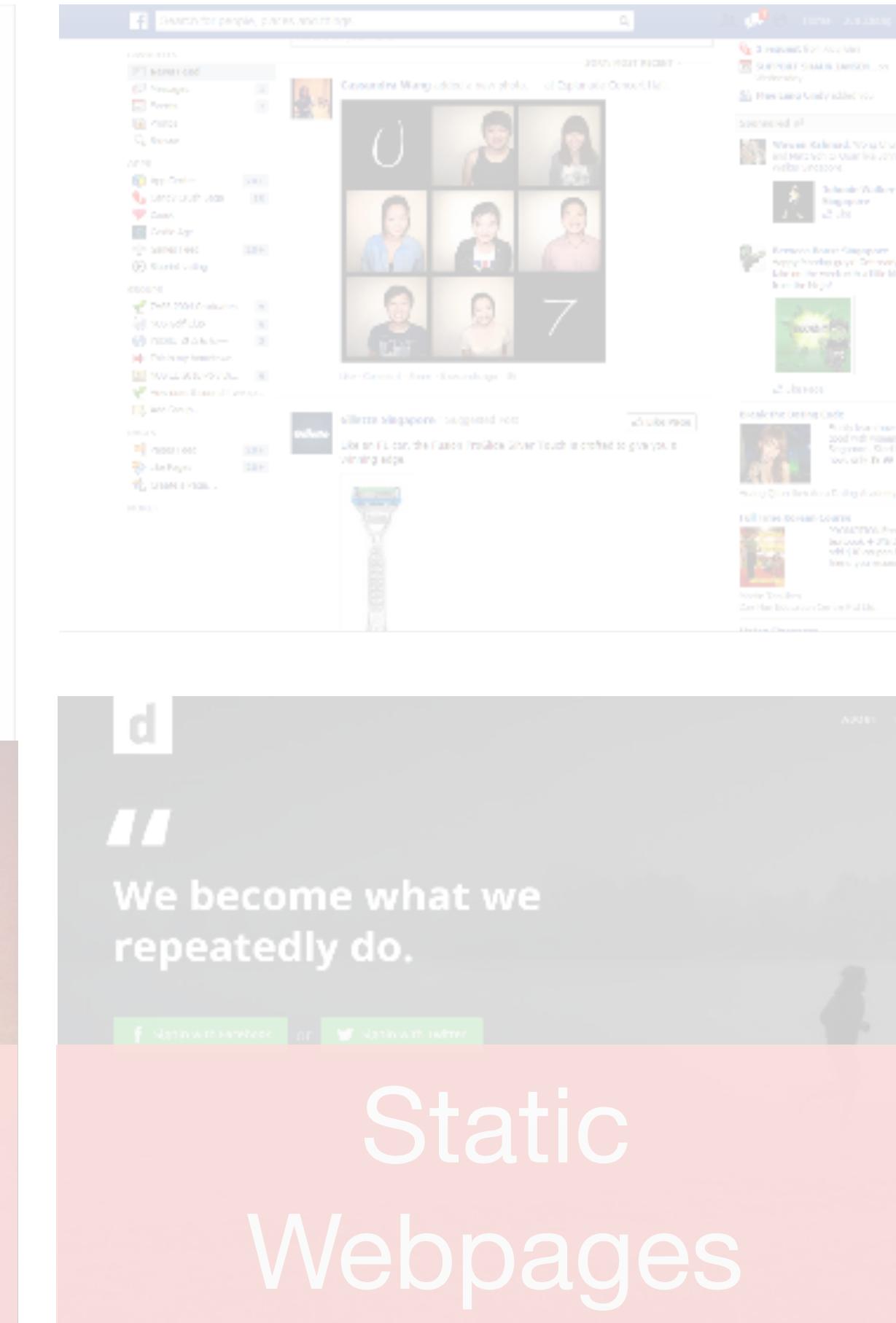
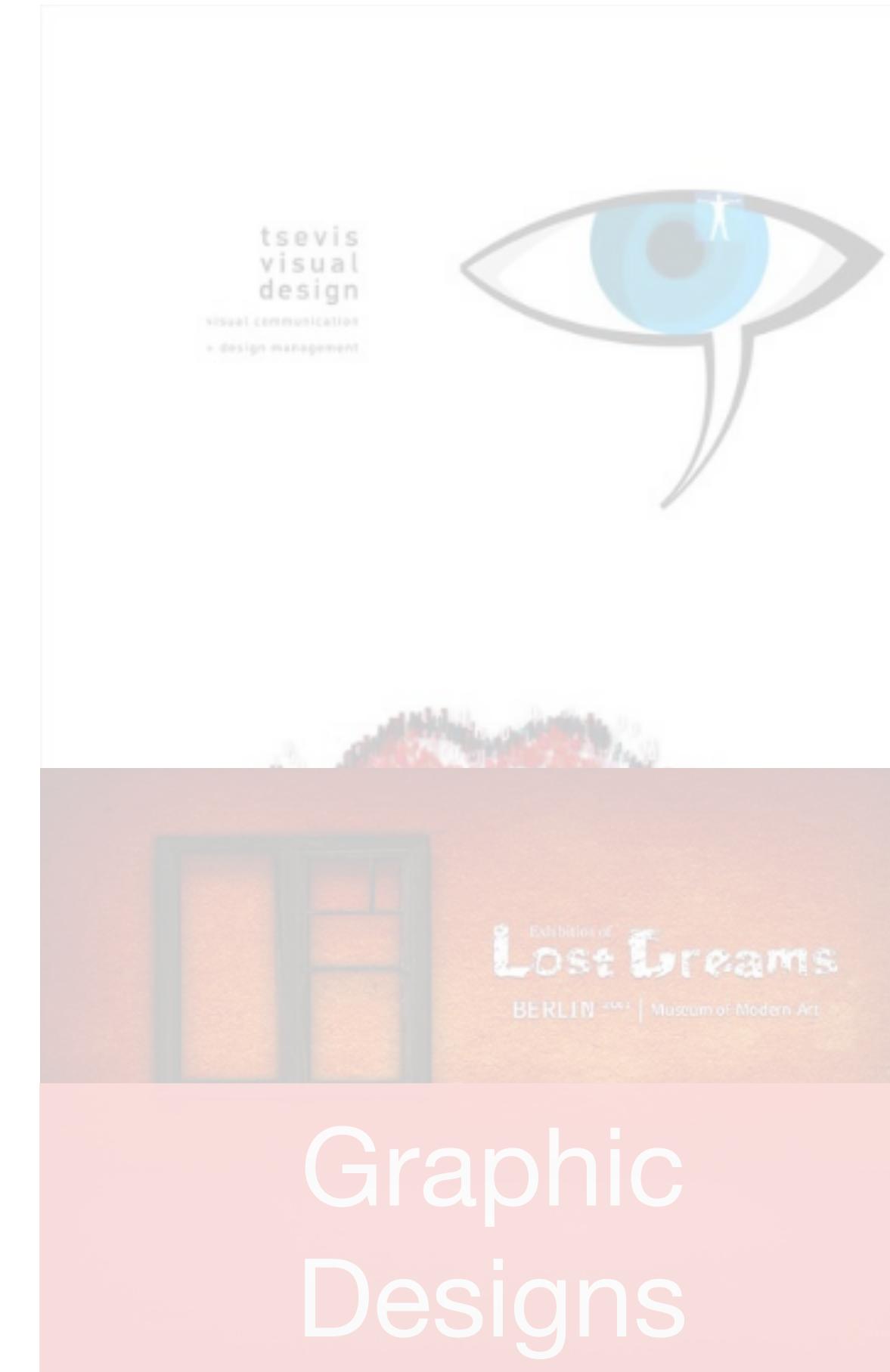
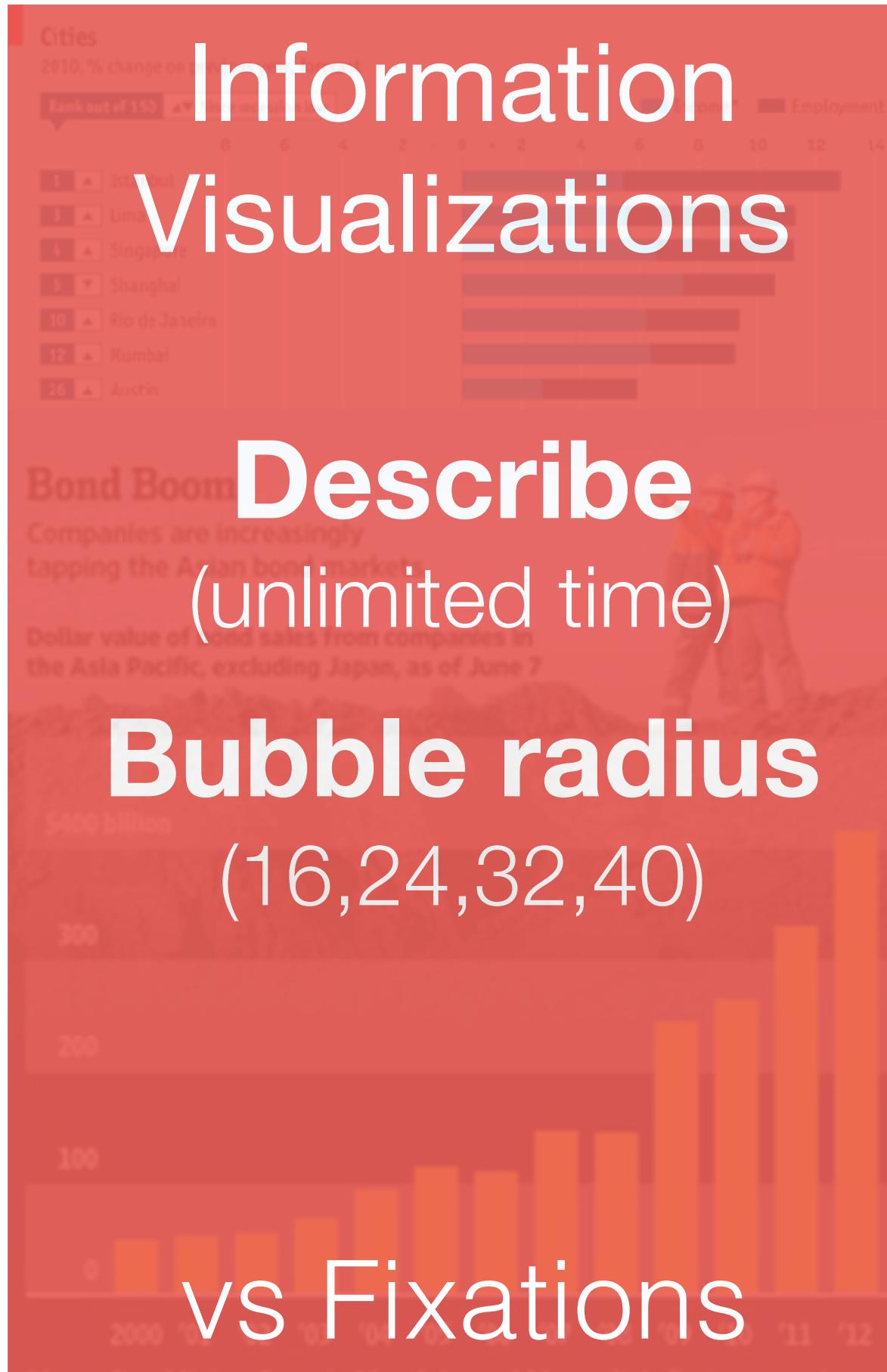
MASSVIS
[Borkin et al. 2016]

GDI
[O'Donovan et al. 2014]

FIWI
[Shen and Zhao 2014]

OSIE
[Xu et al. 2014]

Evaluation Configuration



Description Task

Click and describe the image



0 clicks 0 characters

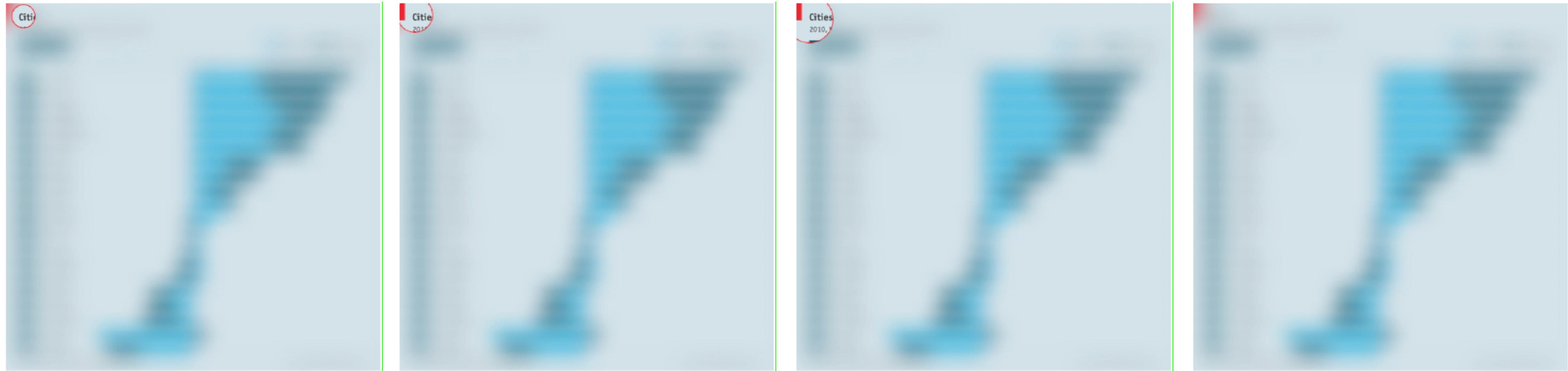
Describe the image in as much detail as possible...

Unlimited time +
150 minimum characters

NEXT

Varied Bubble Sizes

How does bubble radius size affect performance?



16 pixels

24 pixels

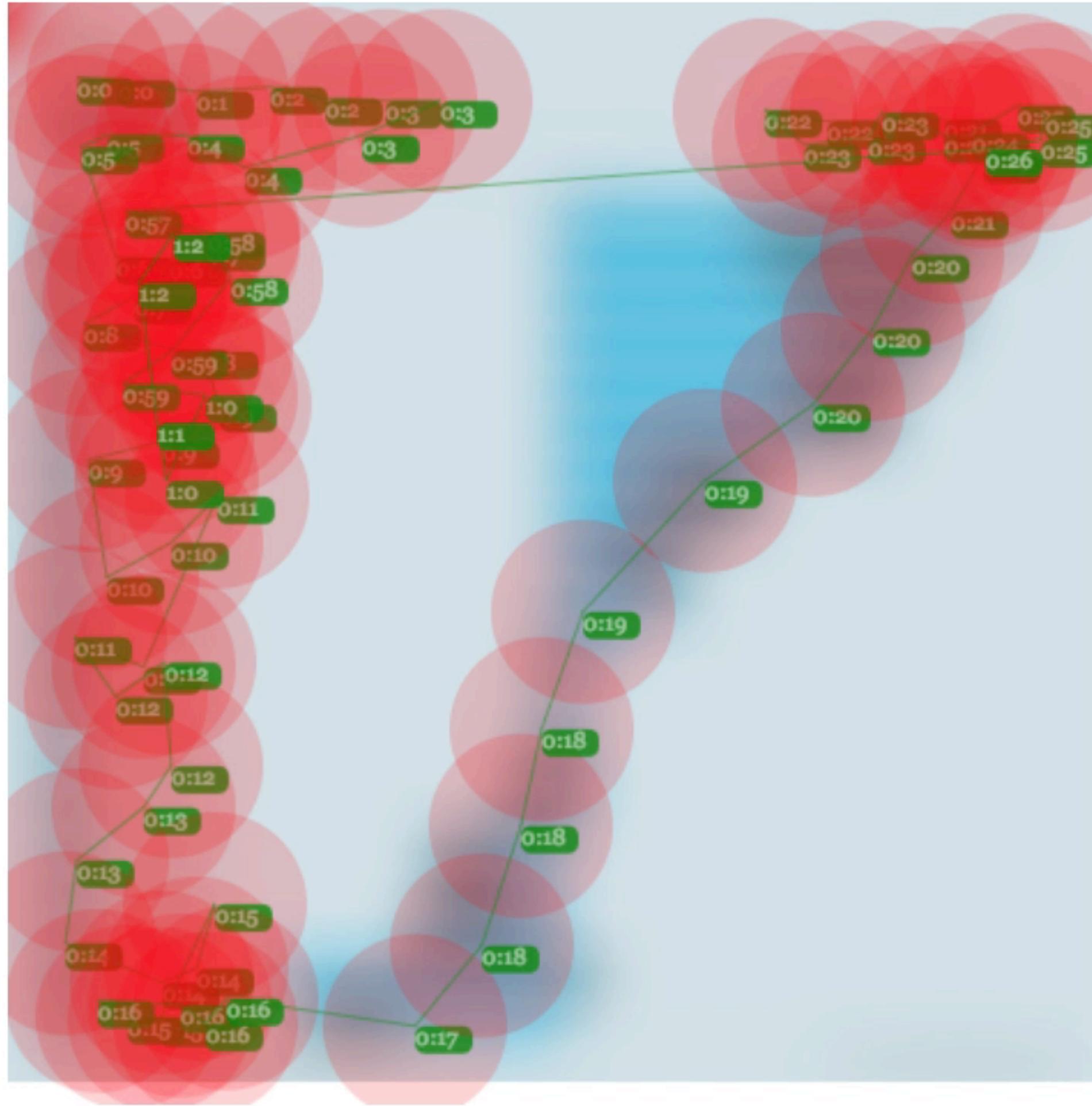
32 pixels

40 pixels

Collected Data

See Original

See Bubbles



Time Slider (75/75)

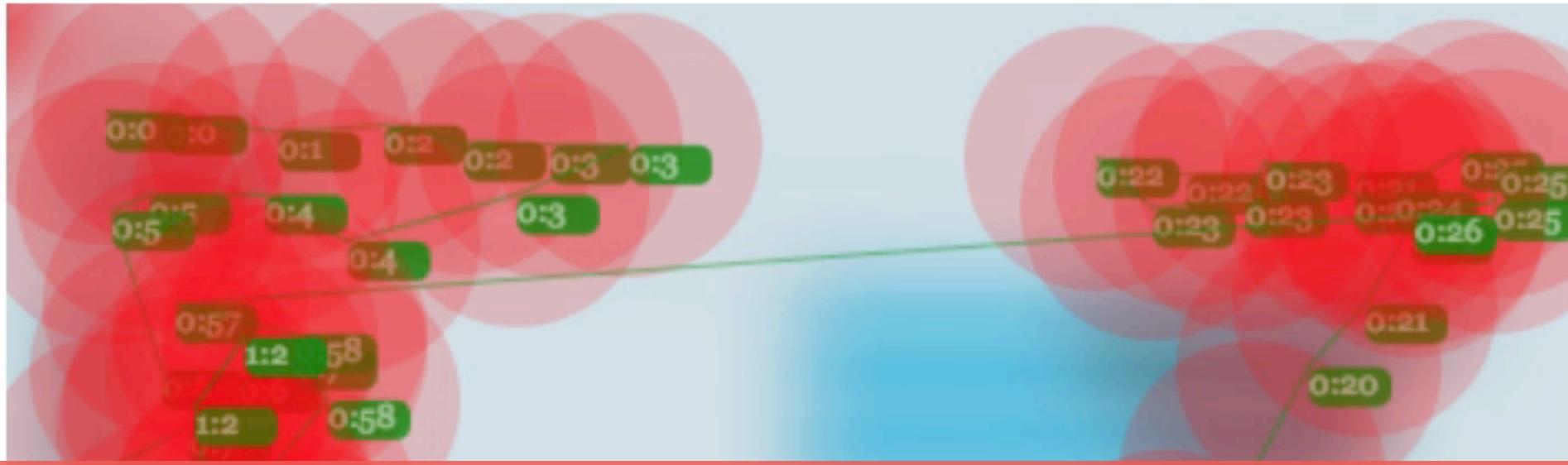
Description Change:

This chart includes the percentage change on the previous year forecast of income versus employment for the year 2010. Cities include Istanbul, Lima, Singapore, Shanghai, Mumbai, Rio de Janeiro.

Clicks &
Description changes over time.

Collected Data

See Original



See Bubbles

Filtered malicious data &
Compared clicks to eye-fixations

Time Slider (75/75)

Description Change:

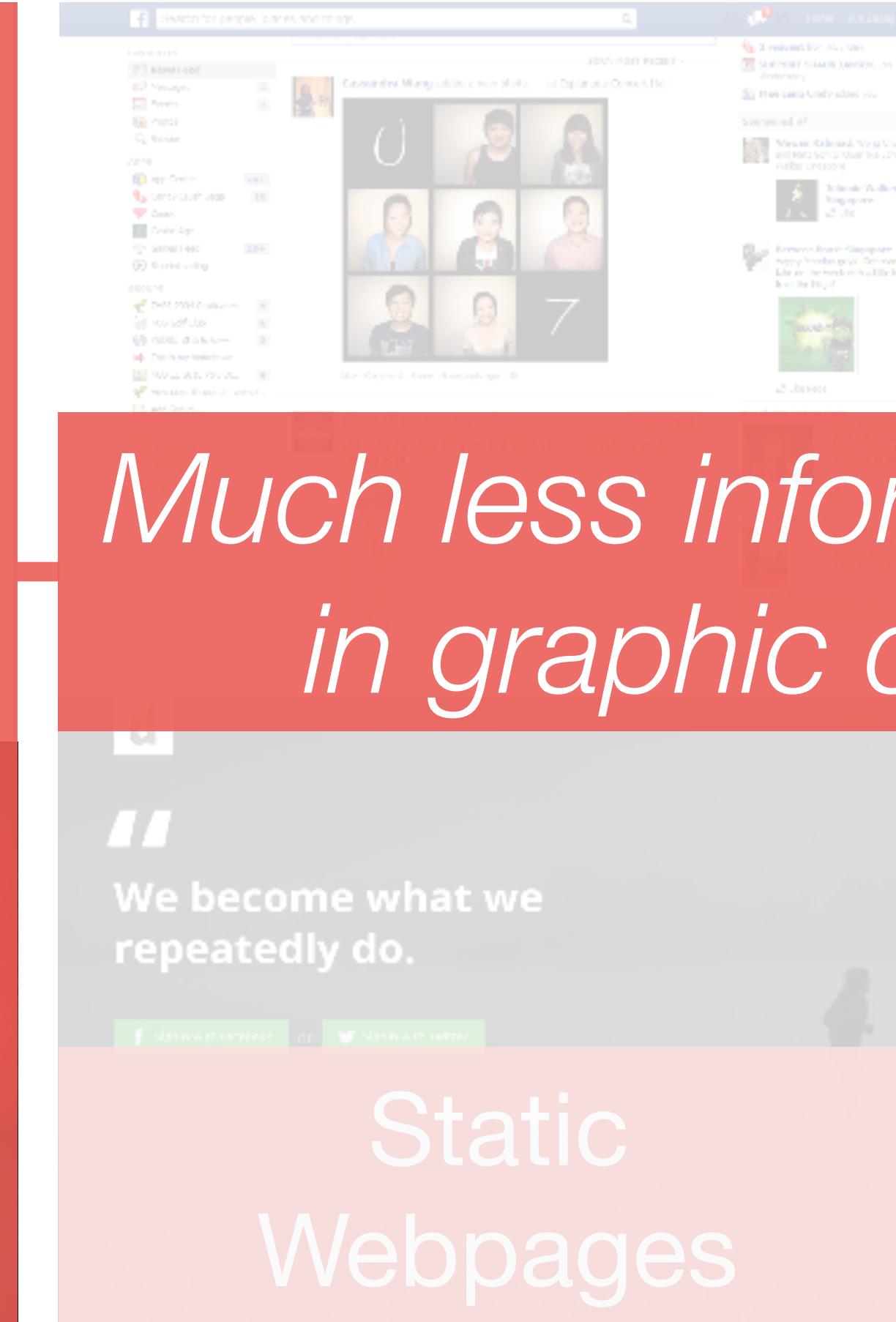
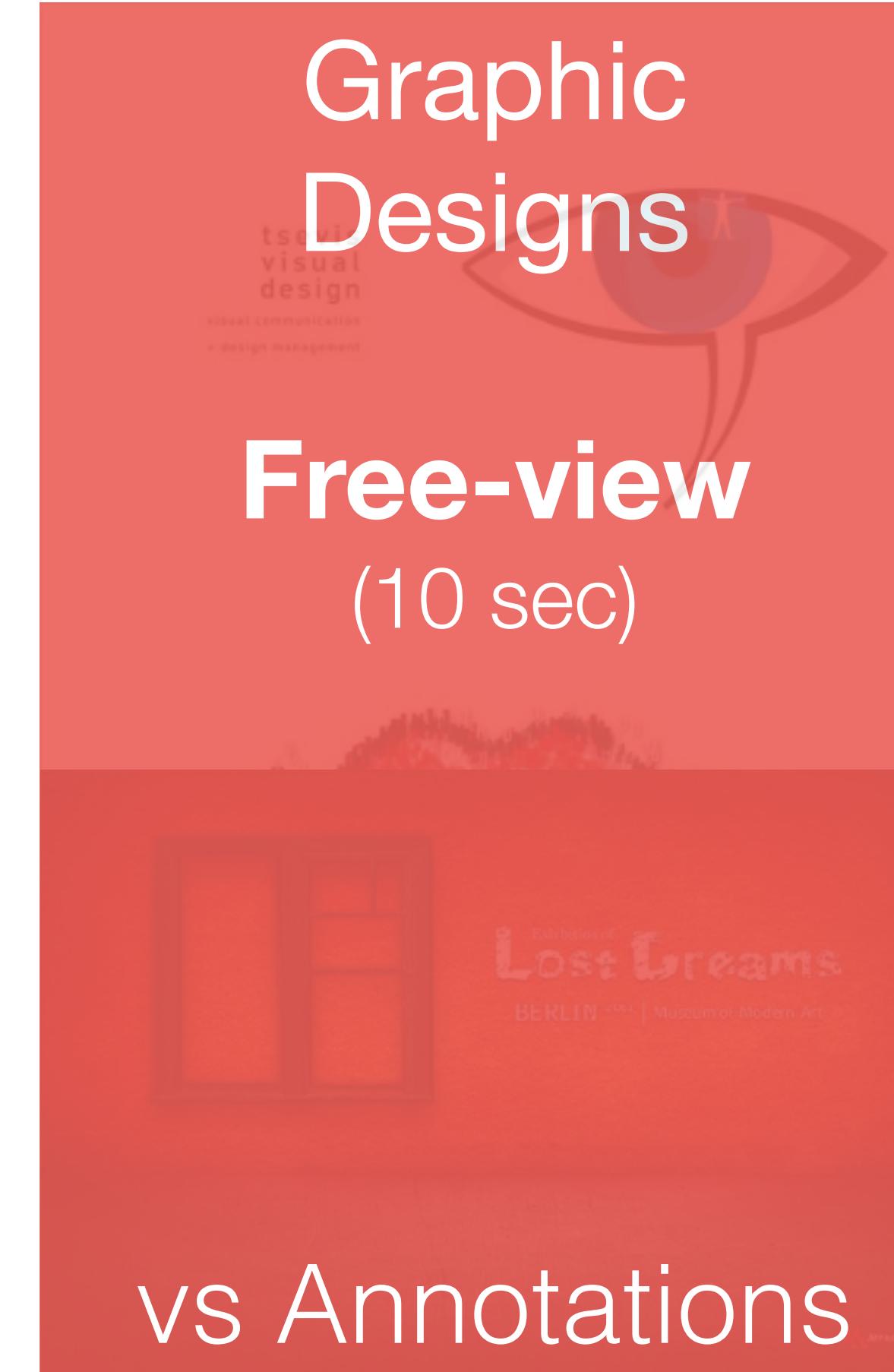
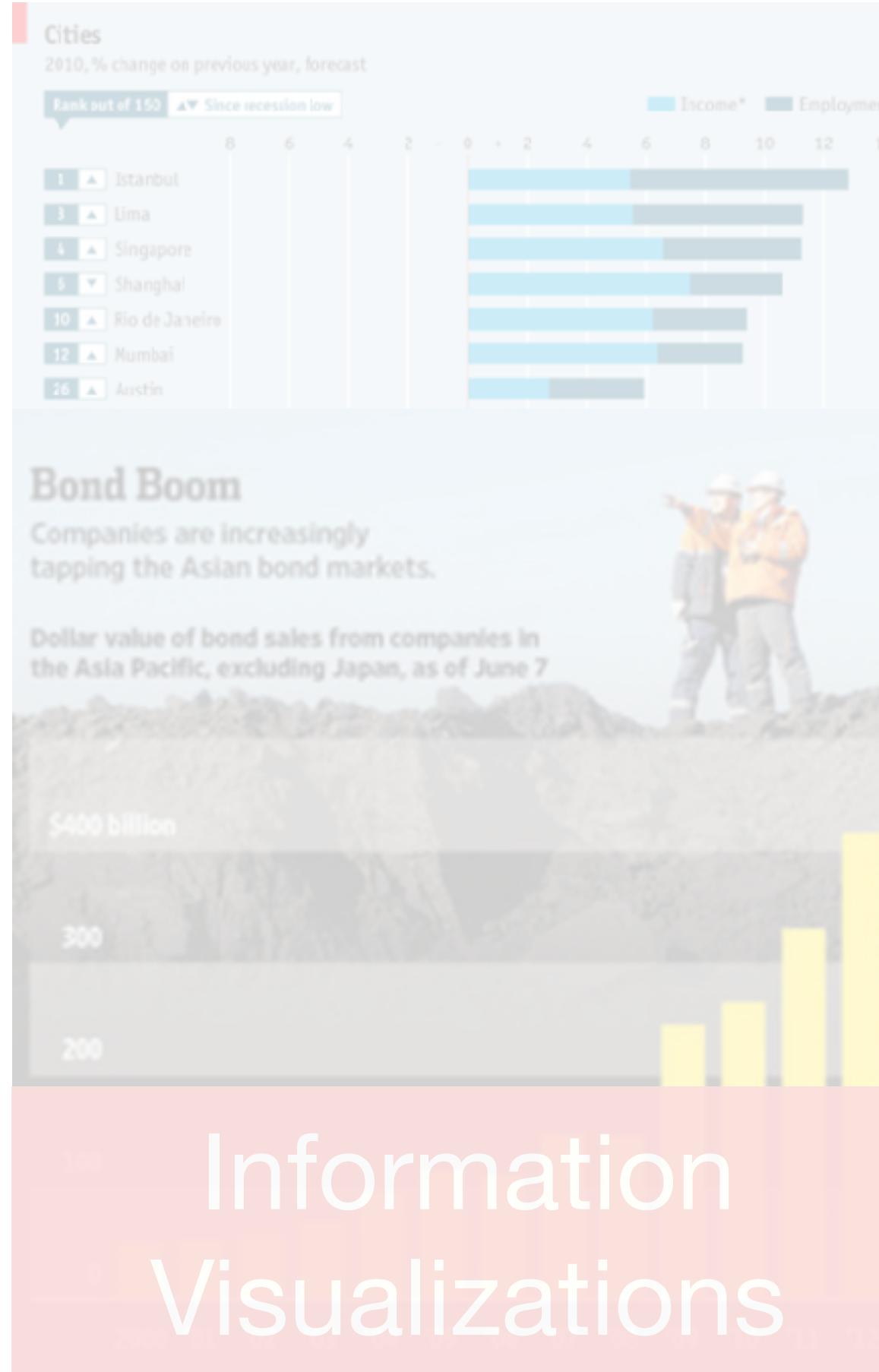
This chart includes the percentage change on the previous year forecast of income versus employment for the year 2010. Cities include Istanbul, Lima, Singapore, Shanghai, Mumbai, Rio de Janeiro.



MASSVIS
[Borkin et al. 2016]

Clicks &
Description changes over time.

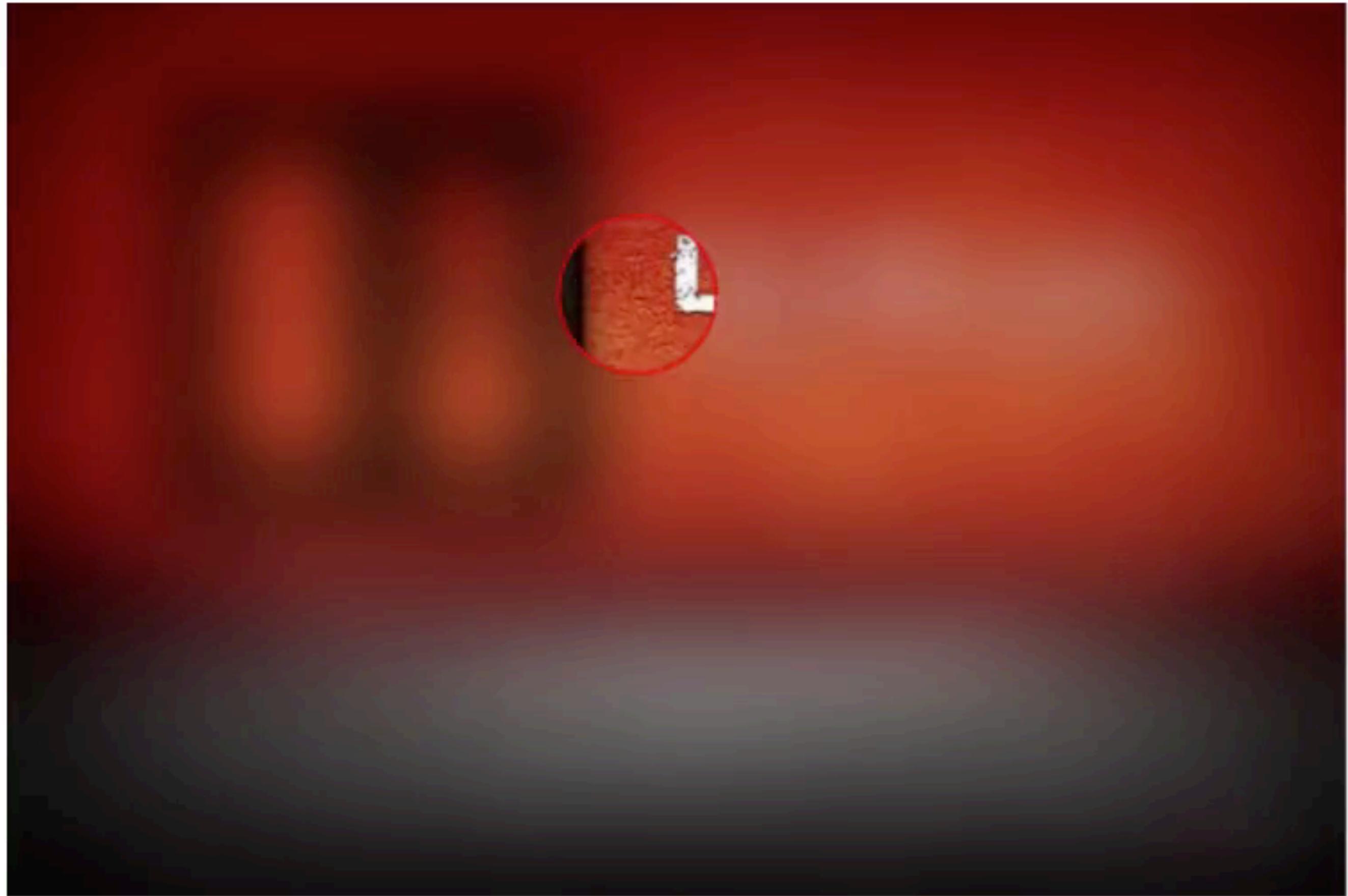
Evaluation Configuration



GDI
[O'Donovan et al. 2014]

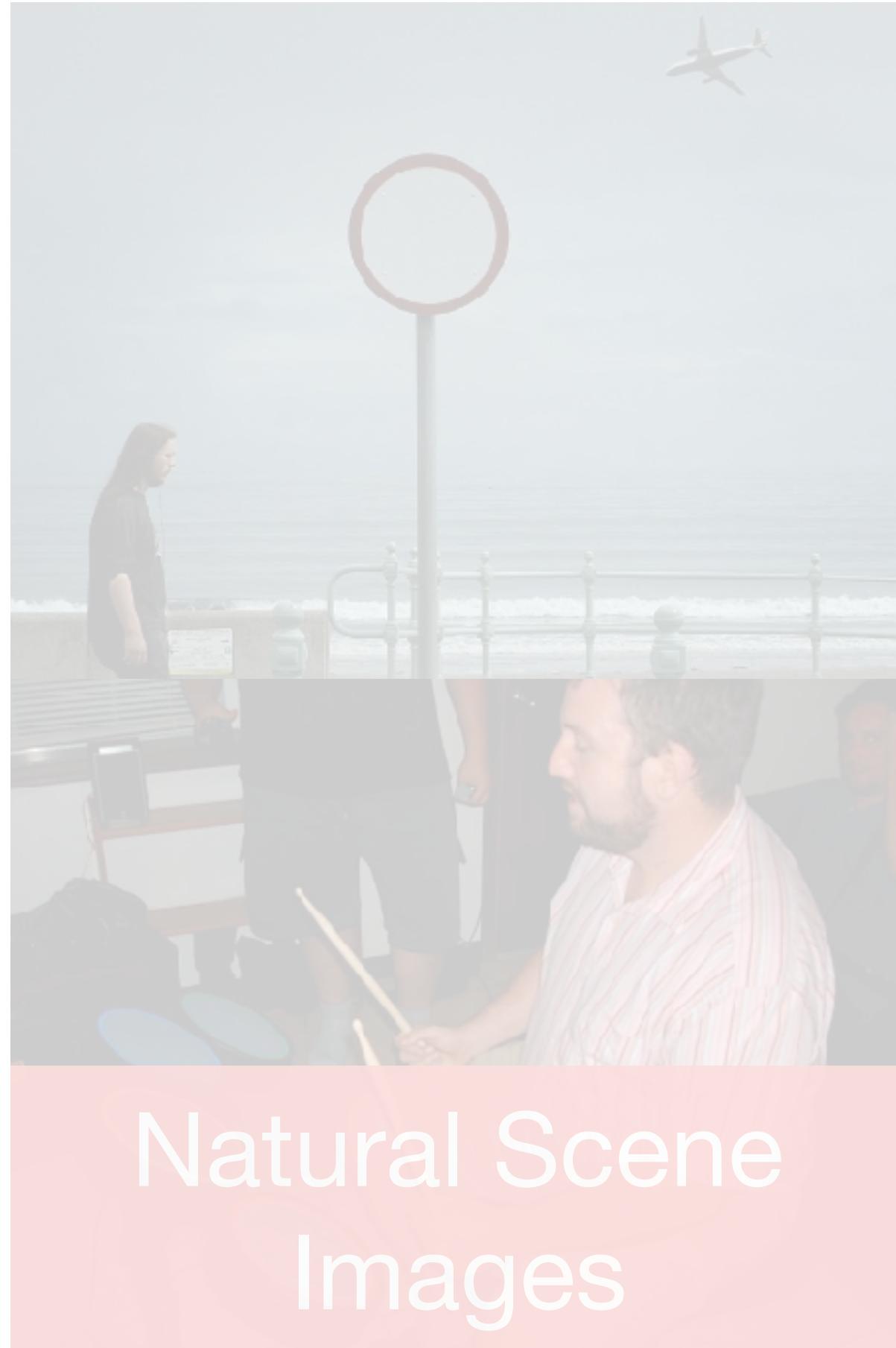
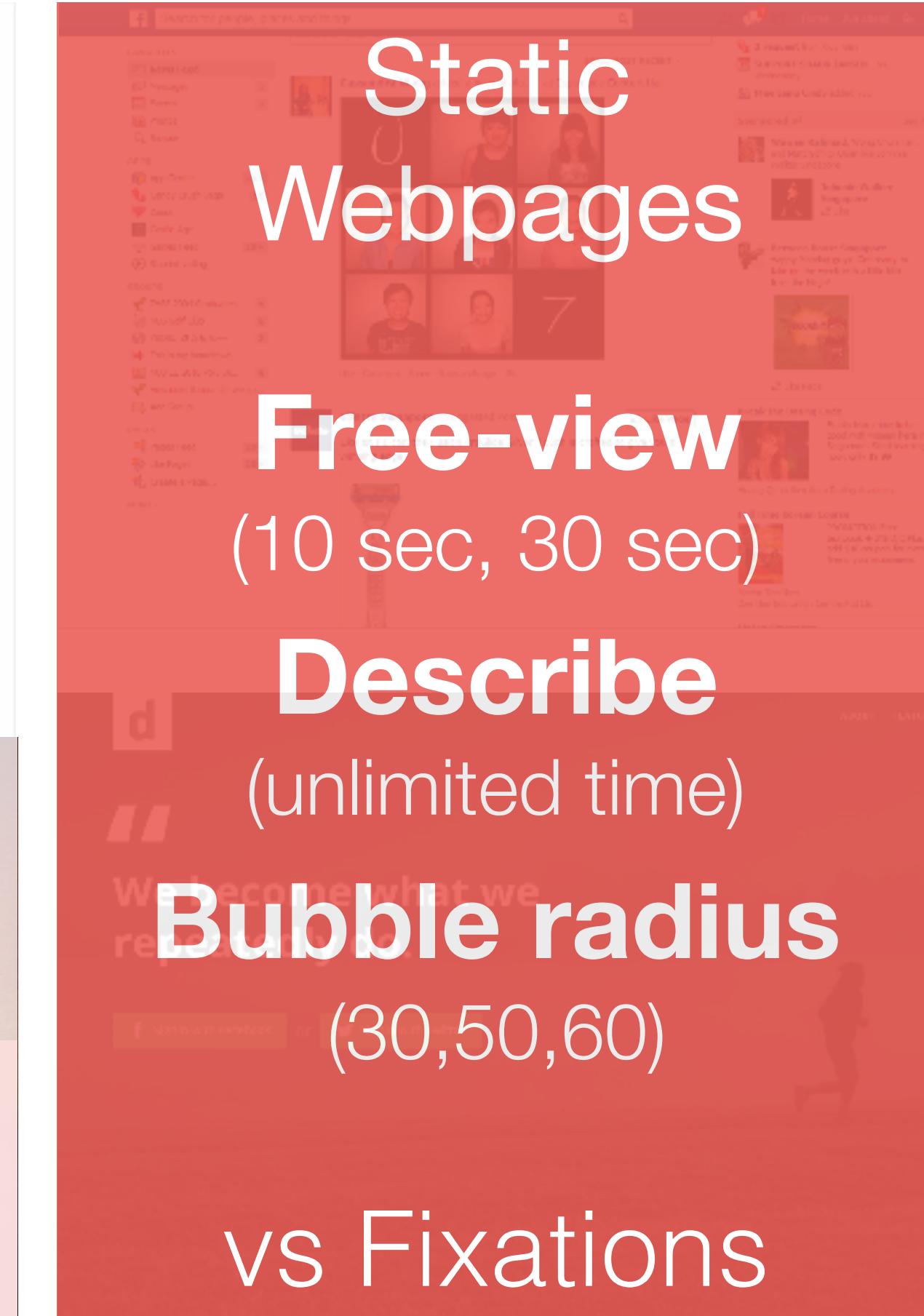
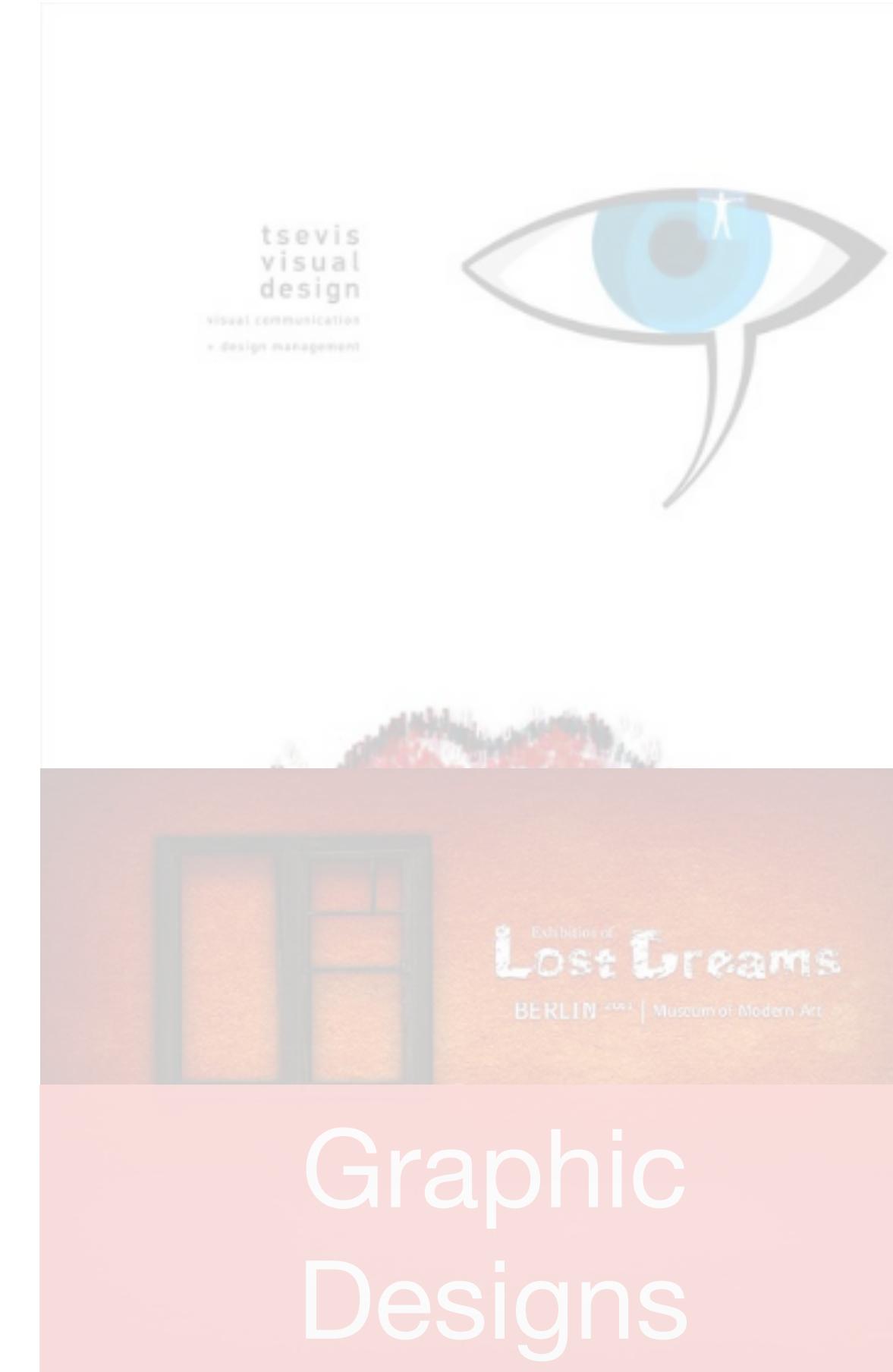
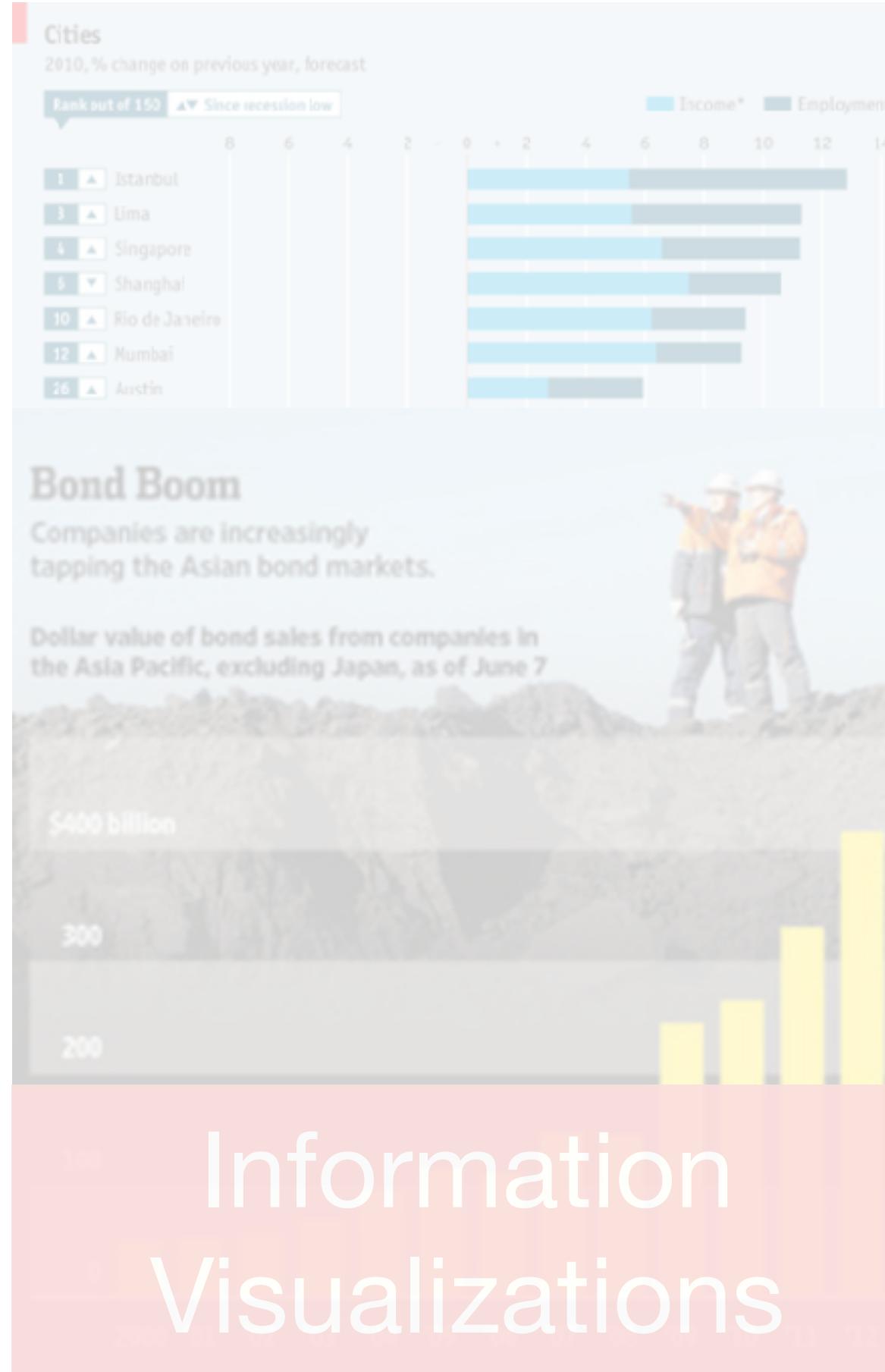
Free-Viewing Task

Click anywhere you want to look.



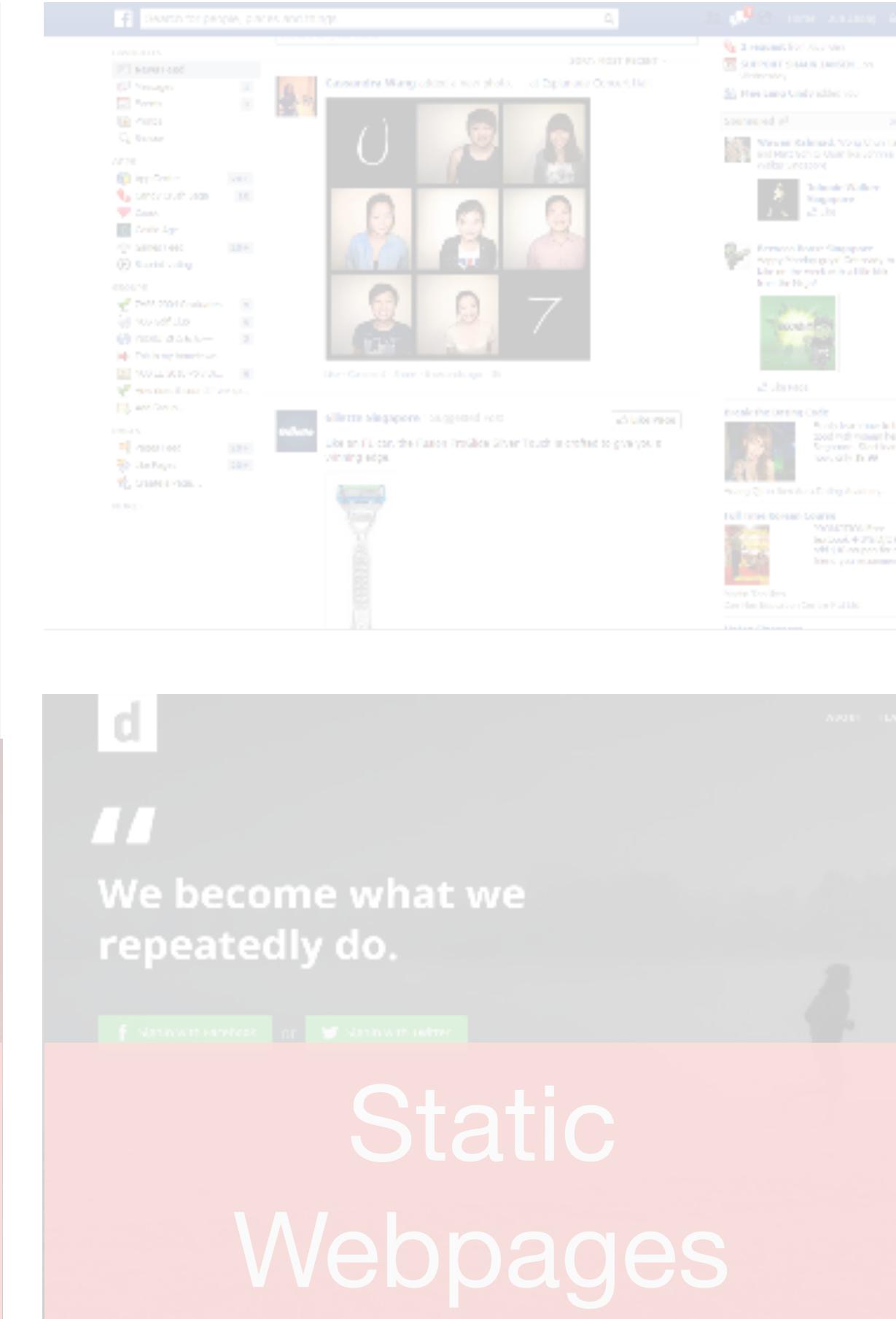
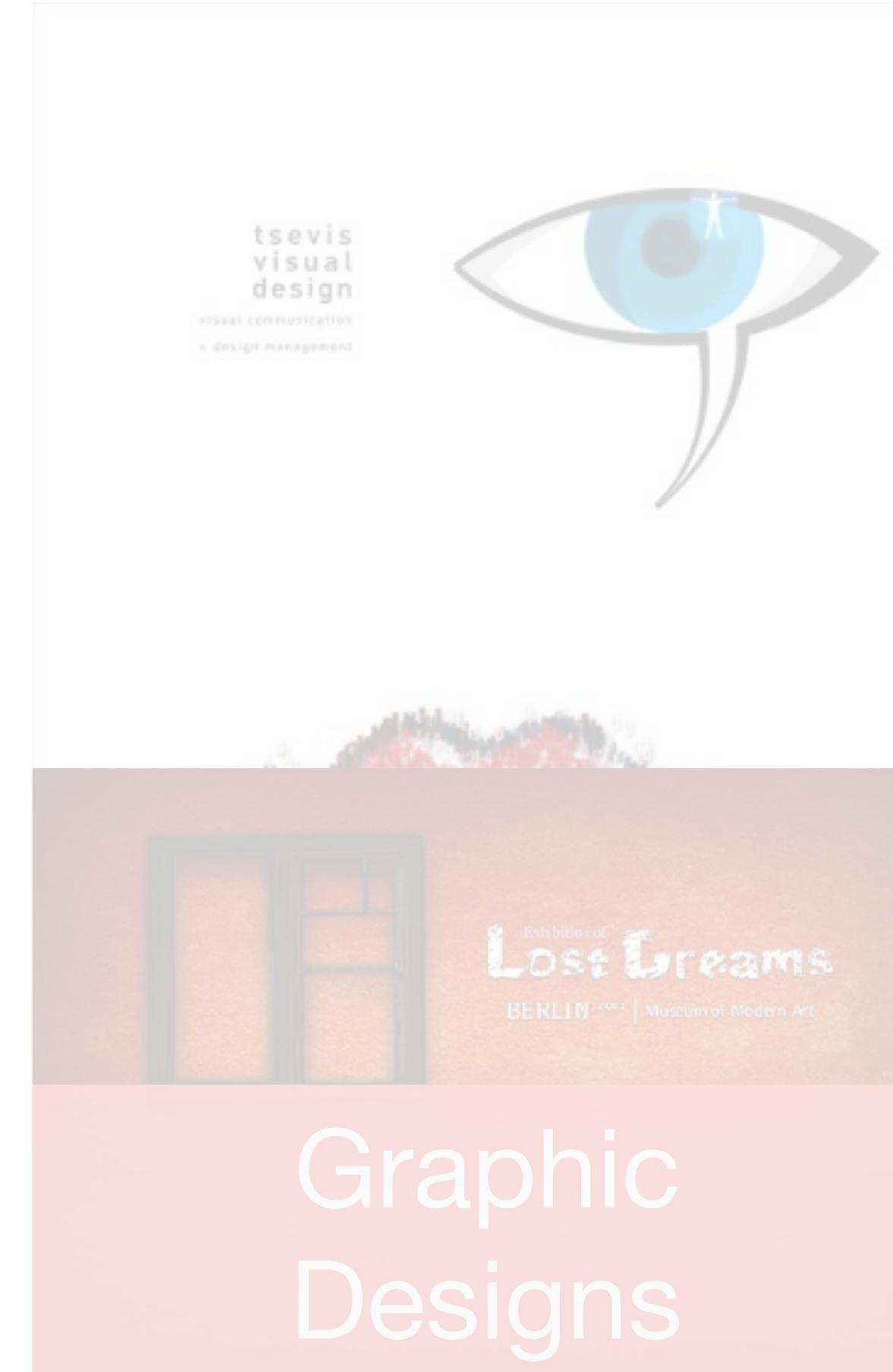
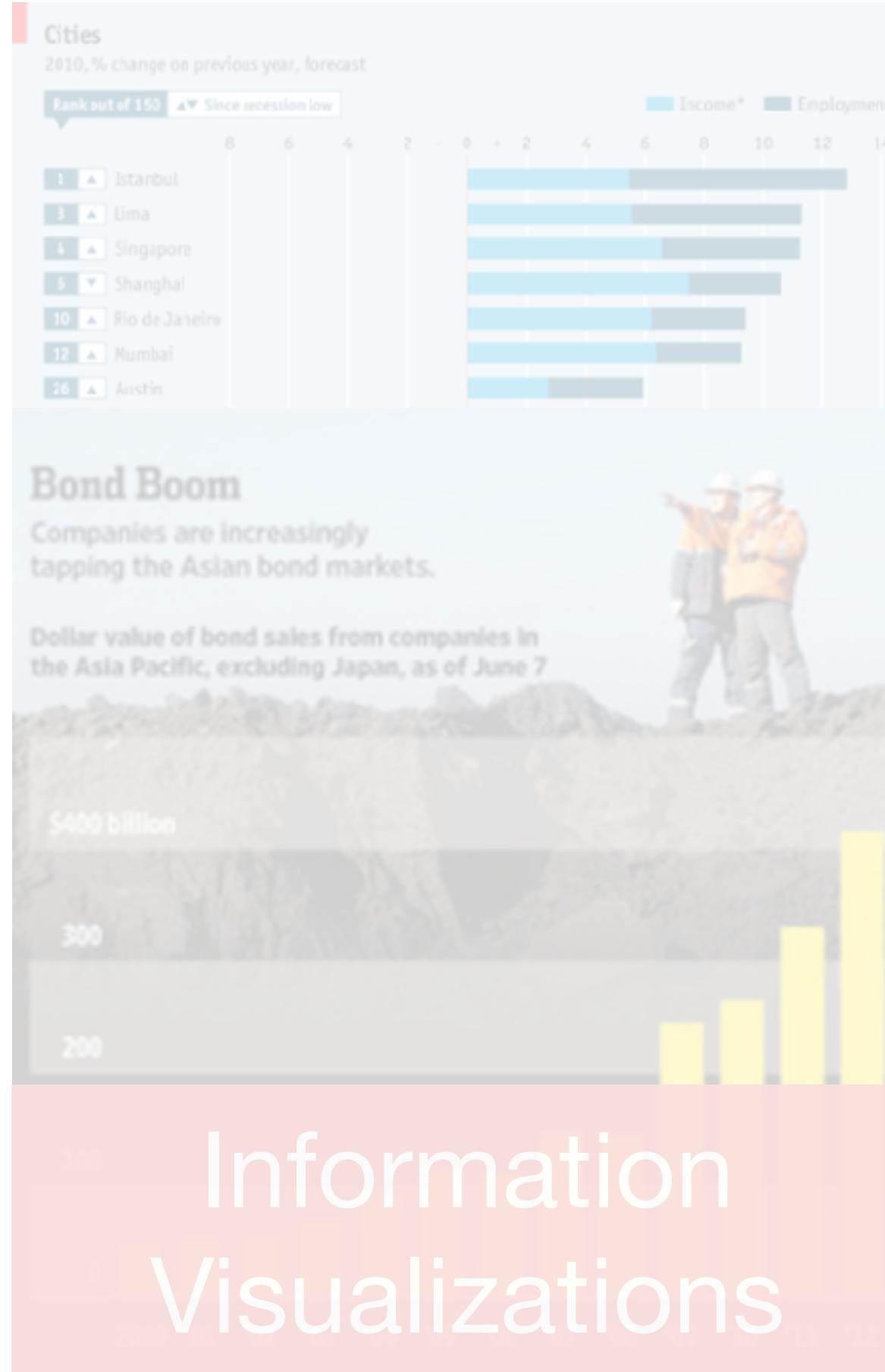
10 seconds of viewing
No description required

Evaluation Configuration



FIWI
[Shen and Zhao 2014]

Evaluation Configuration



Natural Scene Images

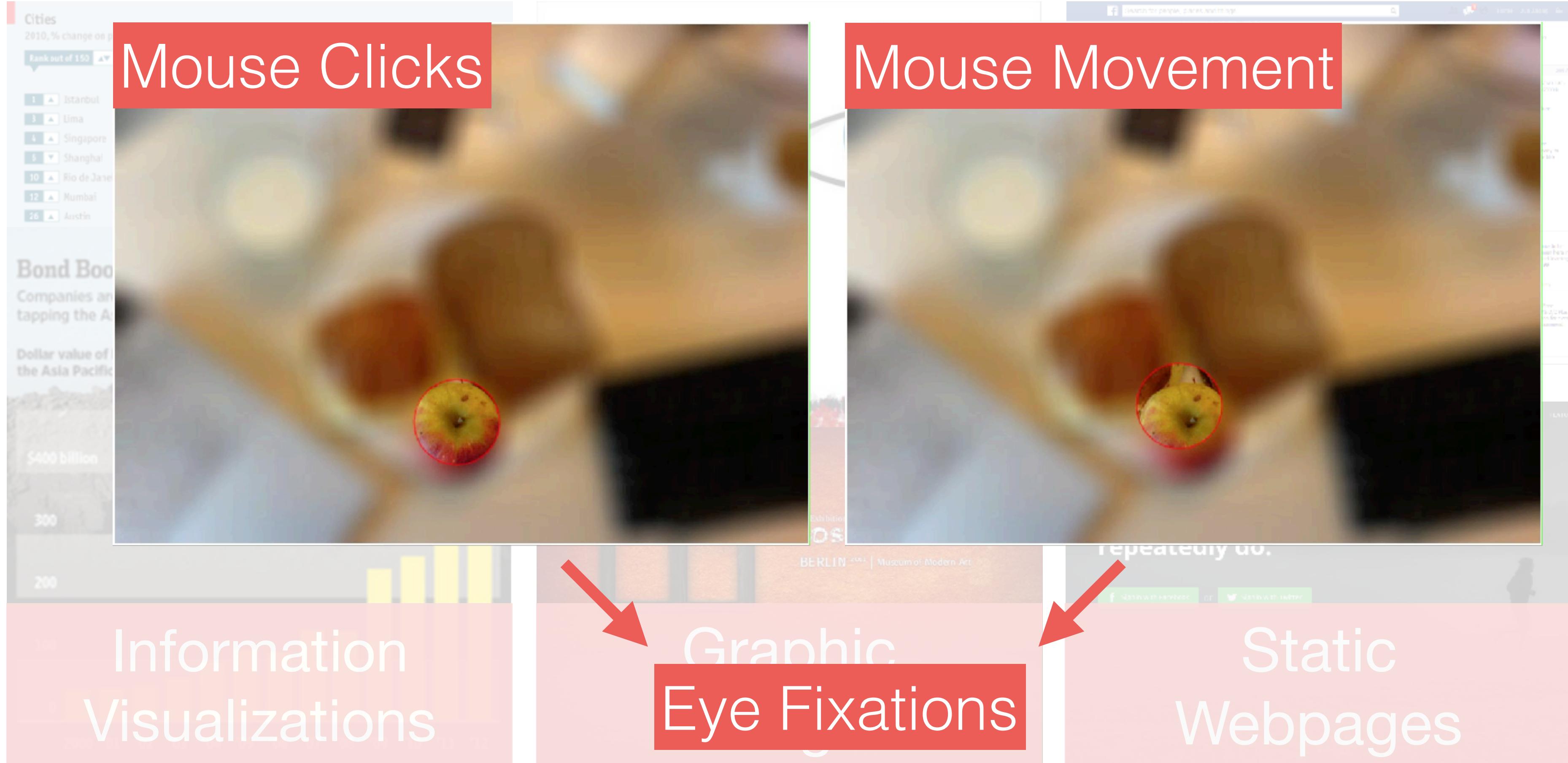
Free-view

1. clicks (10 sec)
2. movements (5 sec)

vs Fixations

OSIE
[Xu et al. 2014]

Evaluation Configuration



Natural Scene Images

Free-view

1. *clicks*
(10 sec)
2. *movements*
(5 sec)

vs Fixations

OSIE
[Xu et al. 2014]

Evaluation Configuration

Information Visualizations

Describe
(unlimited time)
Bubble radius
(16,24,32,40)

vs Fixations

MASSVIS
[Borkin et al. 2016]

Graphic Designs

Free-view
(10 sec, 30 sec)

vs Annotations

GDI
[O'Donovan et al. 2014]

Static Webpages

Free-view
(10 sec, 30 sec)

Describe
(unlimited time)

Bubble radius
(30,50,60)

vs Fixations

FIWI
[Shen and Zhao 2014]

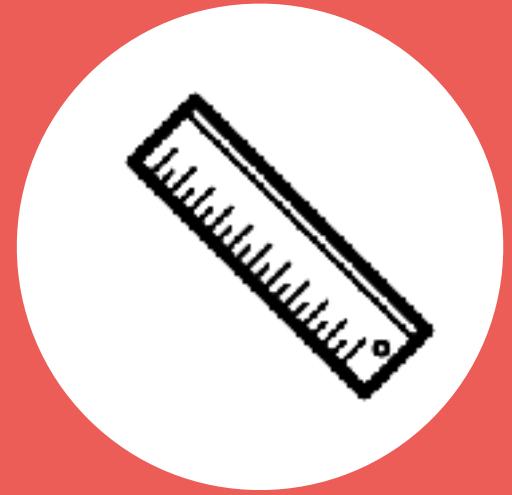
Natural Scene Images

Free-view
1. clicks
(10 sec)

2 movements
(3 sec)

vs Fixations

OSIE
[Xu et al. 2014]



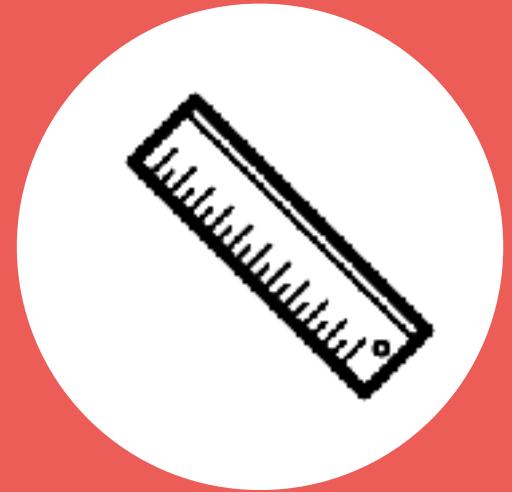
Evaluation Tools



Experimental Results



Future Applications



Evaluation Tools



Experimental Results



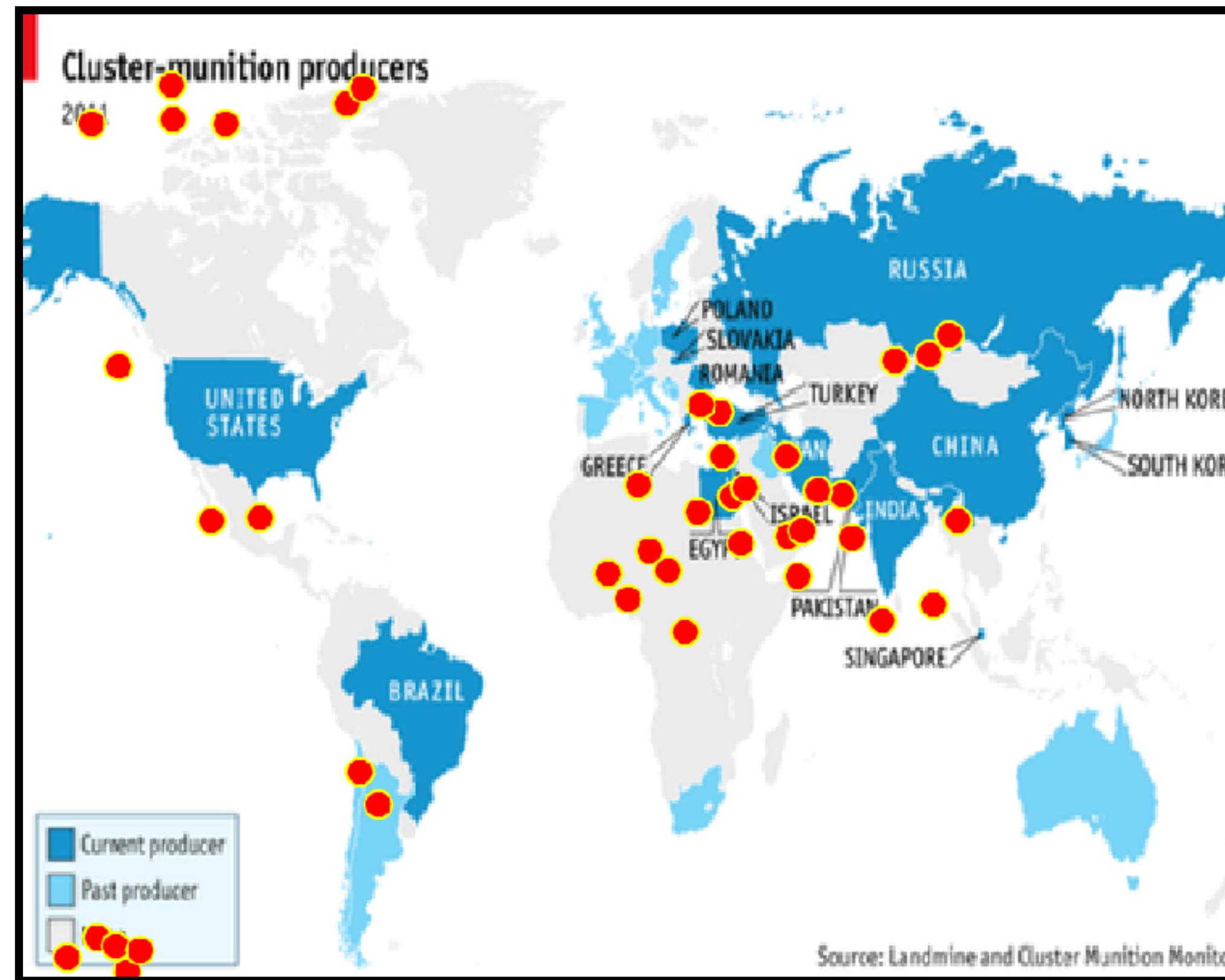
Future Applications



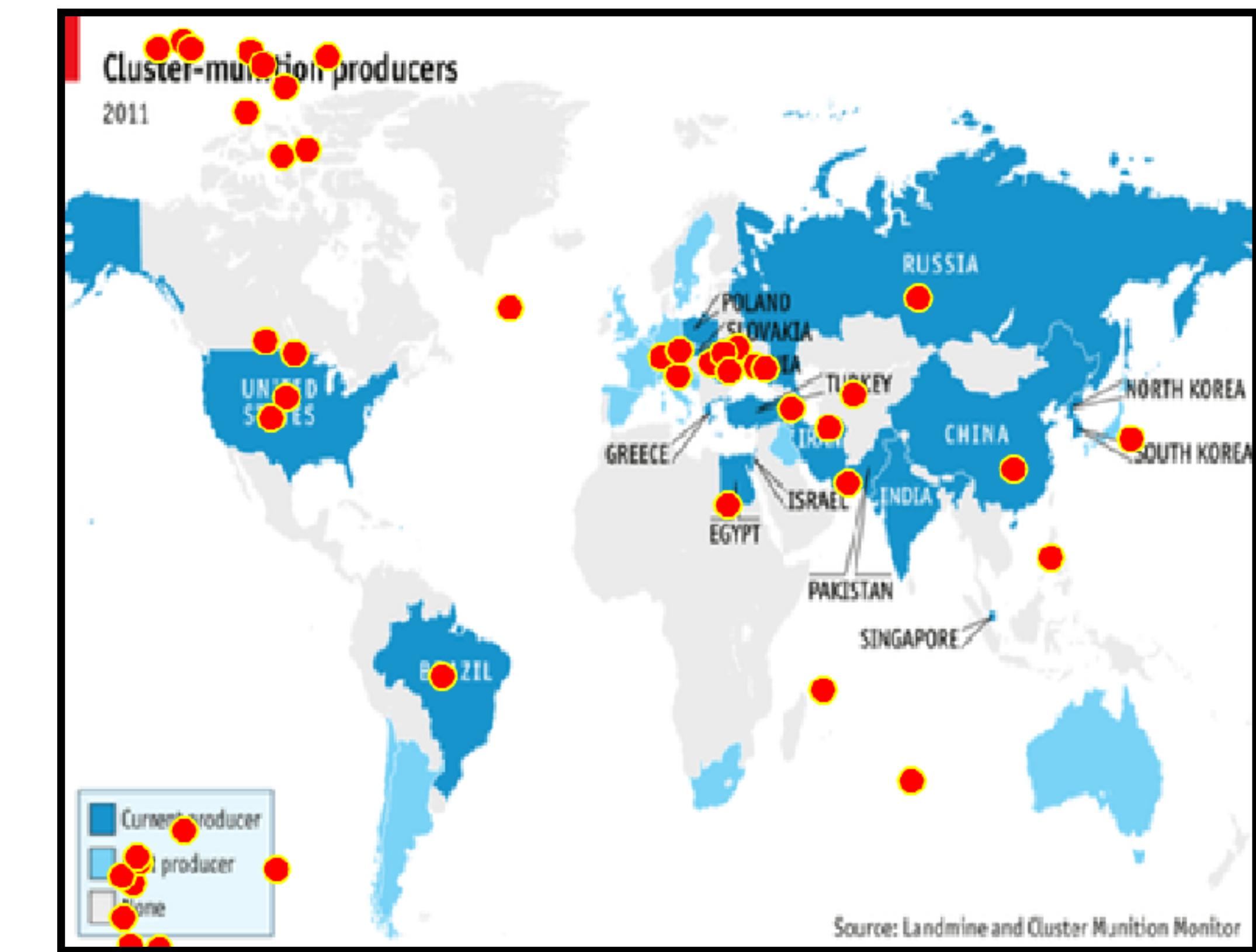
Computing CC score



Clicks



Fixations

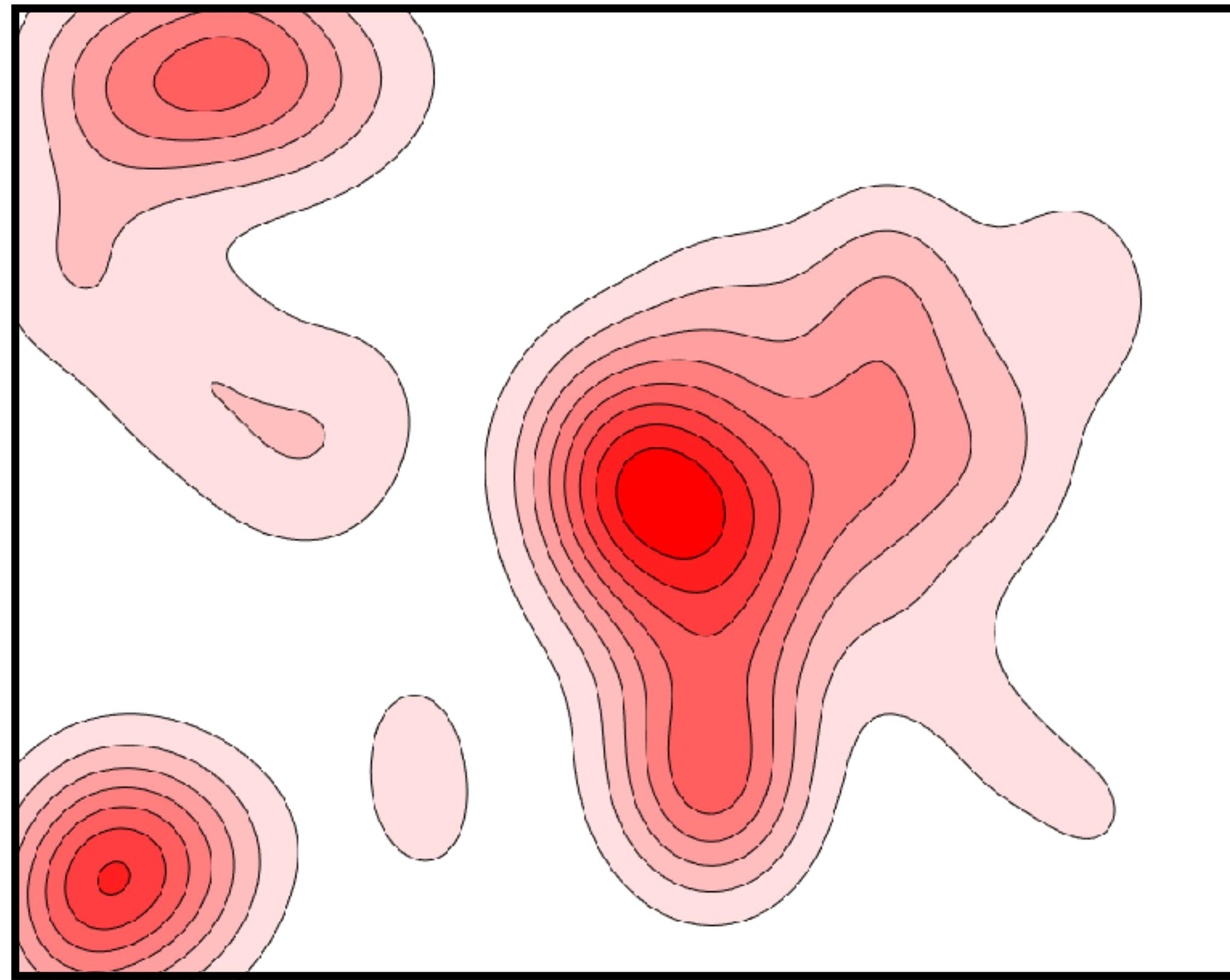




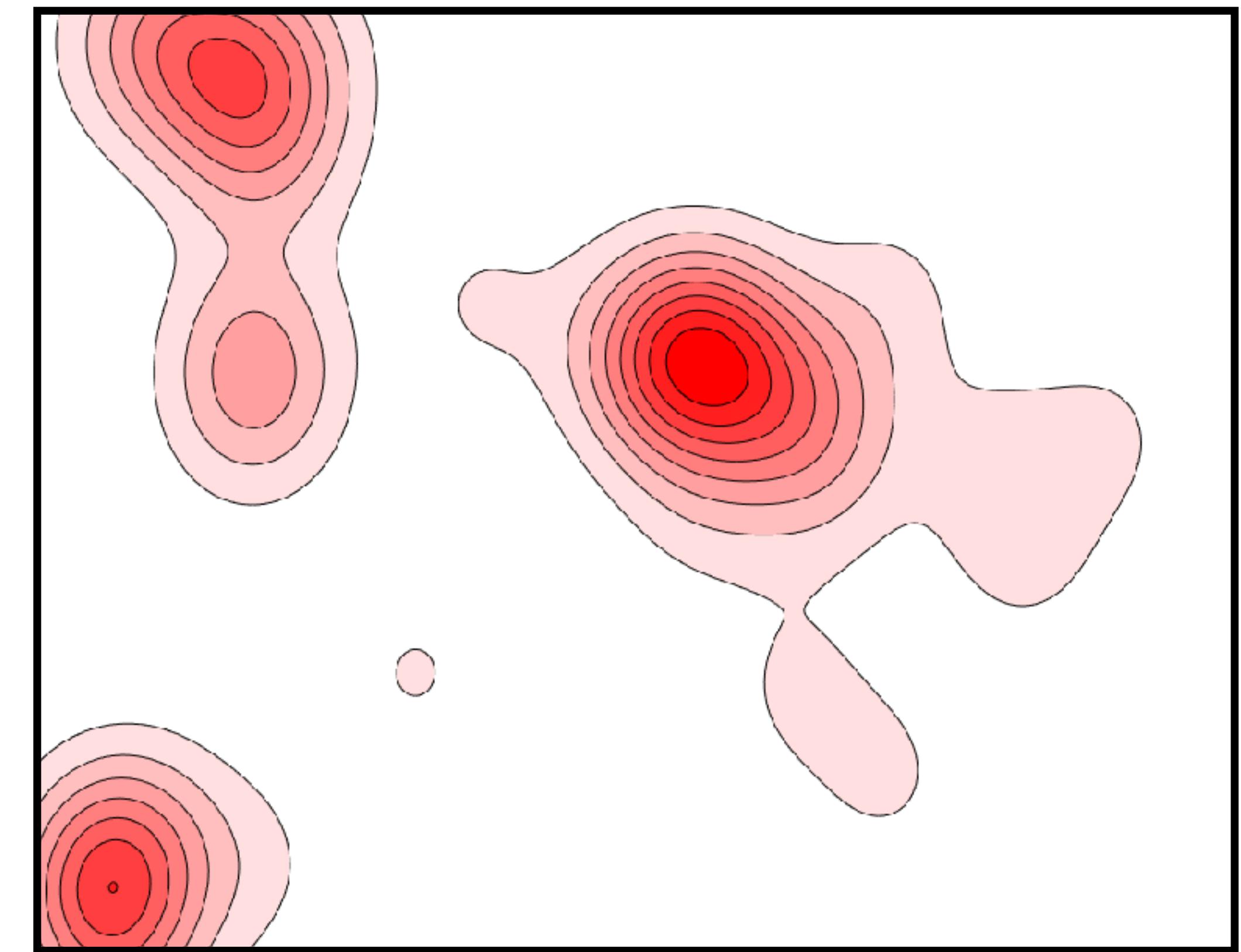
Computing CC score



Clicks

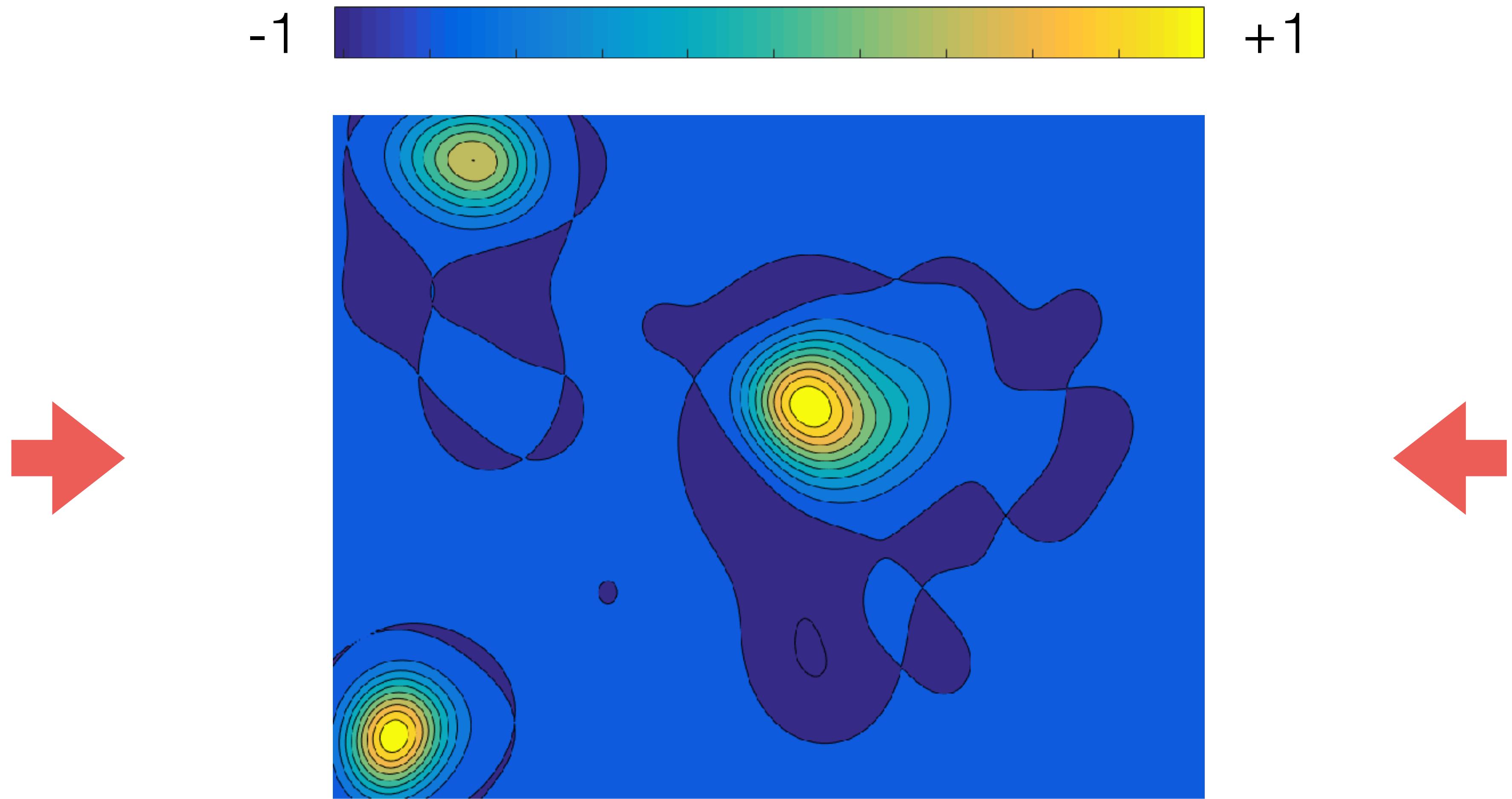


Fixations





Computing CC score

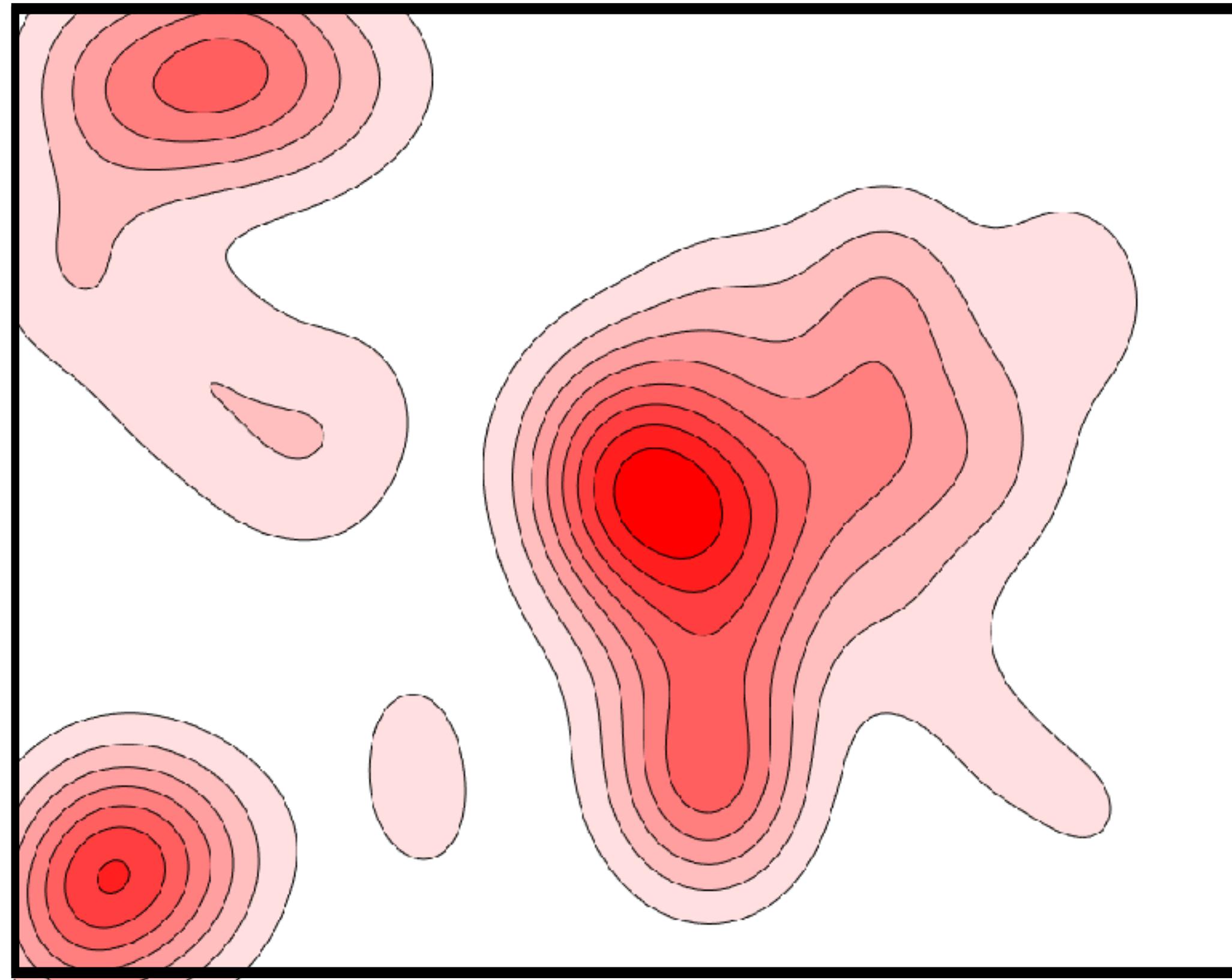




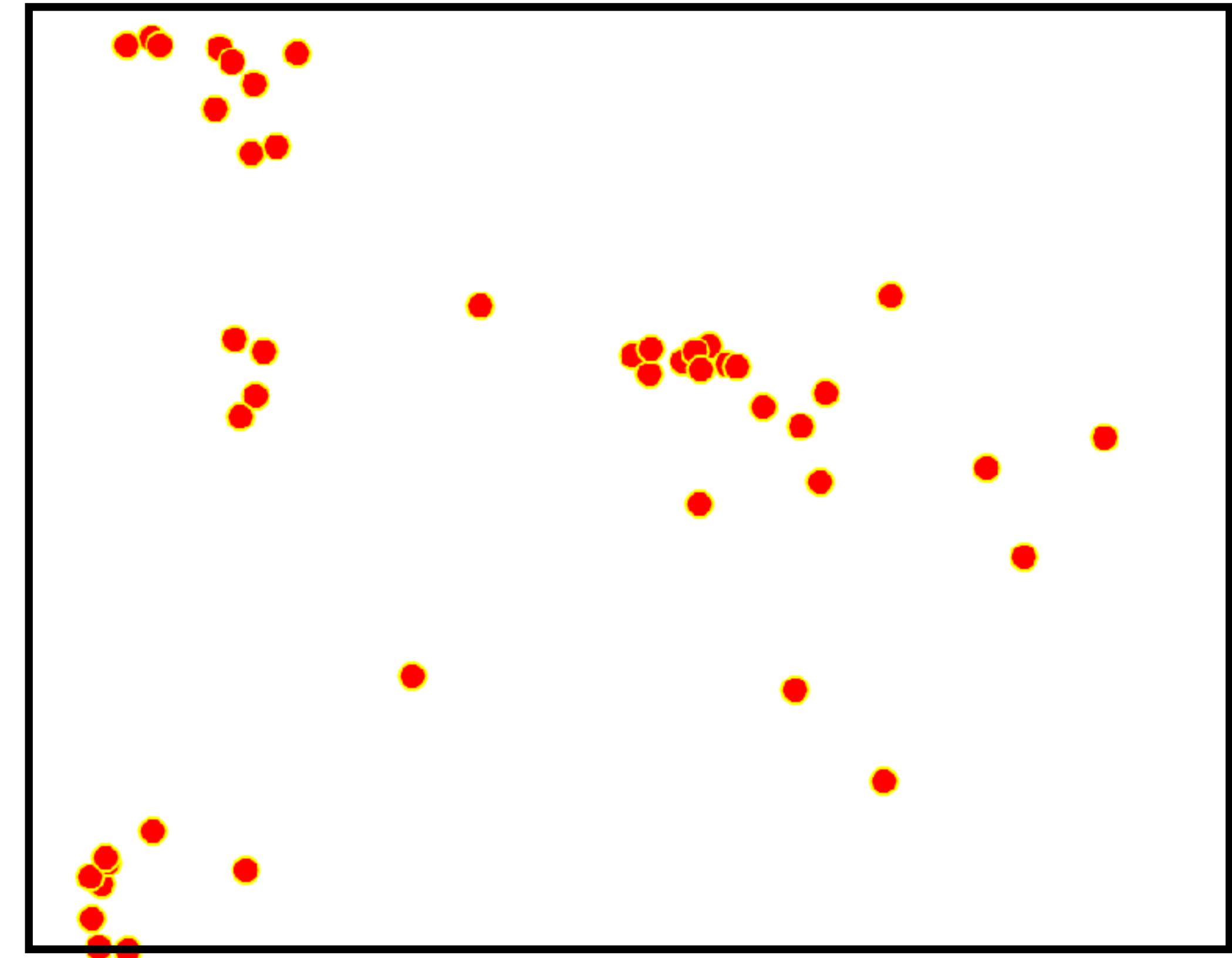
Computing NSS score



Clicks



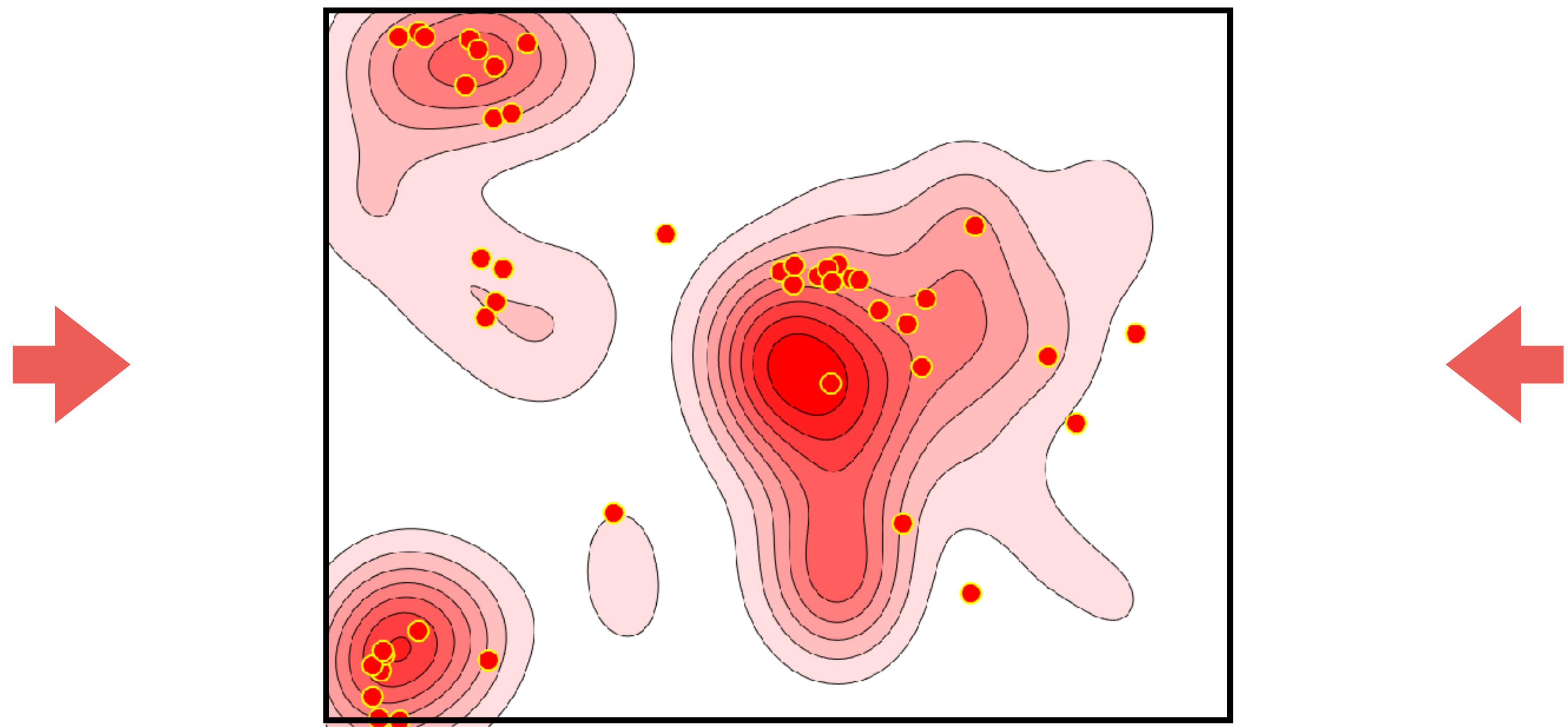
Fixations





Computing NSS score

Normalized by eye fixation consistency

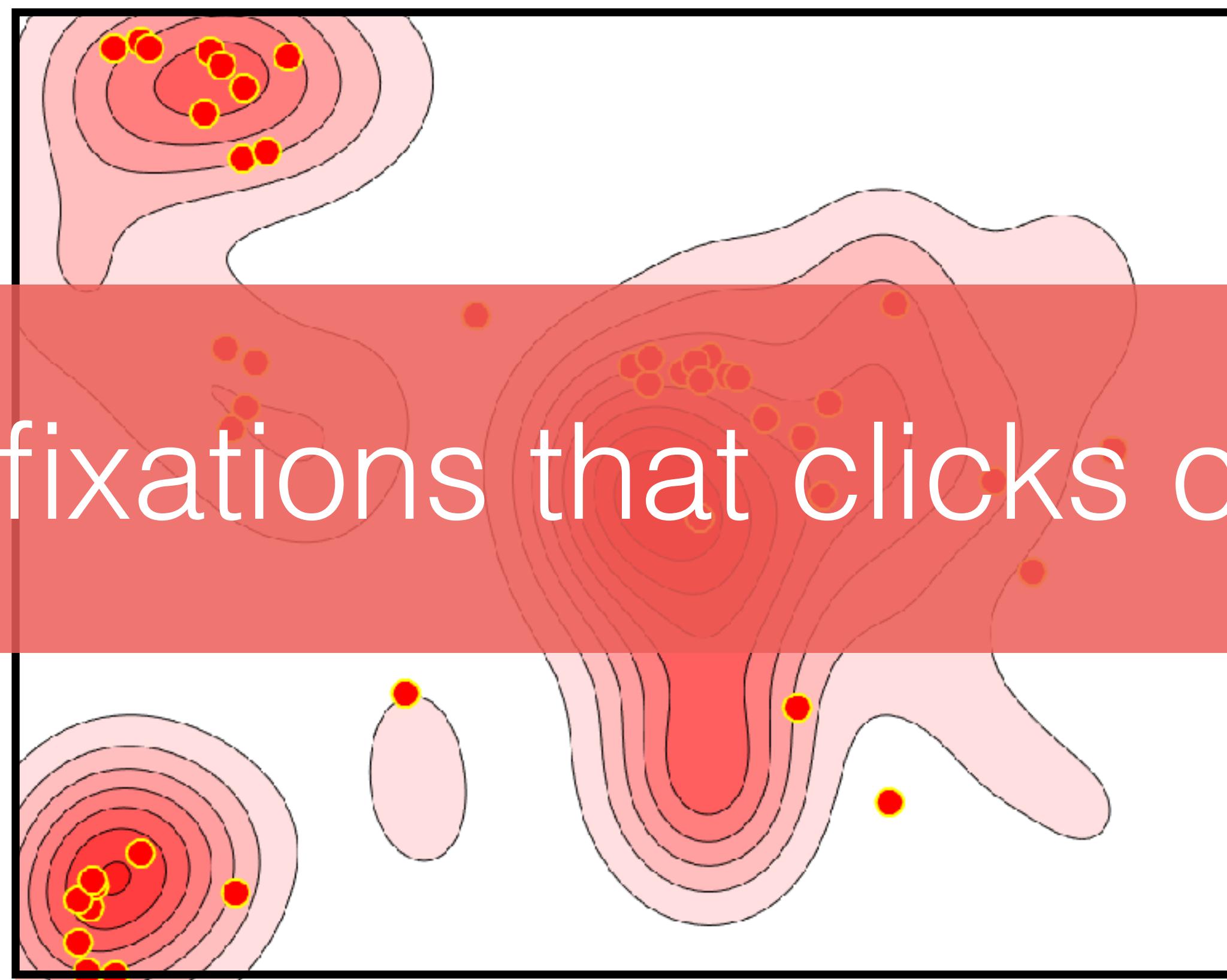


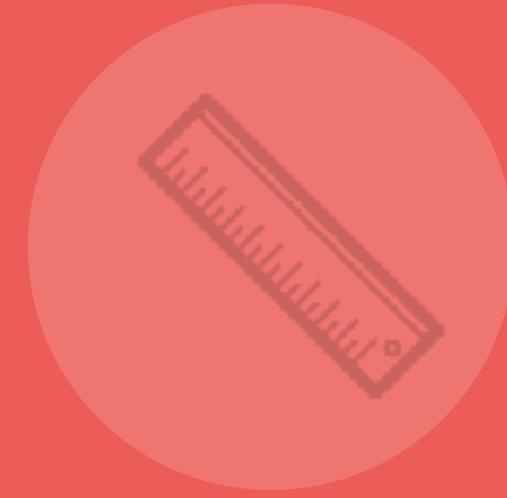


Computing NSS score

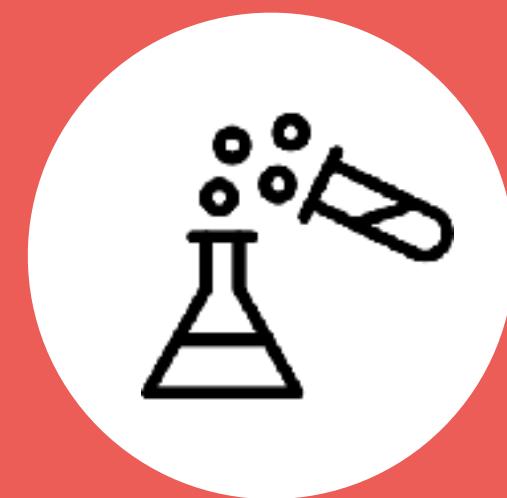
Normalized by eye fixation consistency

Report % of fixations that clicks can explain





Evaluation Tools



Experimental Results



Future Applications

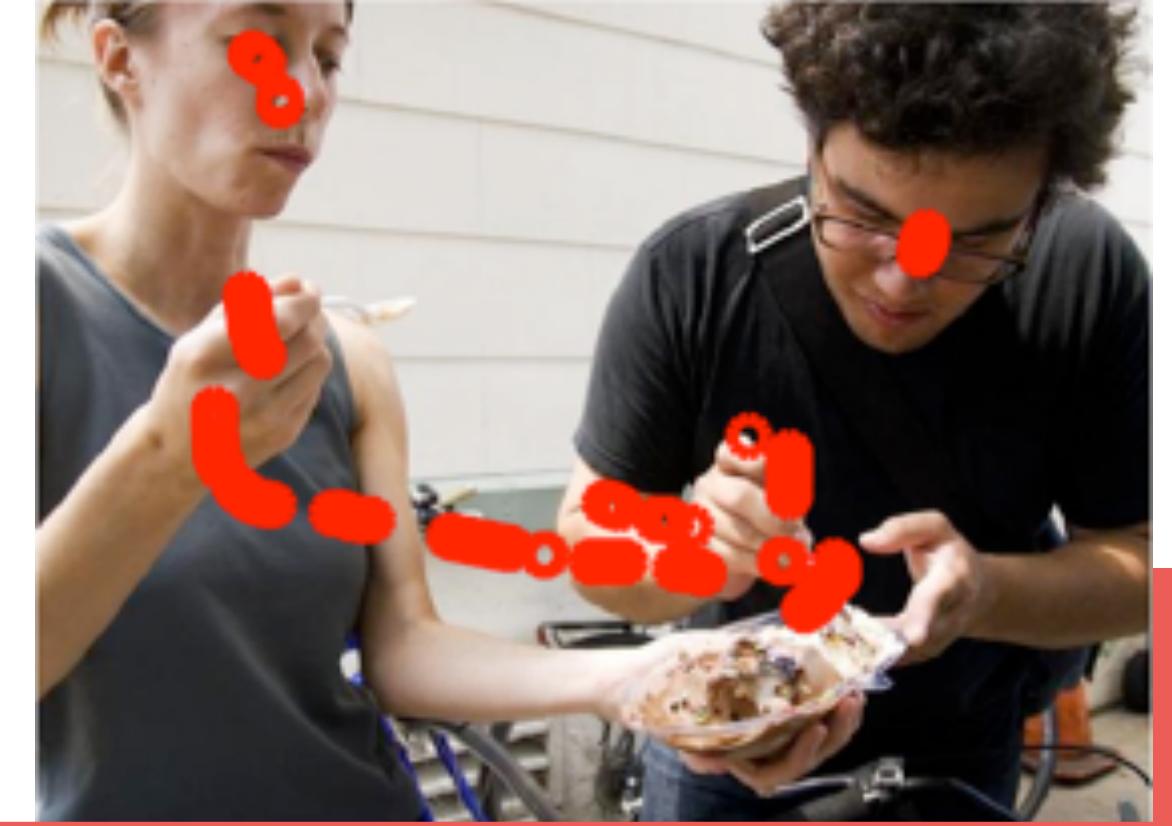


Take-away #1:

Clicks are more effective than mouse movements for measuring observer behavior.



Clicks vs Movements



Movements

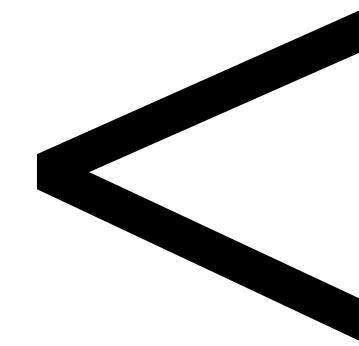


Clicks

Clicks are conscious decisions of importance



Movements



Intentionality

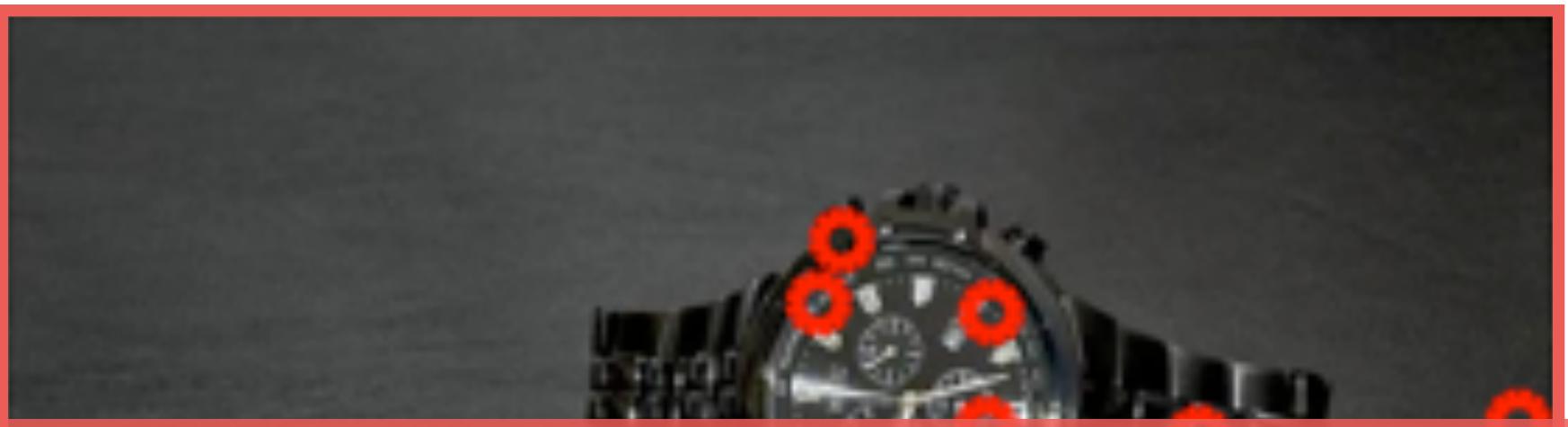
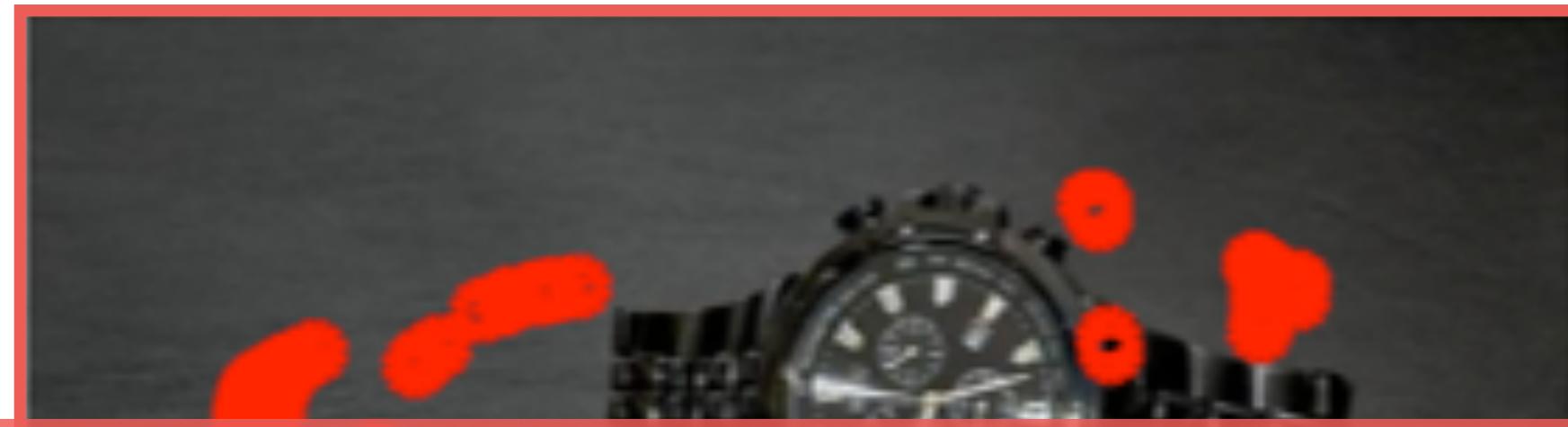


Clicks





Clicks are conscious decisions of importance



Clicks are a better approximation to eye fixations

Movements



Intentionality

Clicks



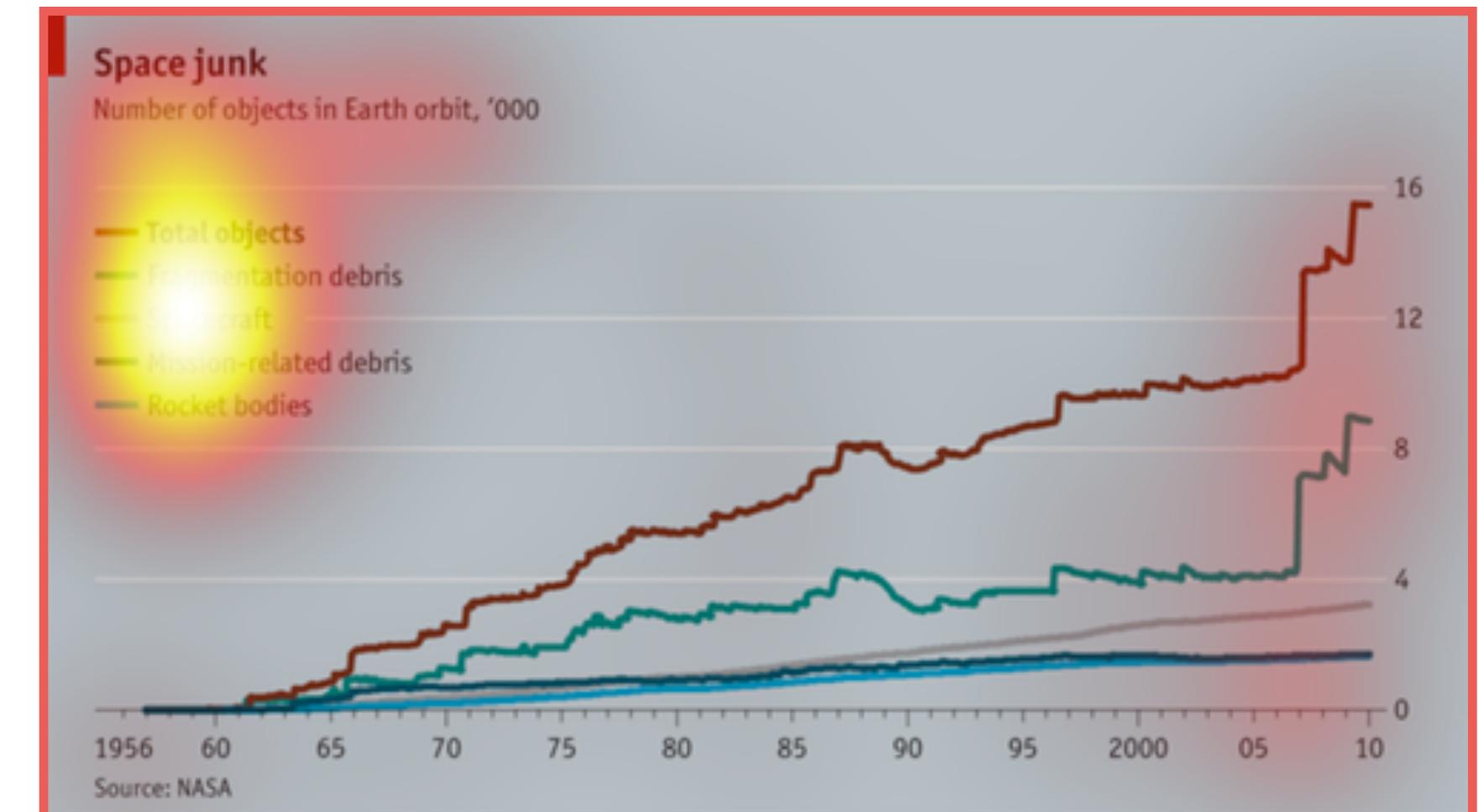
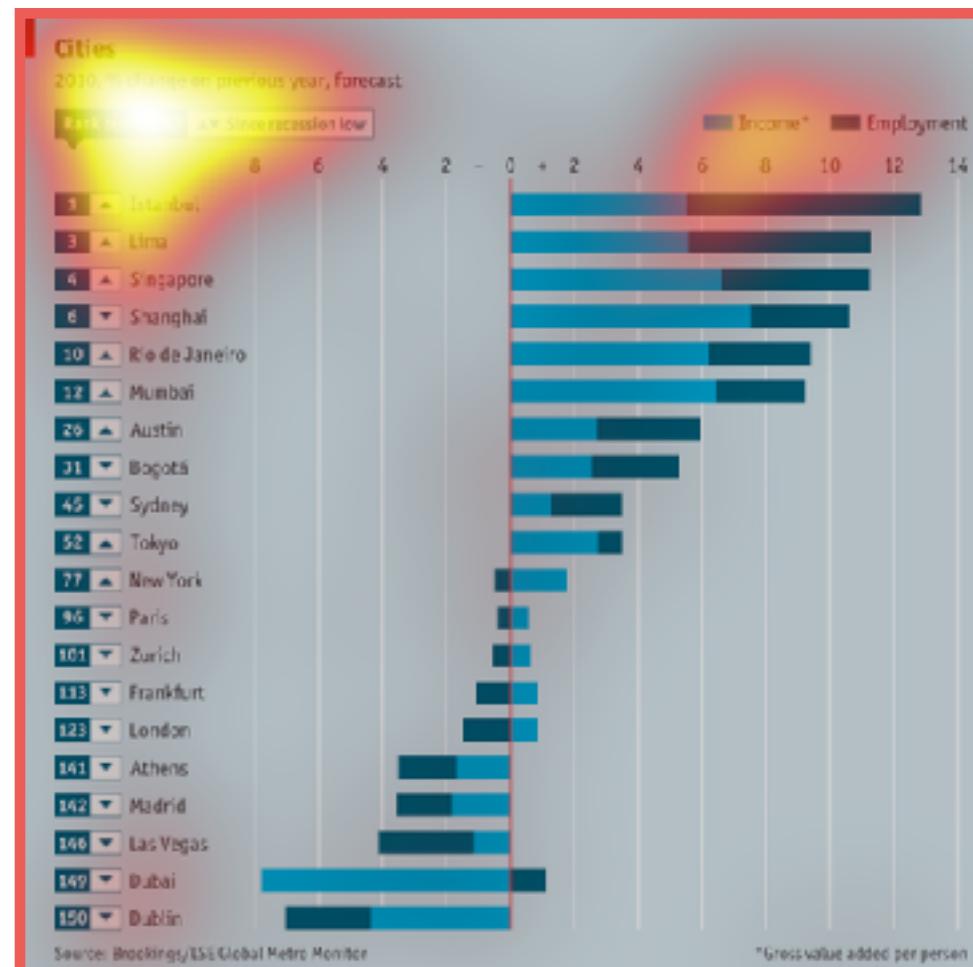
Take-away #2:

Clicks are predictive of eye fixations across a variety of image types and tasks.



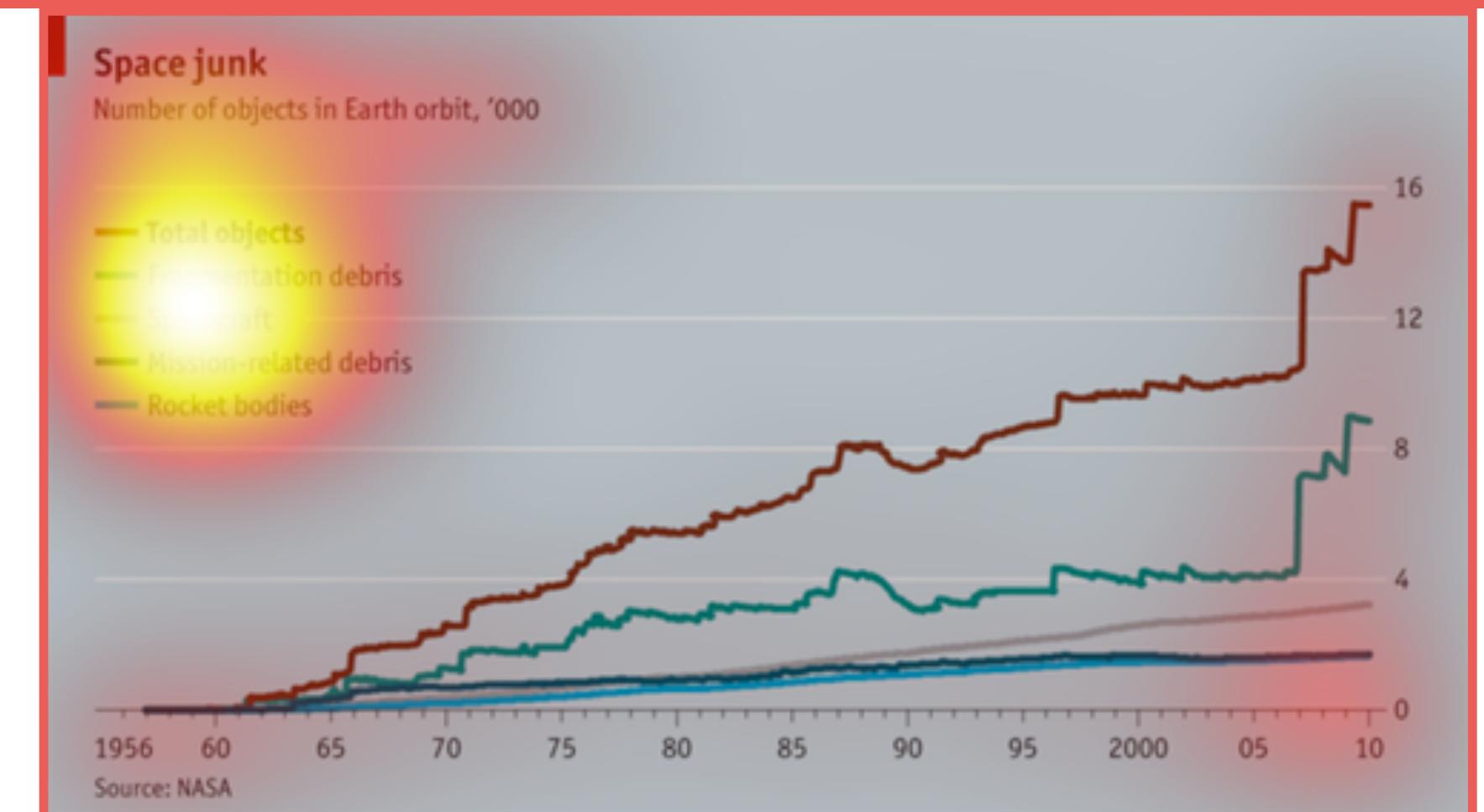
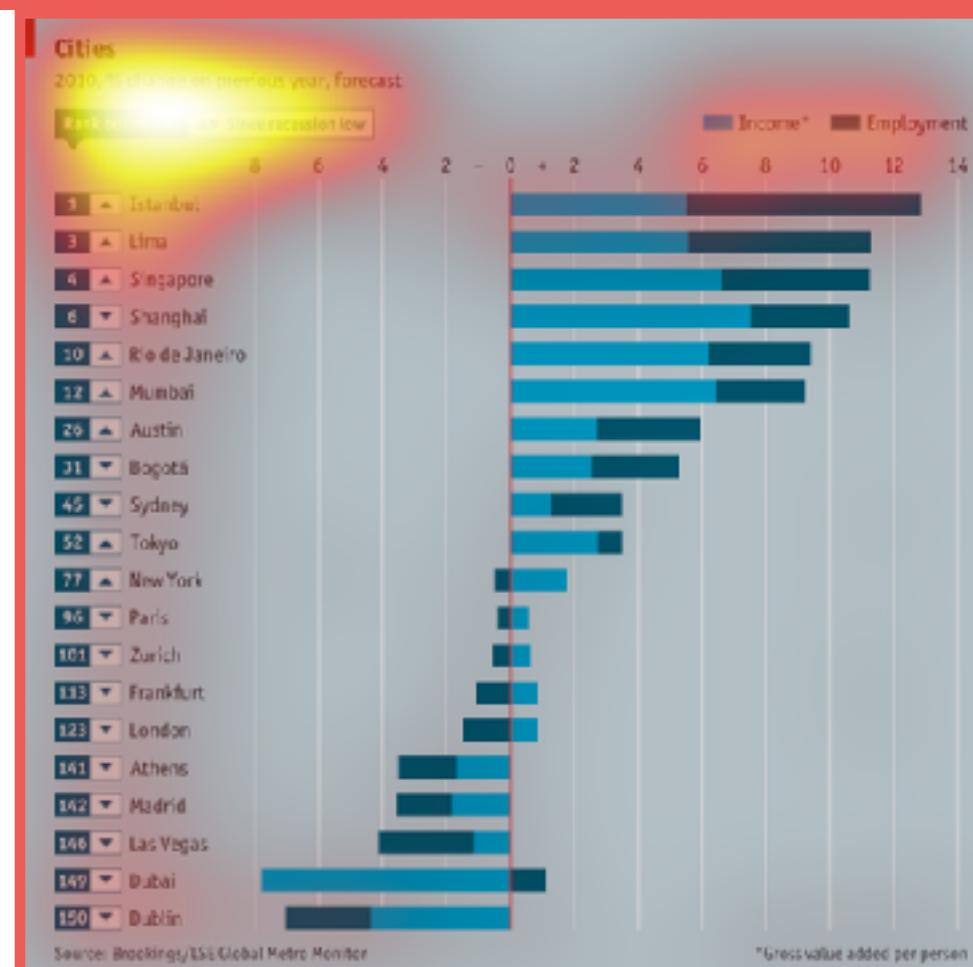
Clicks predict fixations on visualizations

Fixations



clicks of 10 participants explain 90% of fixations

Clicks





Clicks predict fixations on natural images

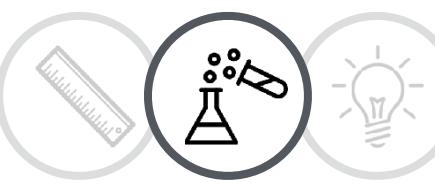
Fixations



clicks of 10 participants explain 78% of fixations

Clicks





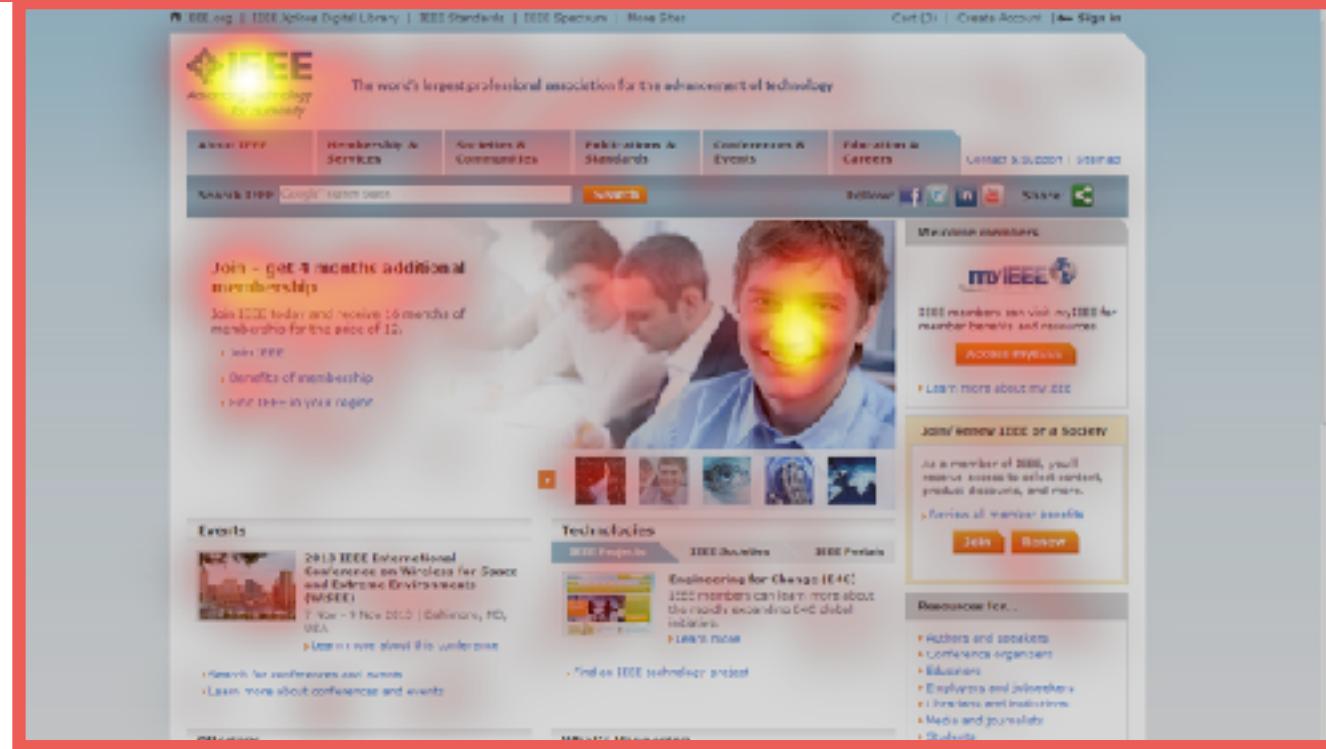
Clicks predict fixations on webpages

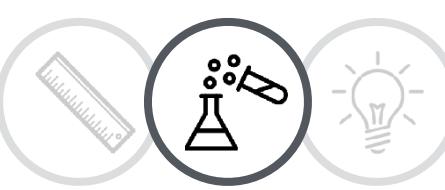
Fixations



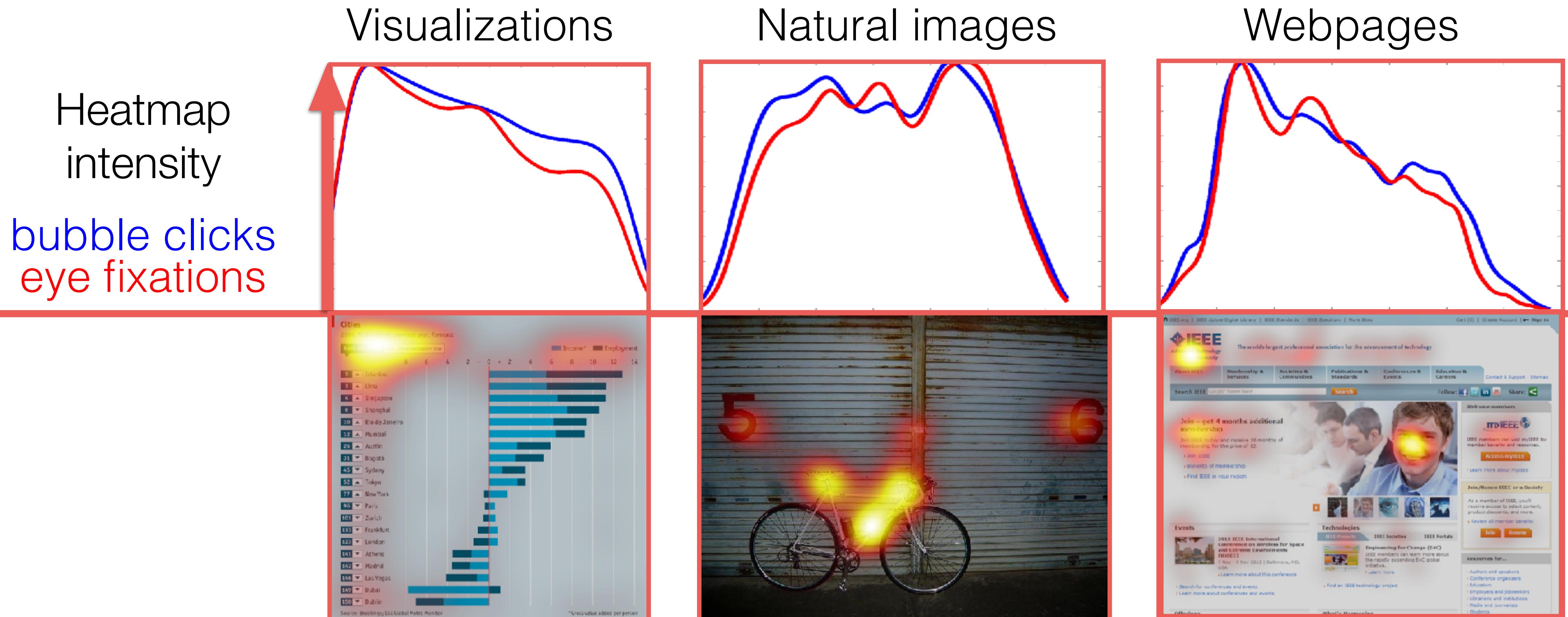
clicks of 10 participants explain 78% of fixations

Clicks



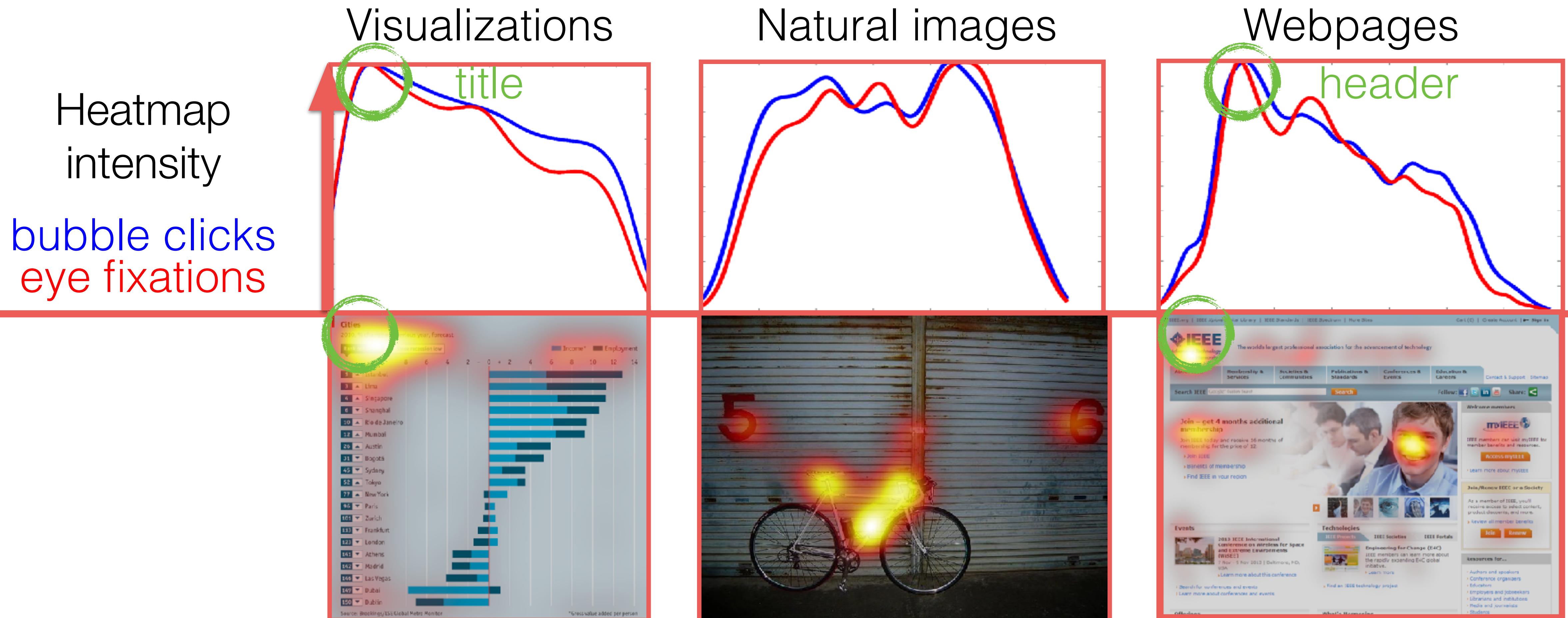


Click patterns match fixation patterns



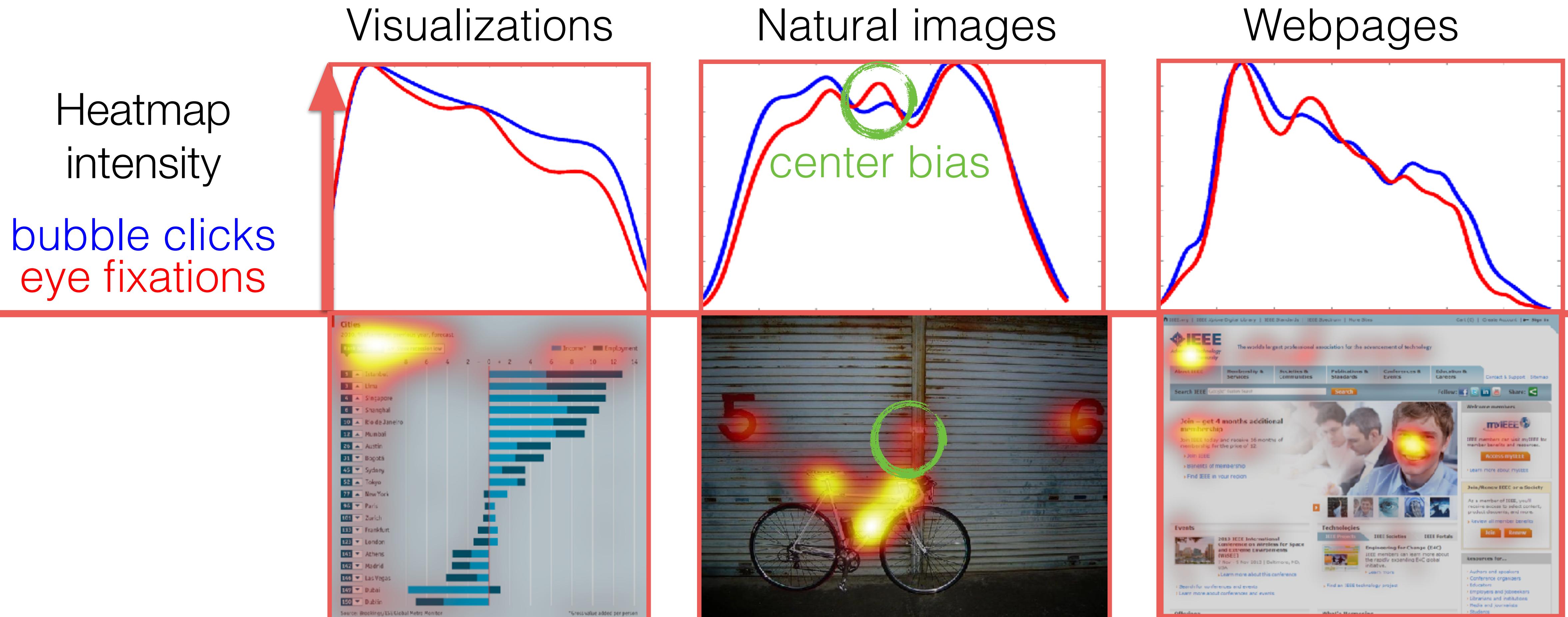


Click patterns match fixation patterns





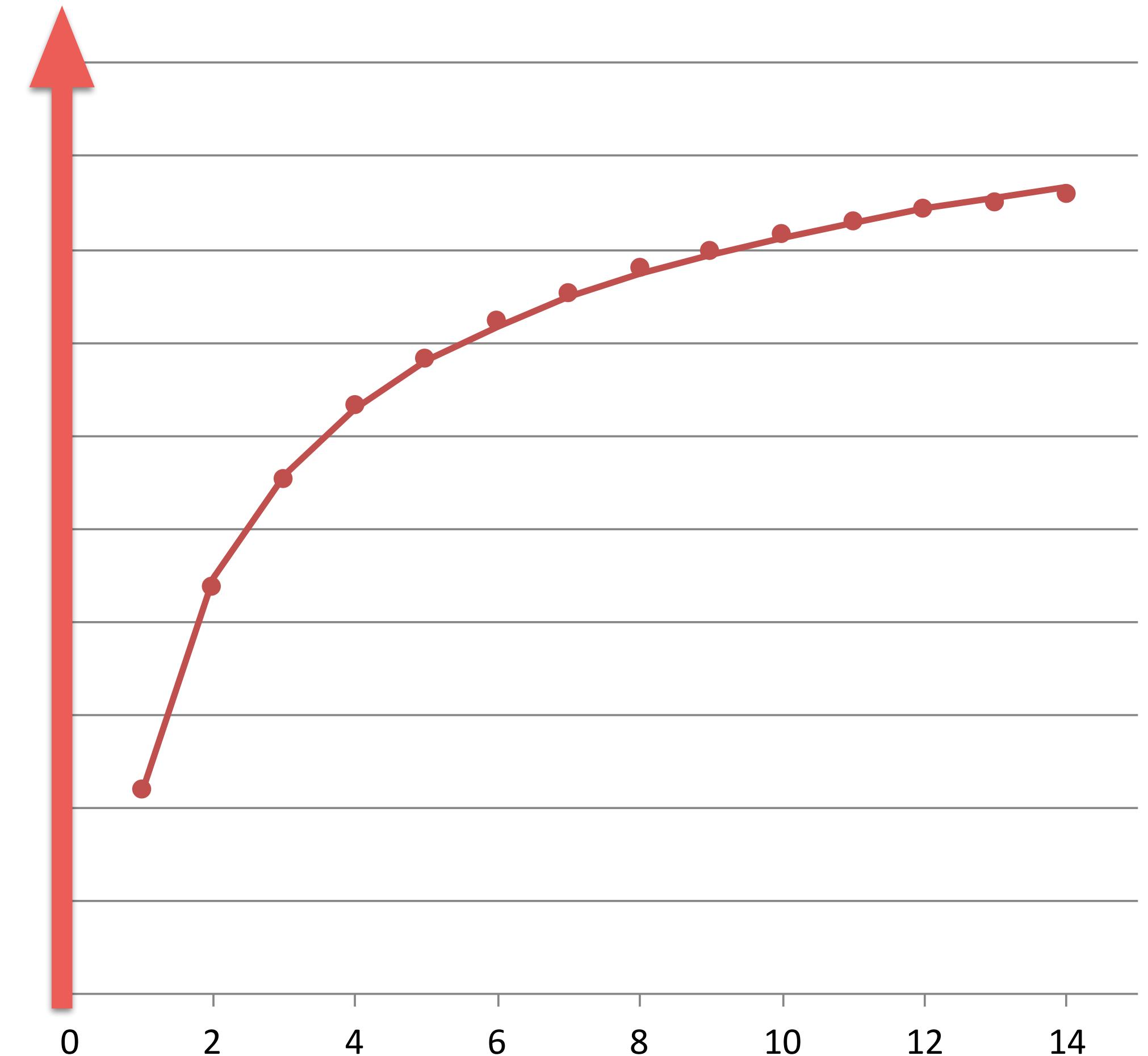
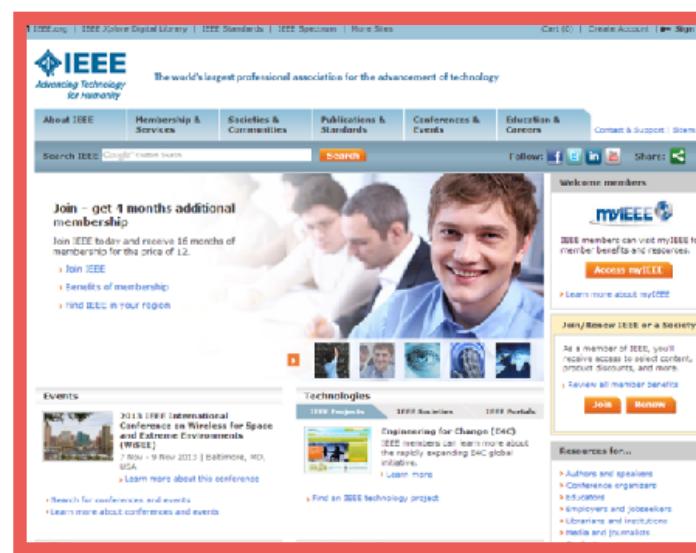
Click patterns match fixation patterns





More involved tasks lead to better clicks

Similarity between
clicks and fixations

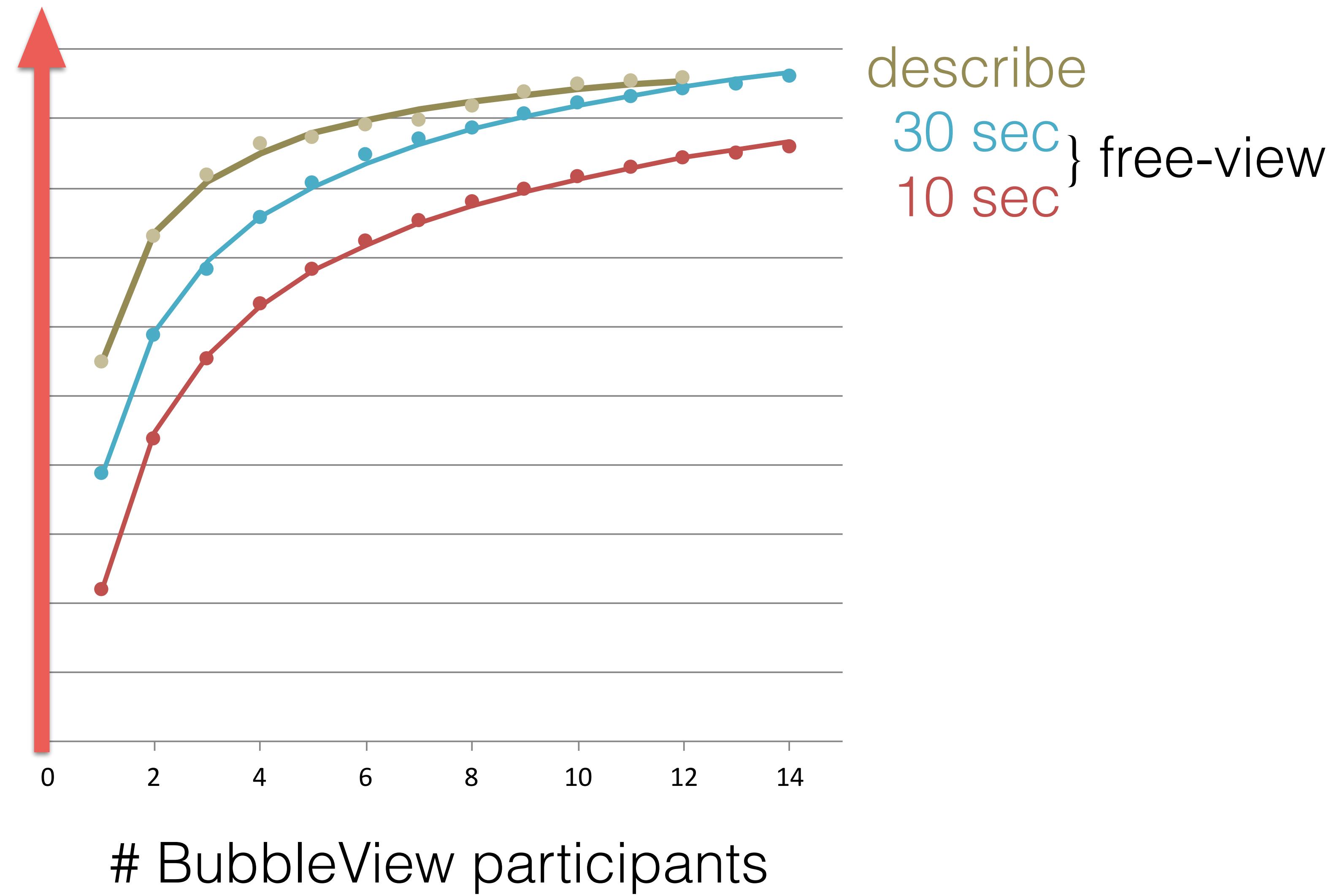


BubbleView participants

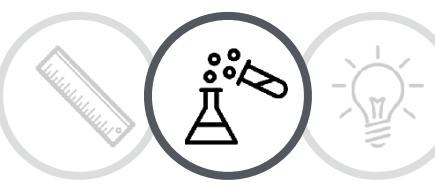


More involved tasks lead to better clicks

Similarity between
clicks and fixations

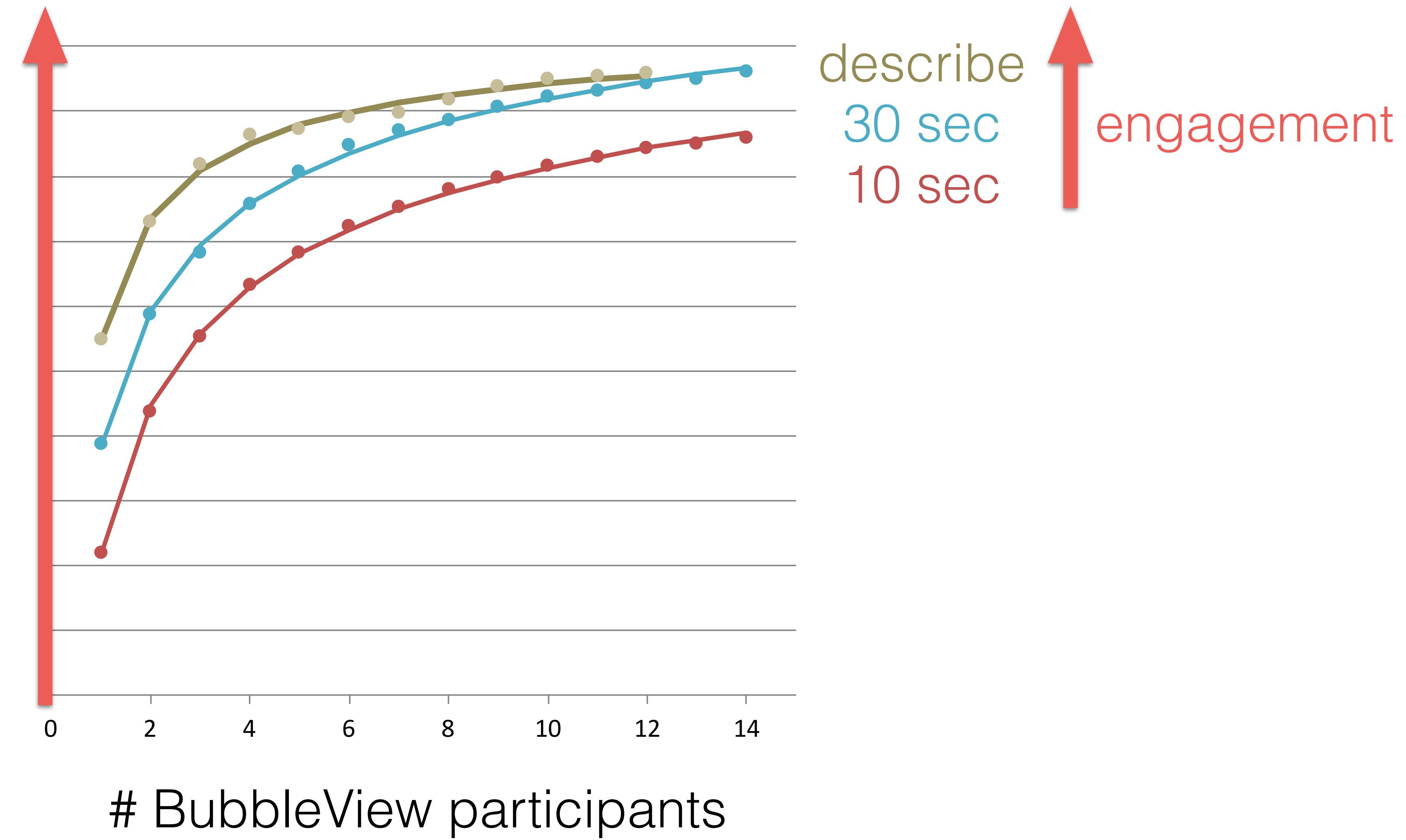
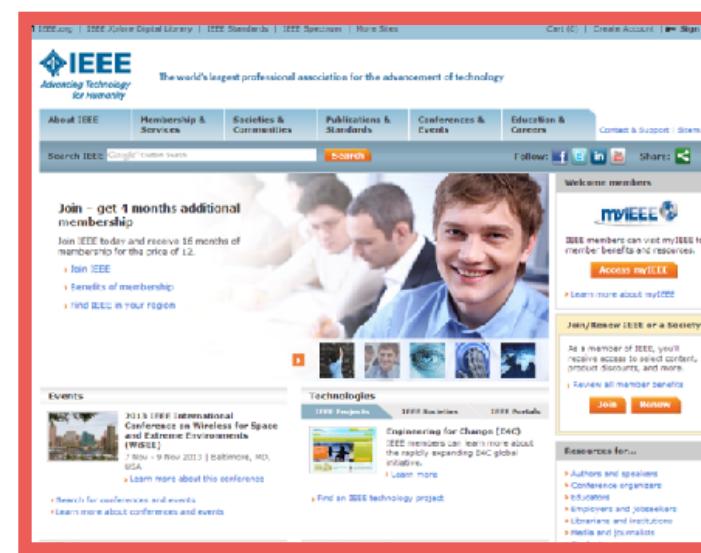


describe
30 sec
10 sec } free-view



More involved tasks lead to better clicks

Similarity between
clicks and fixations





Take-away #3:

Task time and bubble size interact to affect clicks.



Performance is stable across bubble sizes

32 pix



24 pix



16 pix

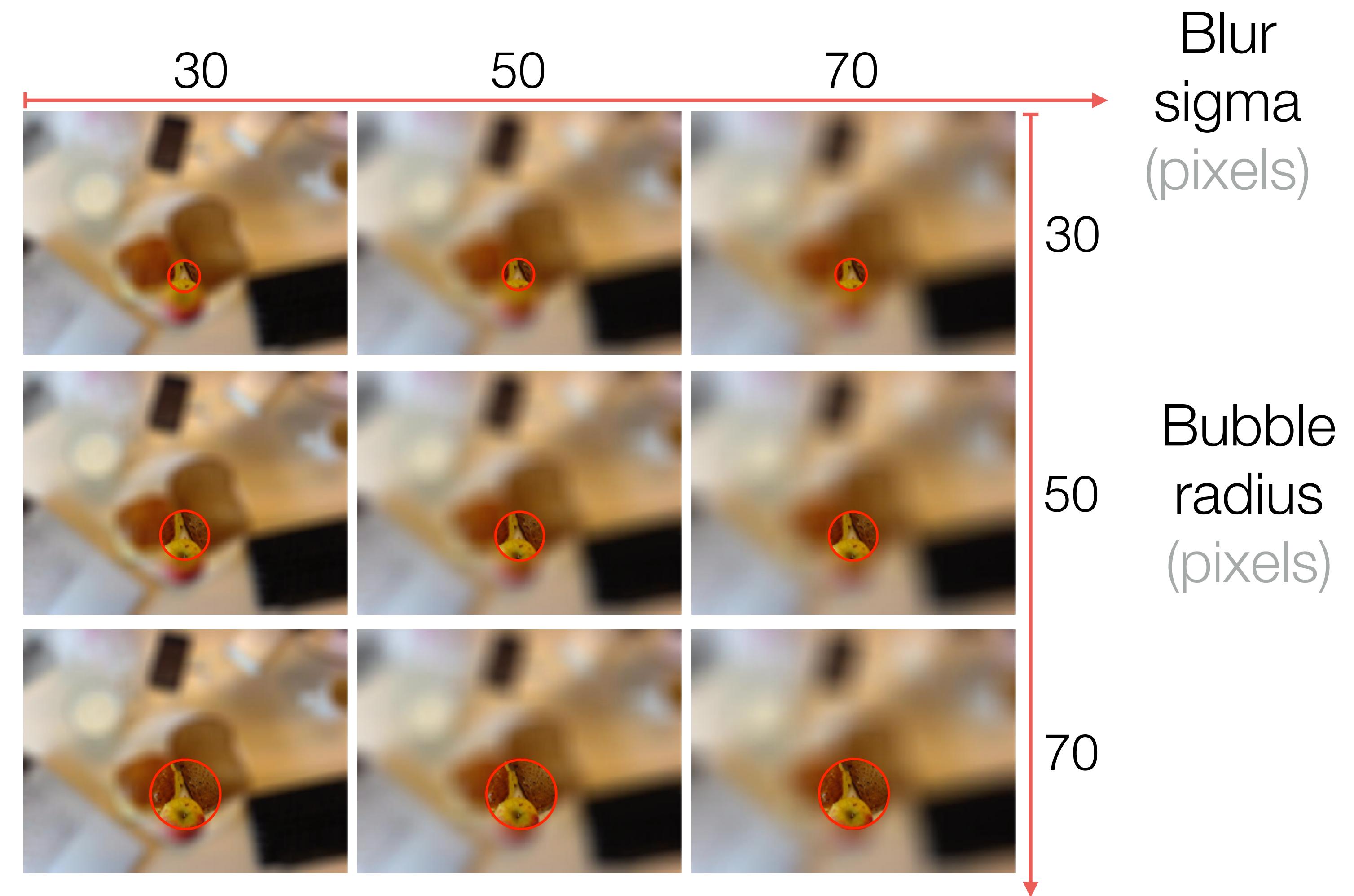


Effort

x 1.5 clicks

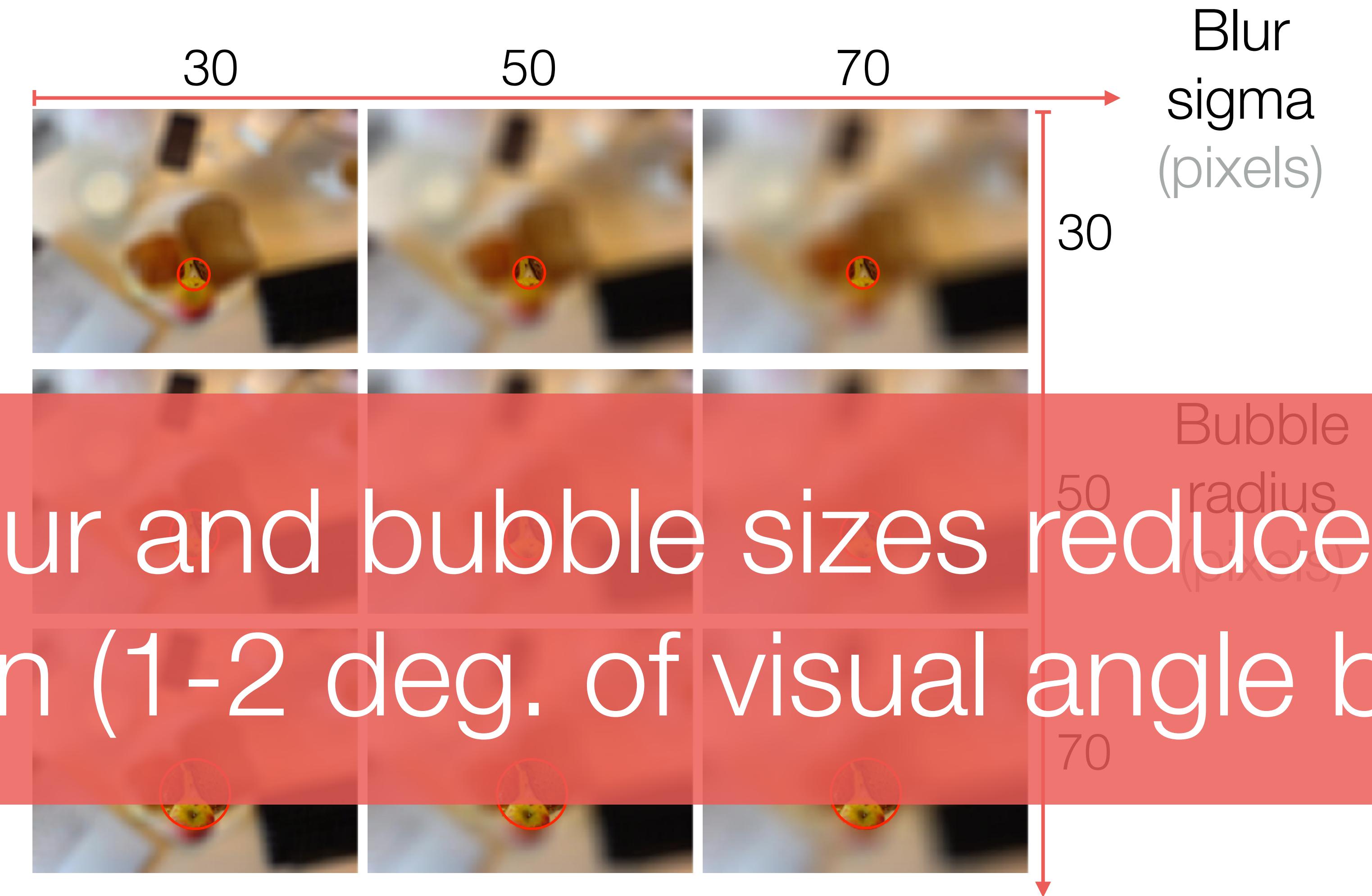


Blur affects clicks more than bubble size



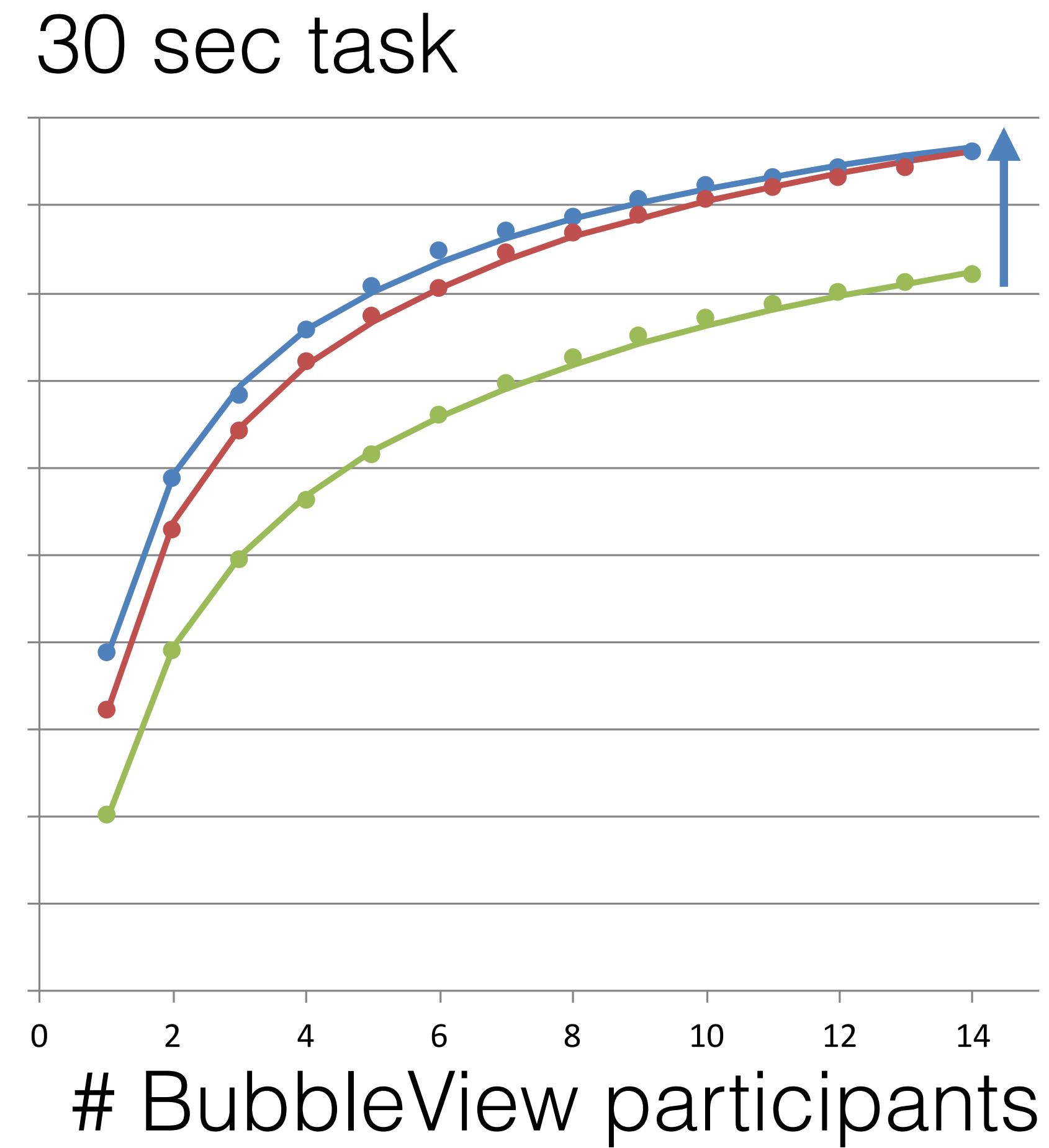
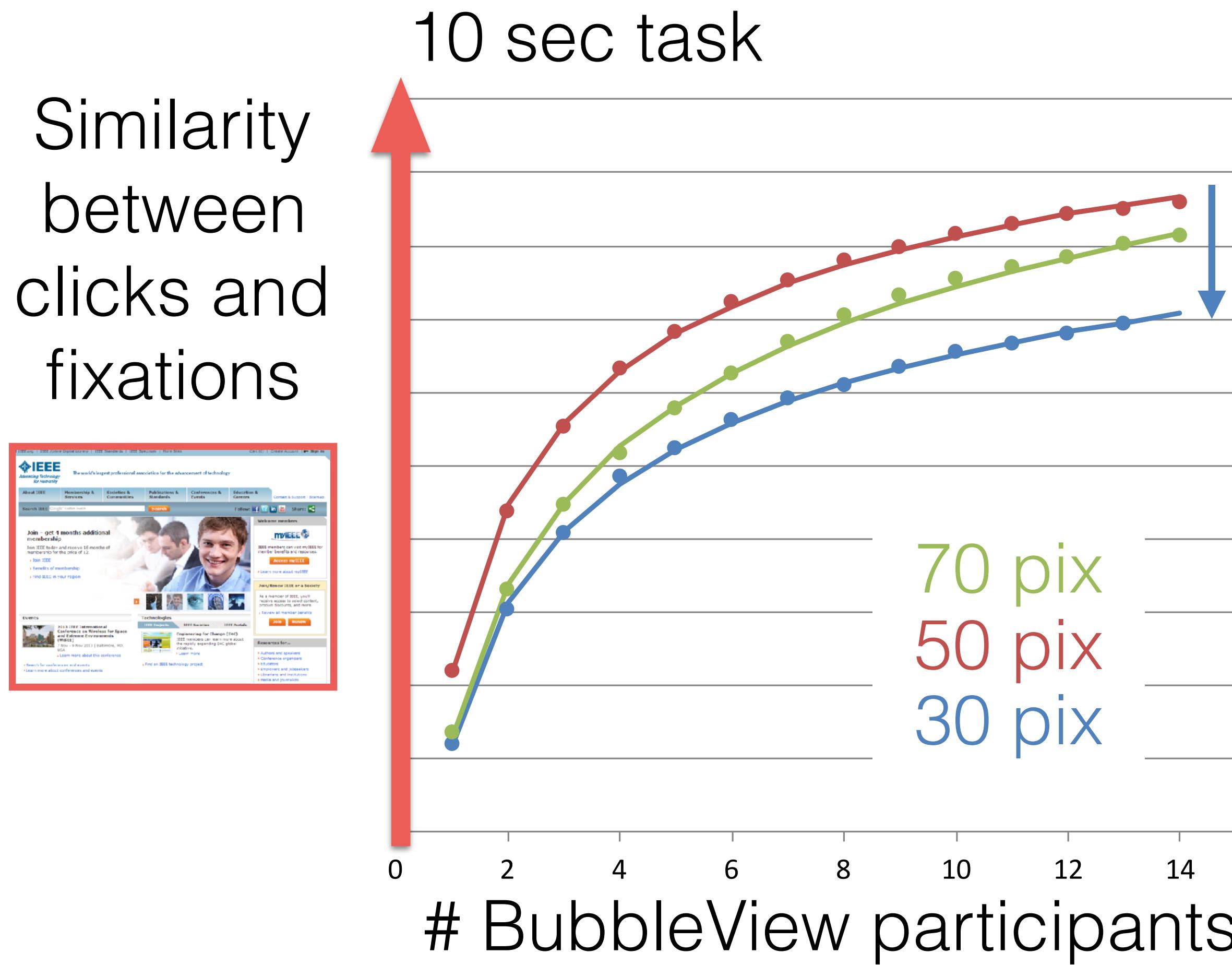


Blur affects clicks more than bubble size





Task time and bubble size interact



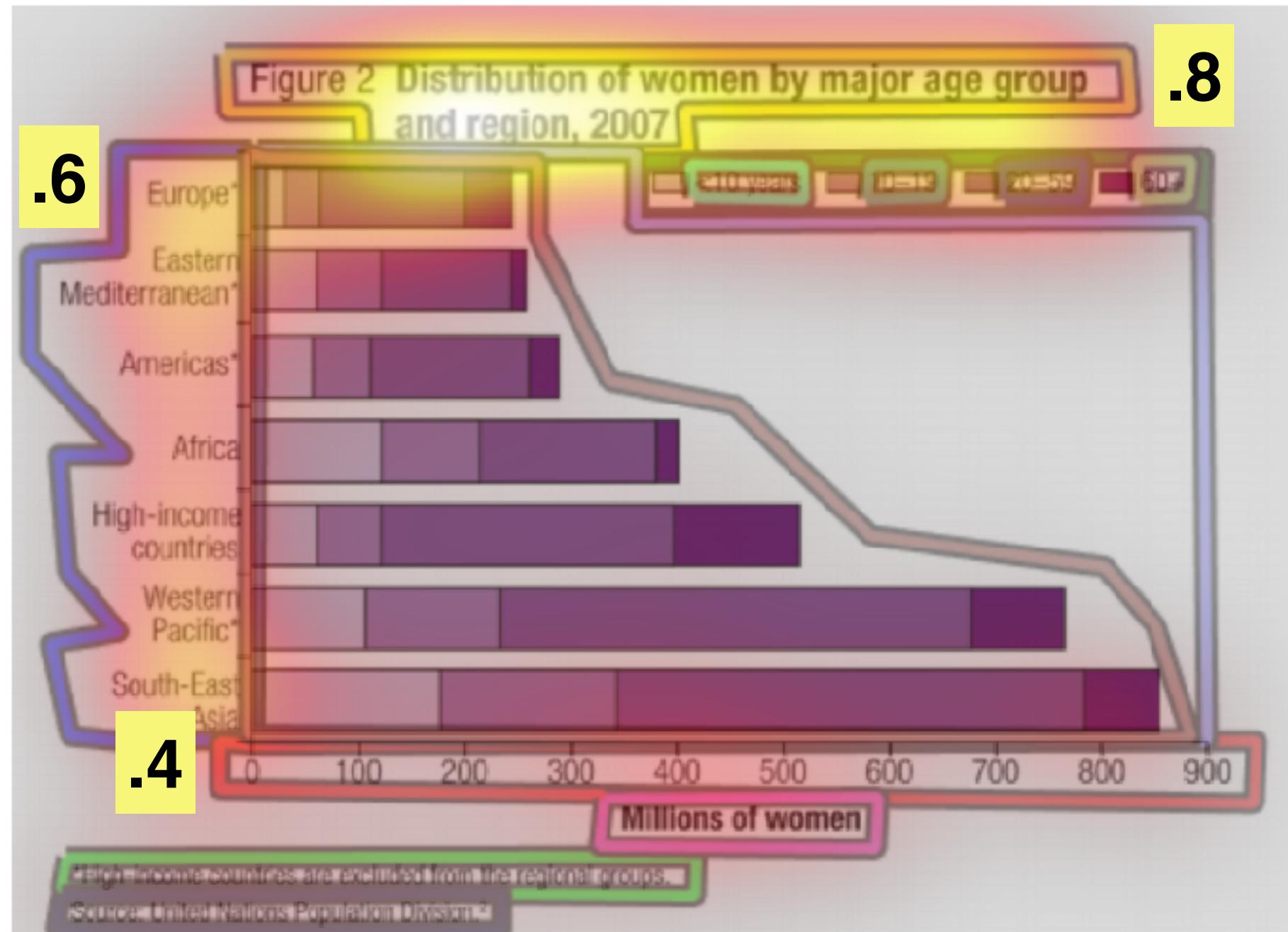


Take-away #4:

BubbleView can be used to rank image elements by importance.



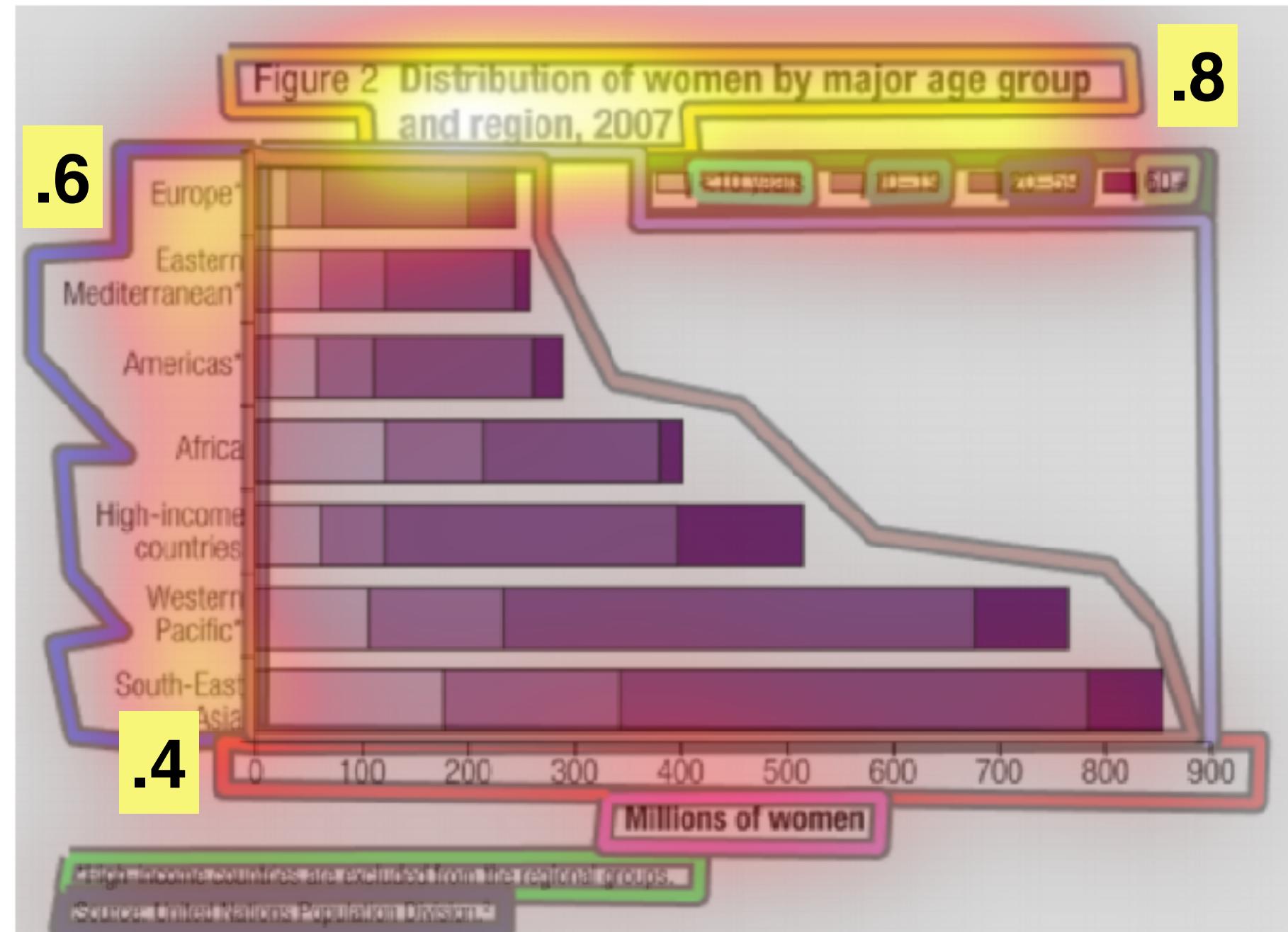
Ranking elements by importance



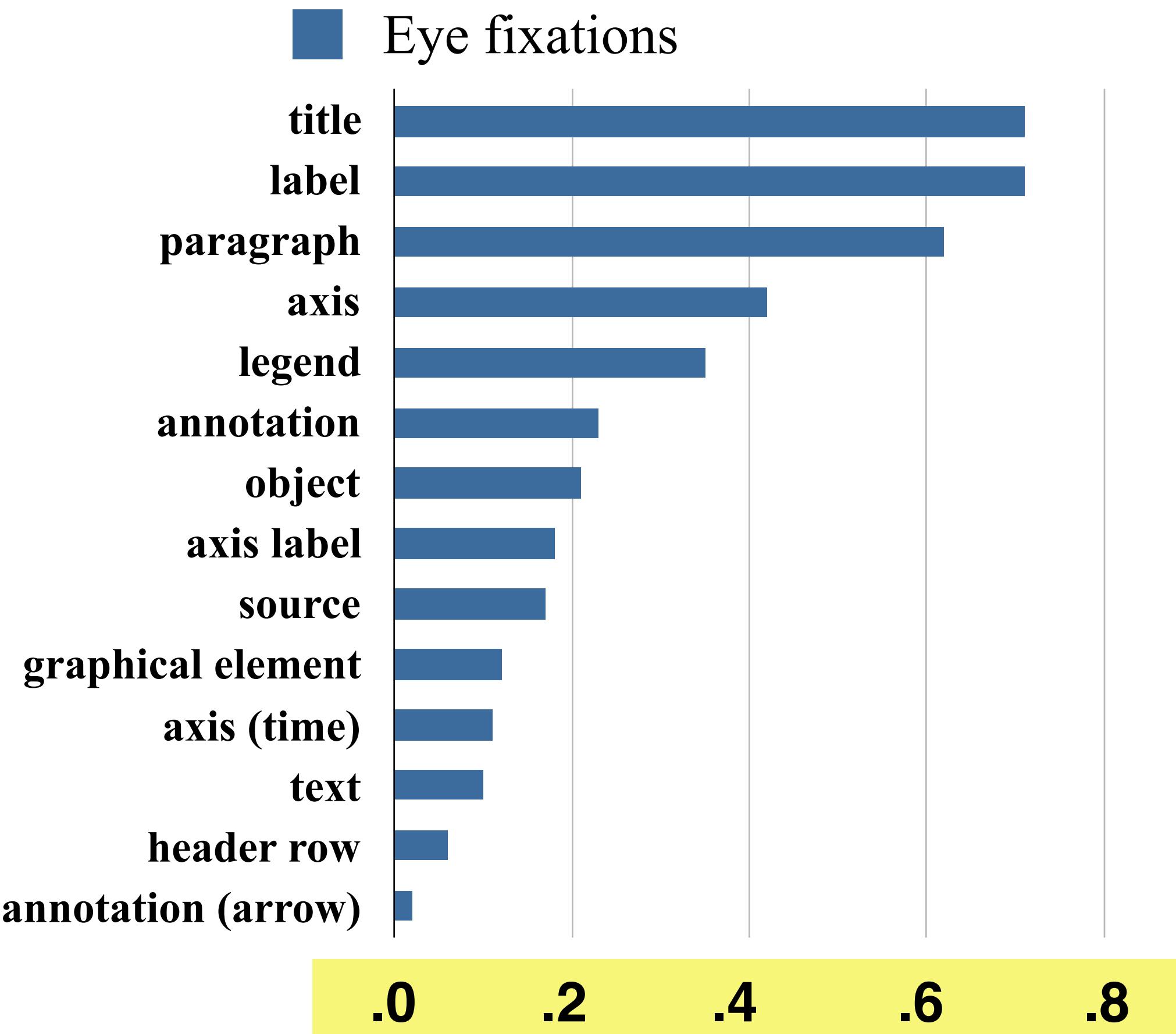
- (1) axis
- (2) axis
- (3) text (paragraph)
- (4) text (source)
- (5) text (axis label)
- (6) text (title)
- (7) legend
- (8) data
- (9) data (bars)
- (10) text (label)
- (11) text (label)
- (12) text (label)
- (13) text (label)



Ranking elements by importance

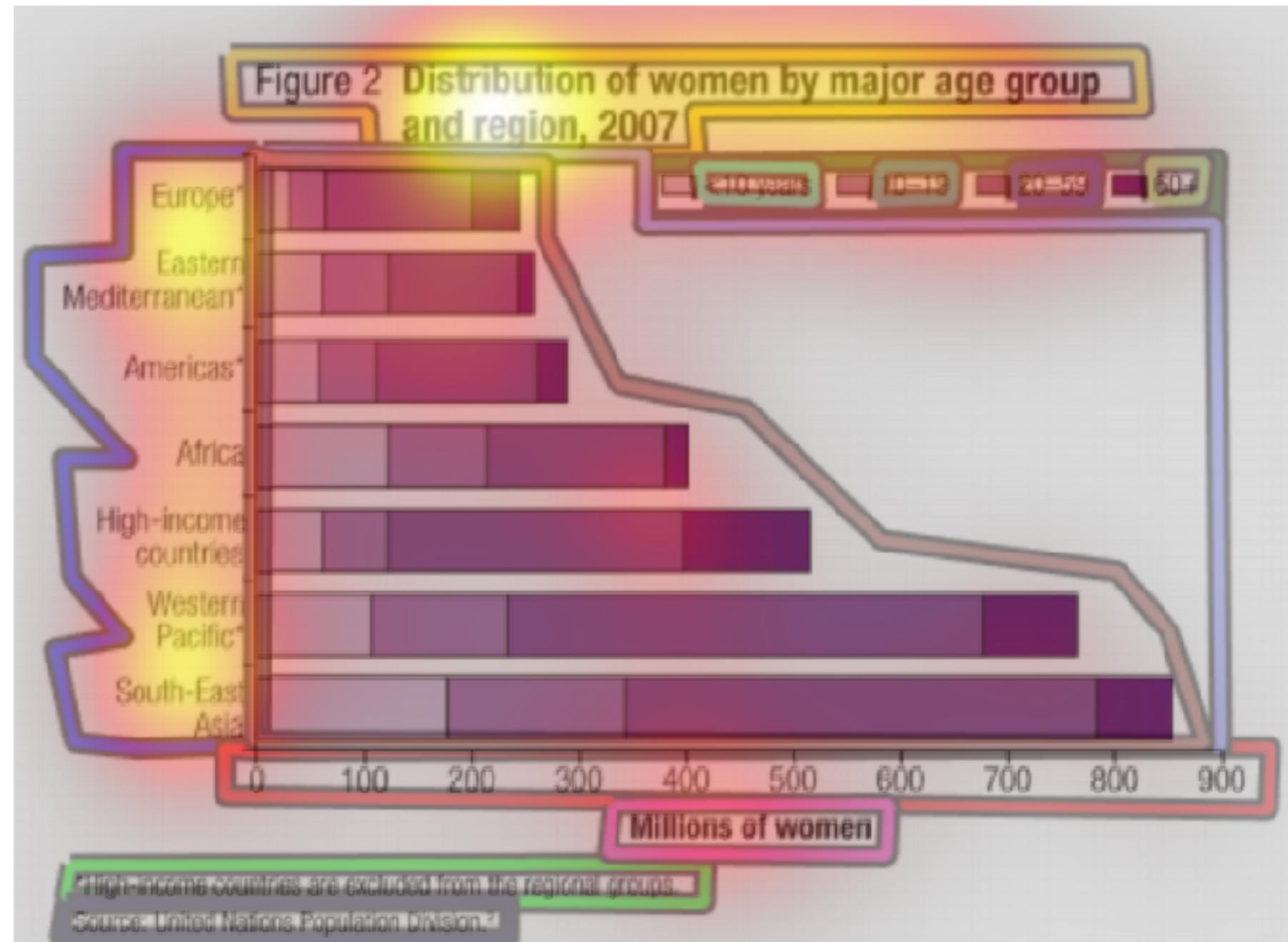


- | | |
|-----------------------|-------------------|
| (1) axis | (8) data |
| (2) axis | (9) data (bars) |
| (3) text (paragraph) | (10) text (label) |
| (4) text (source) | (11) text (label) |
| (5) text (axis label) | (12) text (label) |
| (6) text (title) | (13) text (label) |
| (7) legend | |

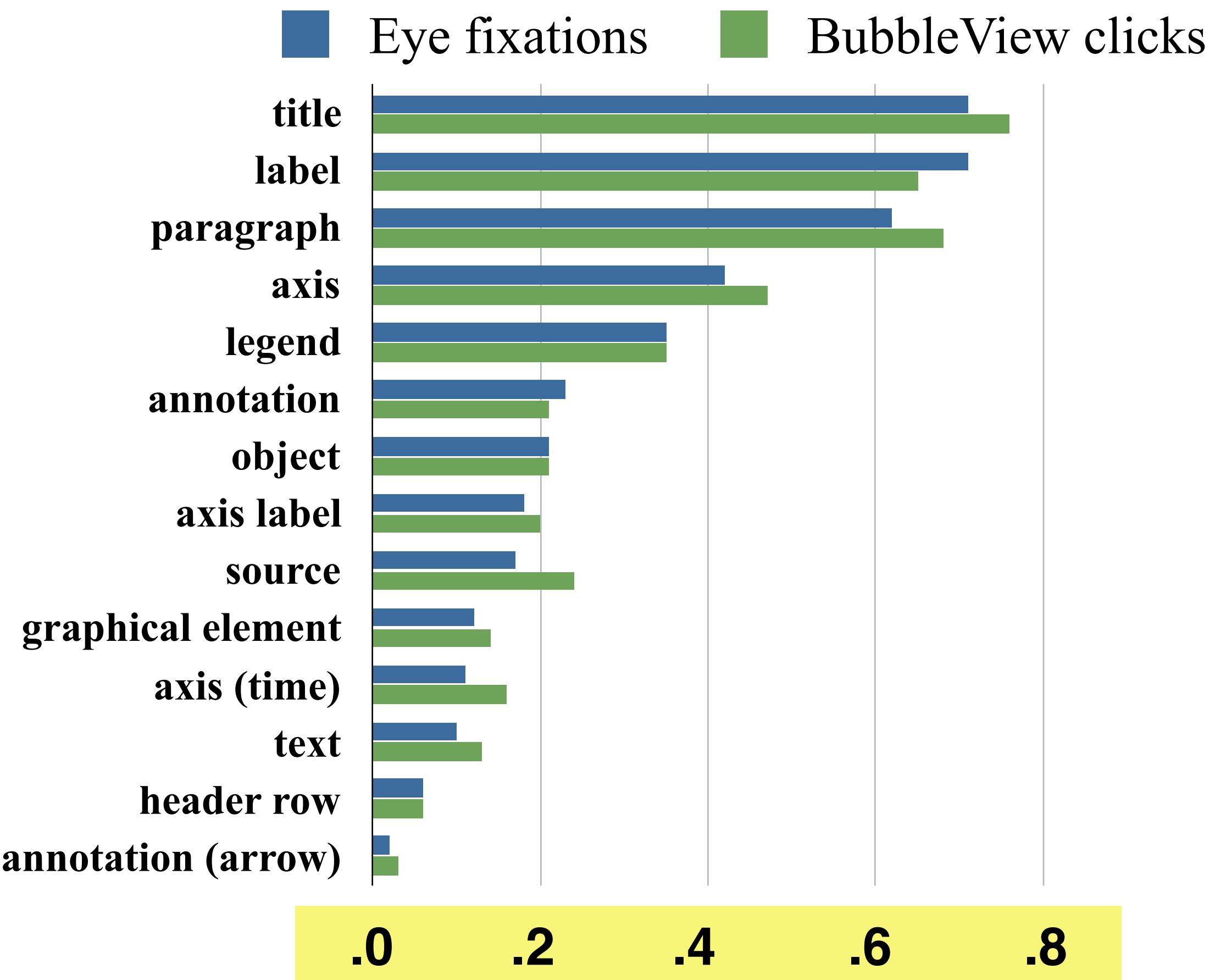




Ranking elements by importance

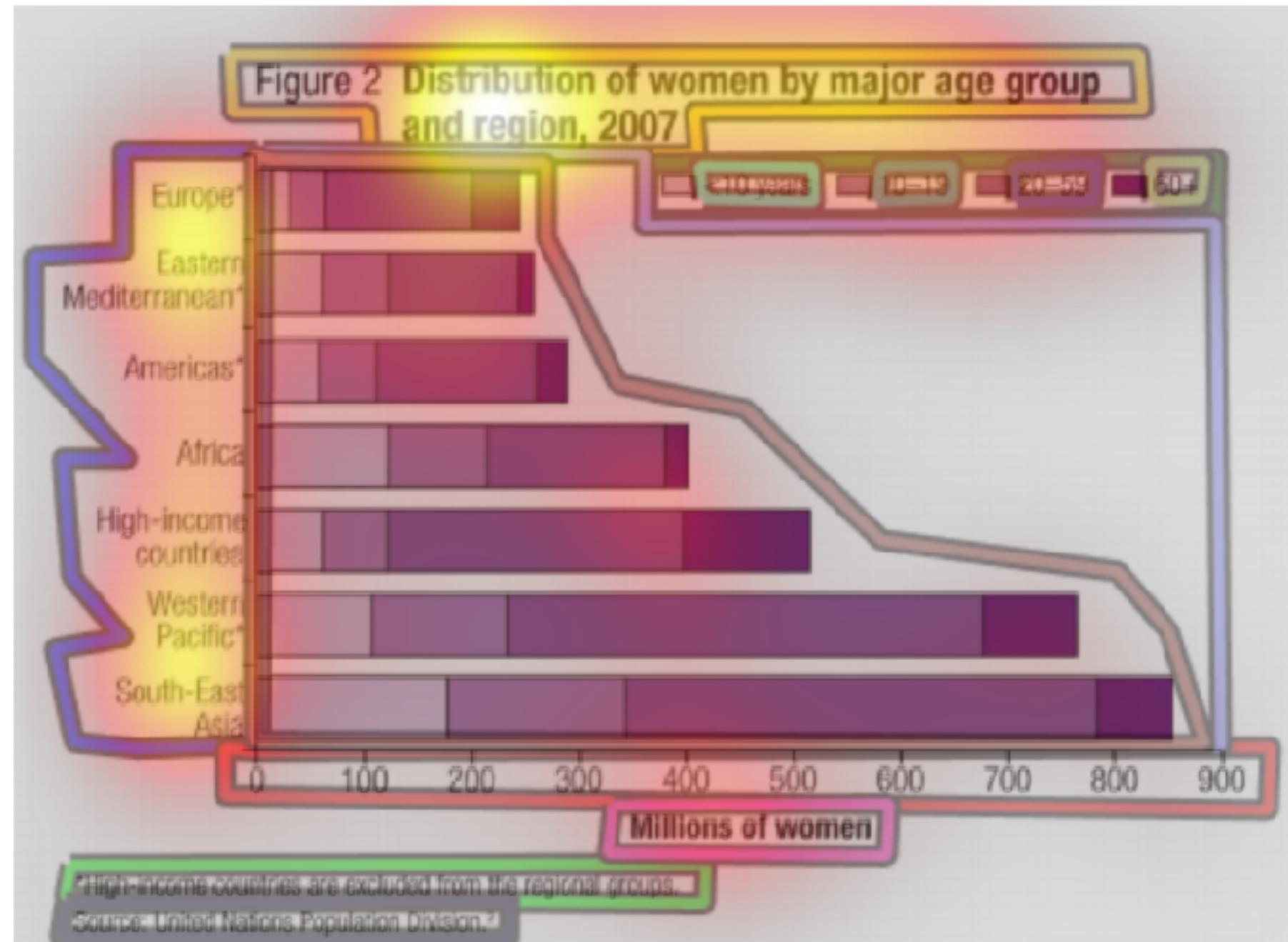


- | | |
|-----------------------|-------------------|
| (1) axis | (8) data |
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| (4) text (source) | (11) text (label) |
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| (6) text (title) | (13) text (label) |
| (7) legend | |

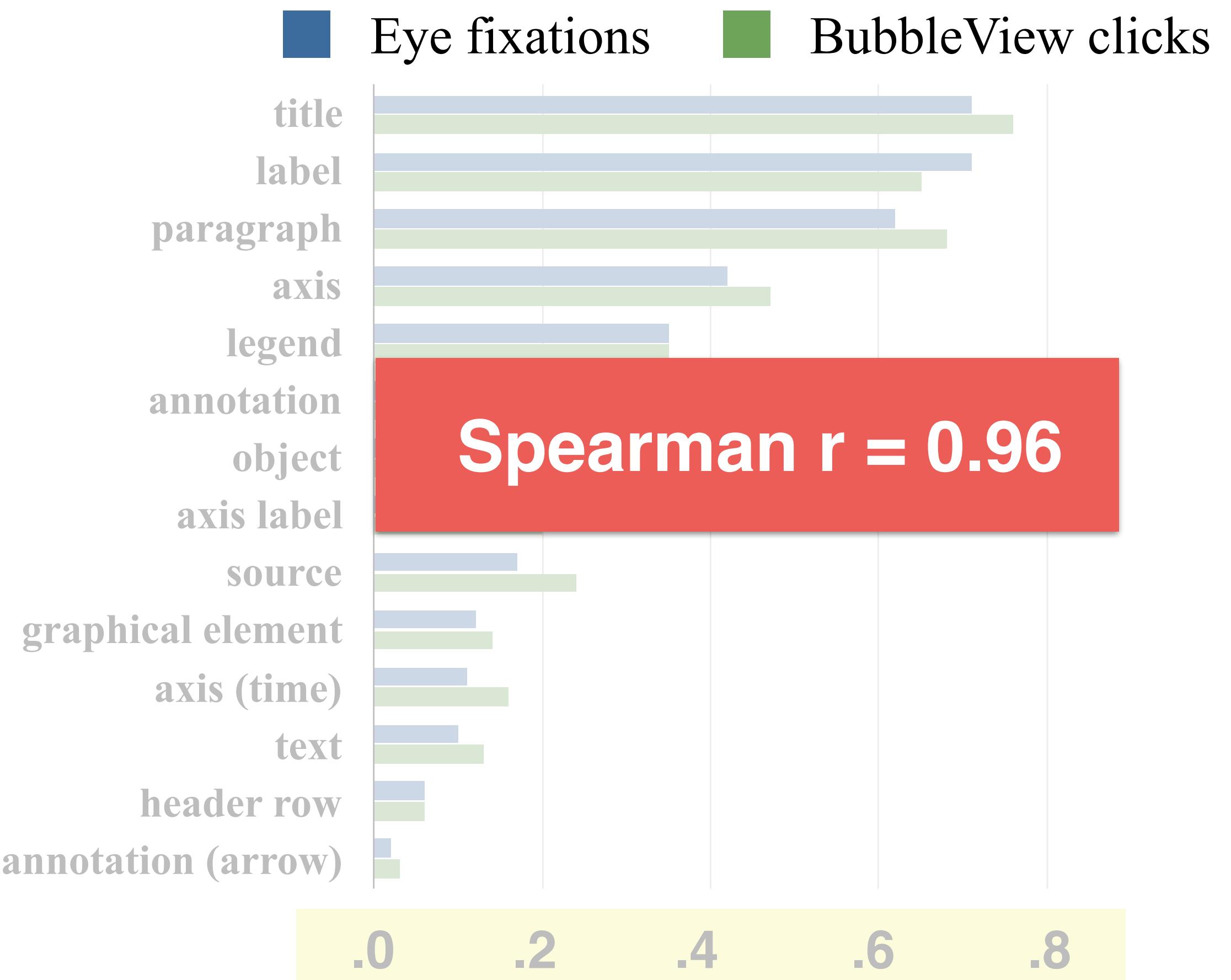




Ranking elements by importance

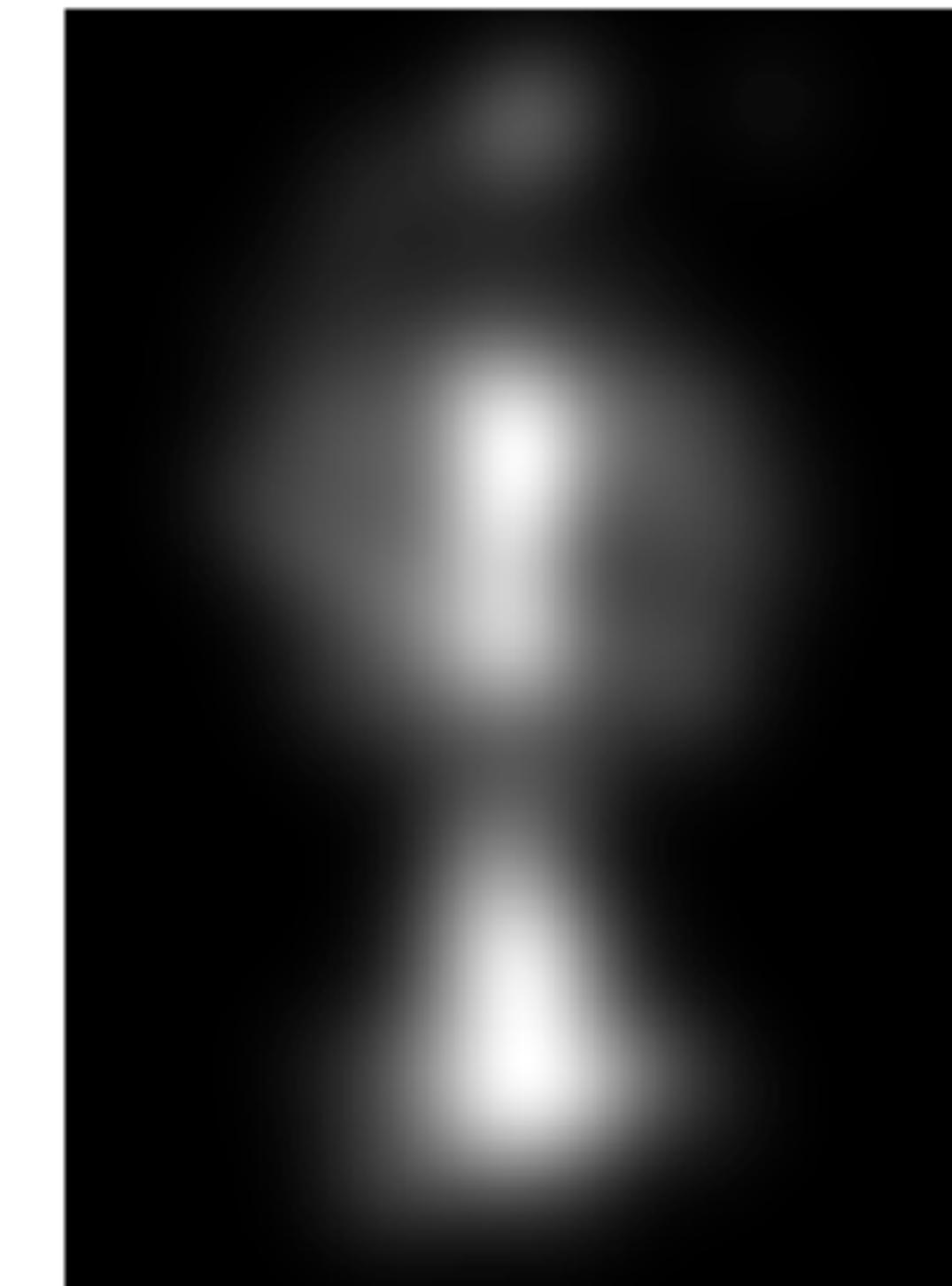
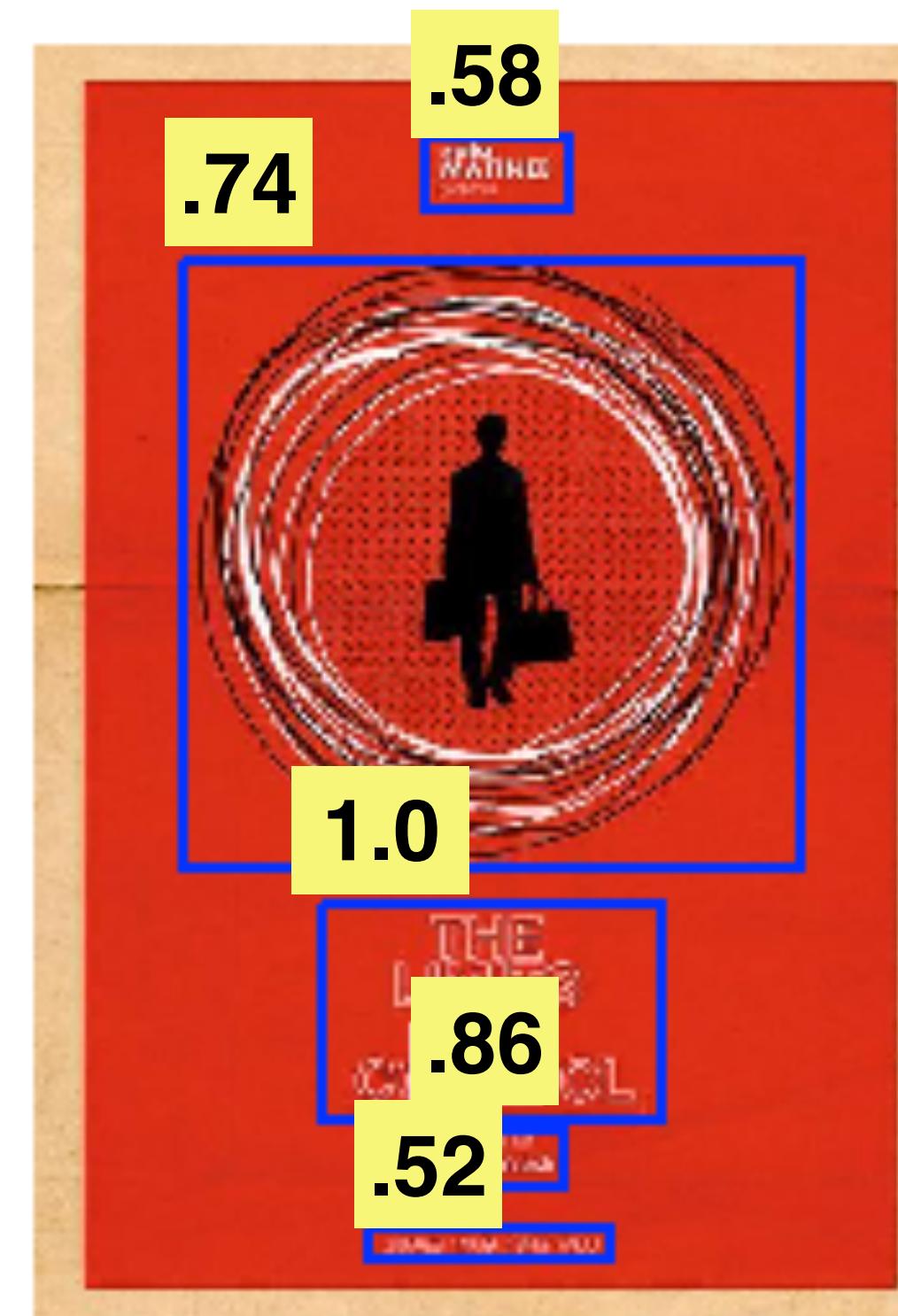
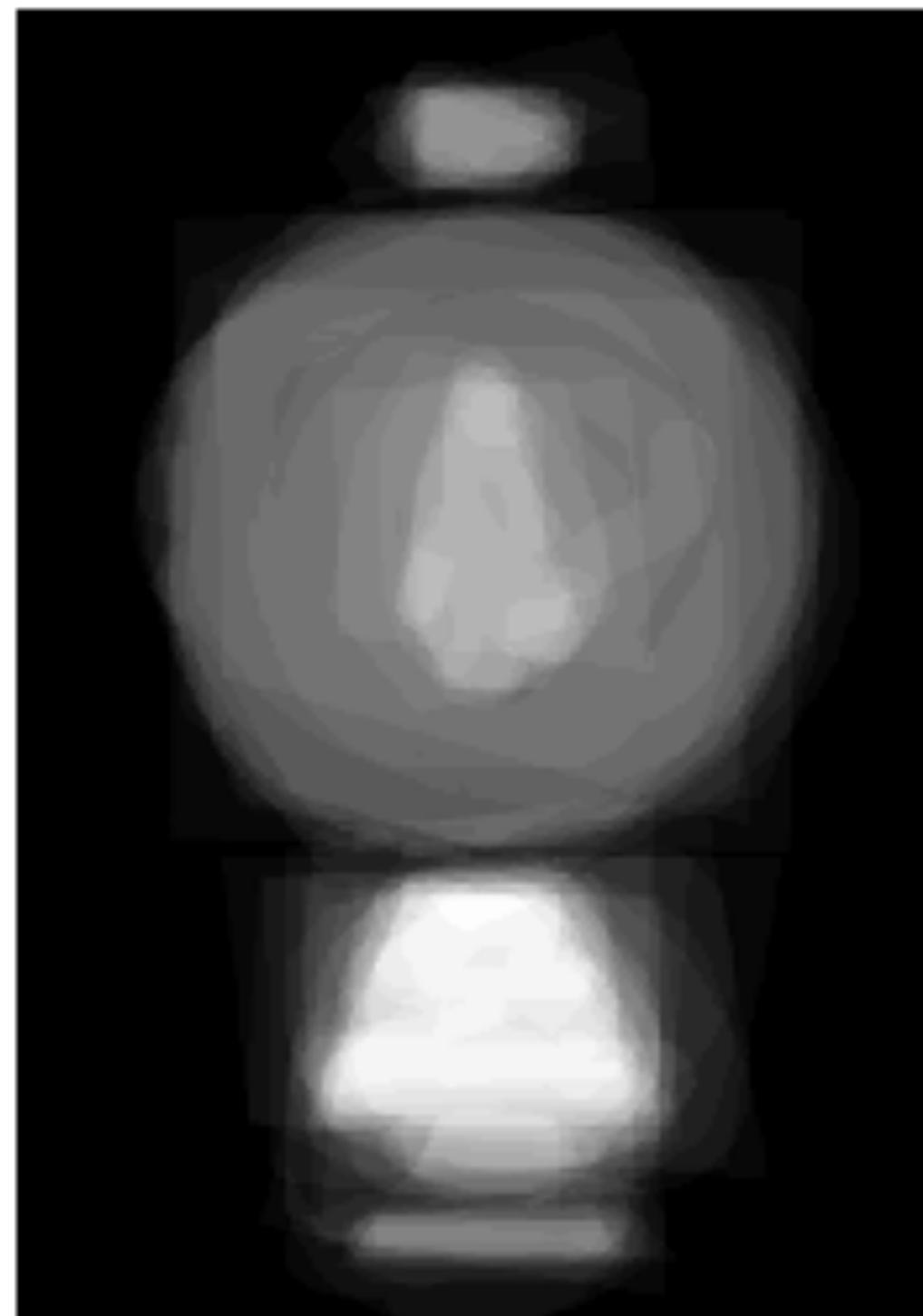


- | | |
|-----------------------|-------------------|
| (1) axis | (8) data |
| (2) axis | (9) data (bars) |
| (3) text (paragraph) | (10) text (label) |
| (4) text (source) | (11) text (label) |
| (5) text (axis label) | (12) text (label) |
| (6) text (title) | (13) text (label) |
| (7) legend | |





Ranking elements by importance



Spearman $r = 0.60$

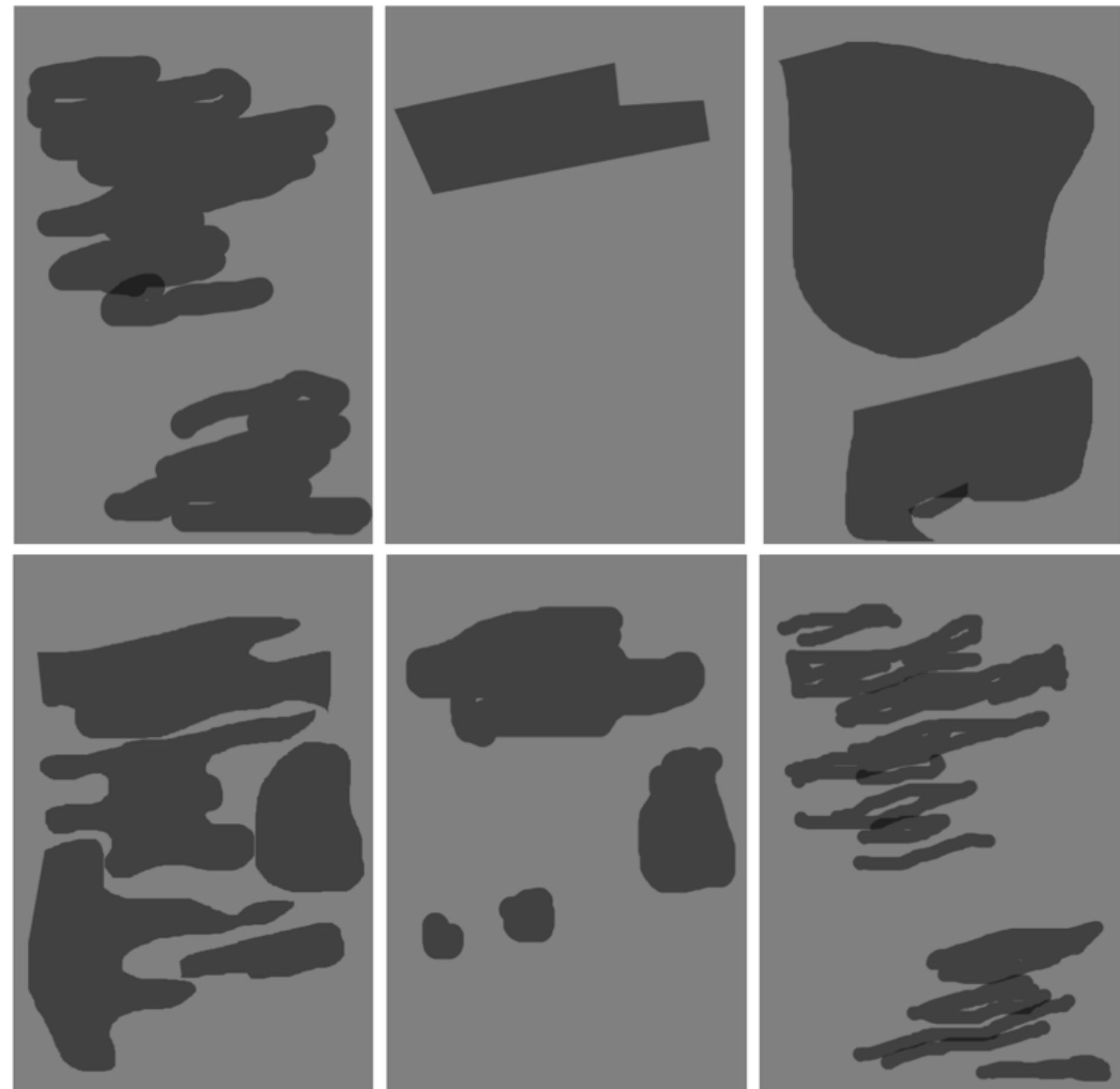


Another measurement of importance

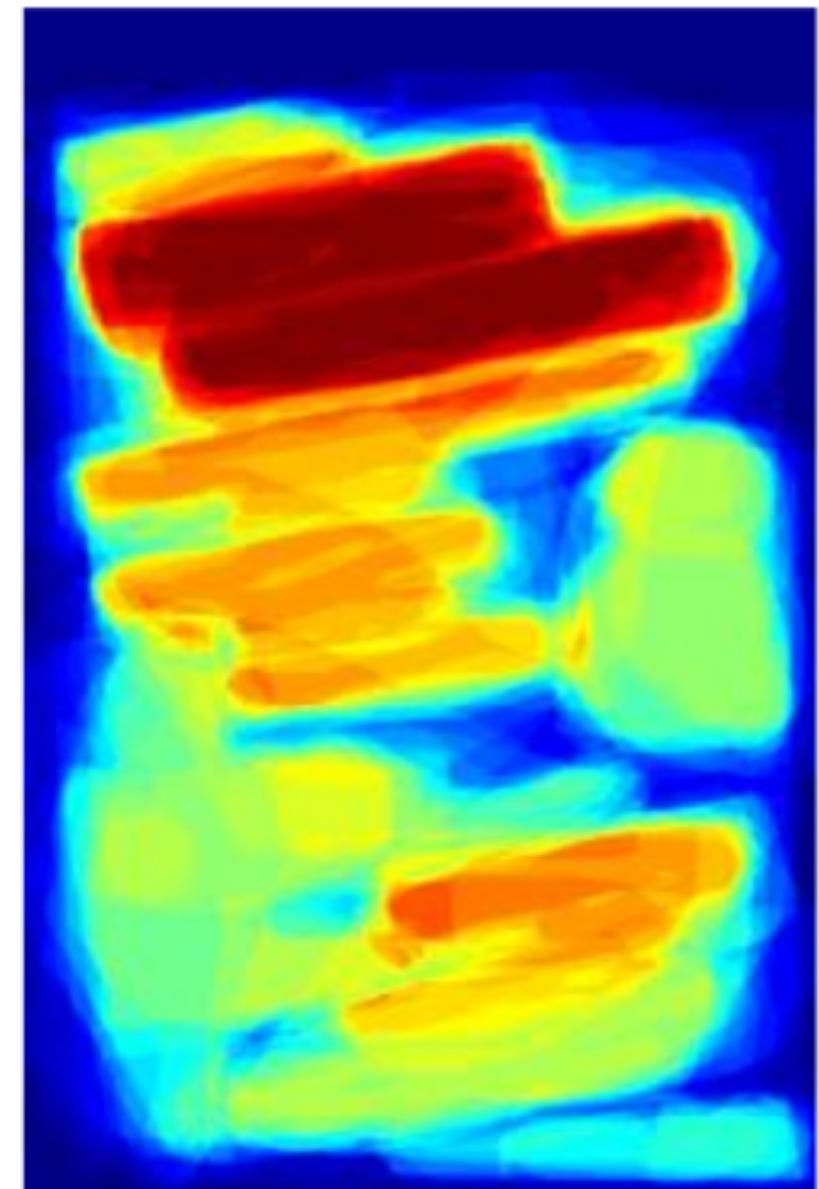
Graphic design

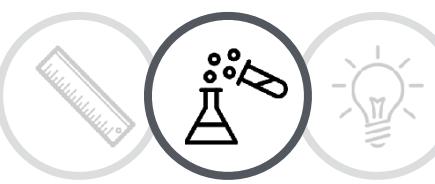


Crowd annotations



Avg. annotation





Design choice: collecting importance

Fixations



“unconscious”

explorative

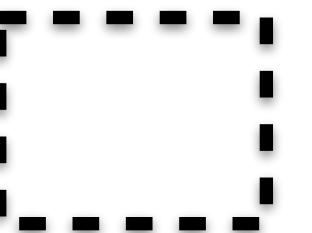
Clicks



conscious

explorative

Annotations



conscious

constrained



BubbleView measures importance

Fixations



with free-viewing

Clicks



with free-viewing

Clicks



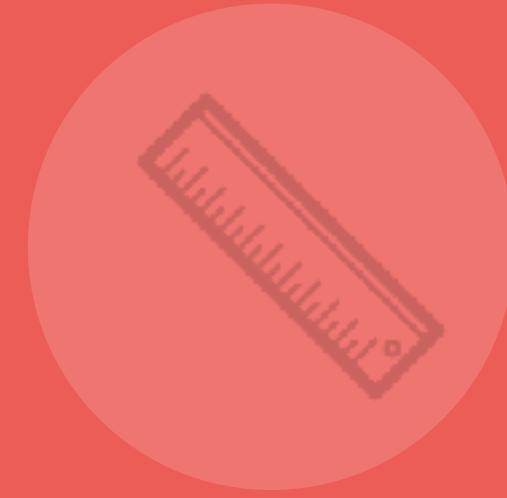
with description

“Saliency”

Intentionality

“Importance”

Effort, task time, consistency



Evaluation Tools



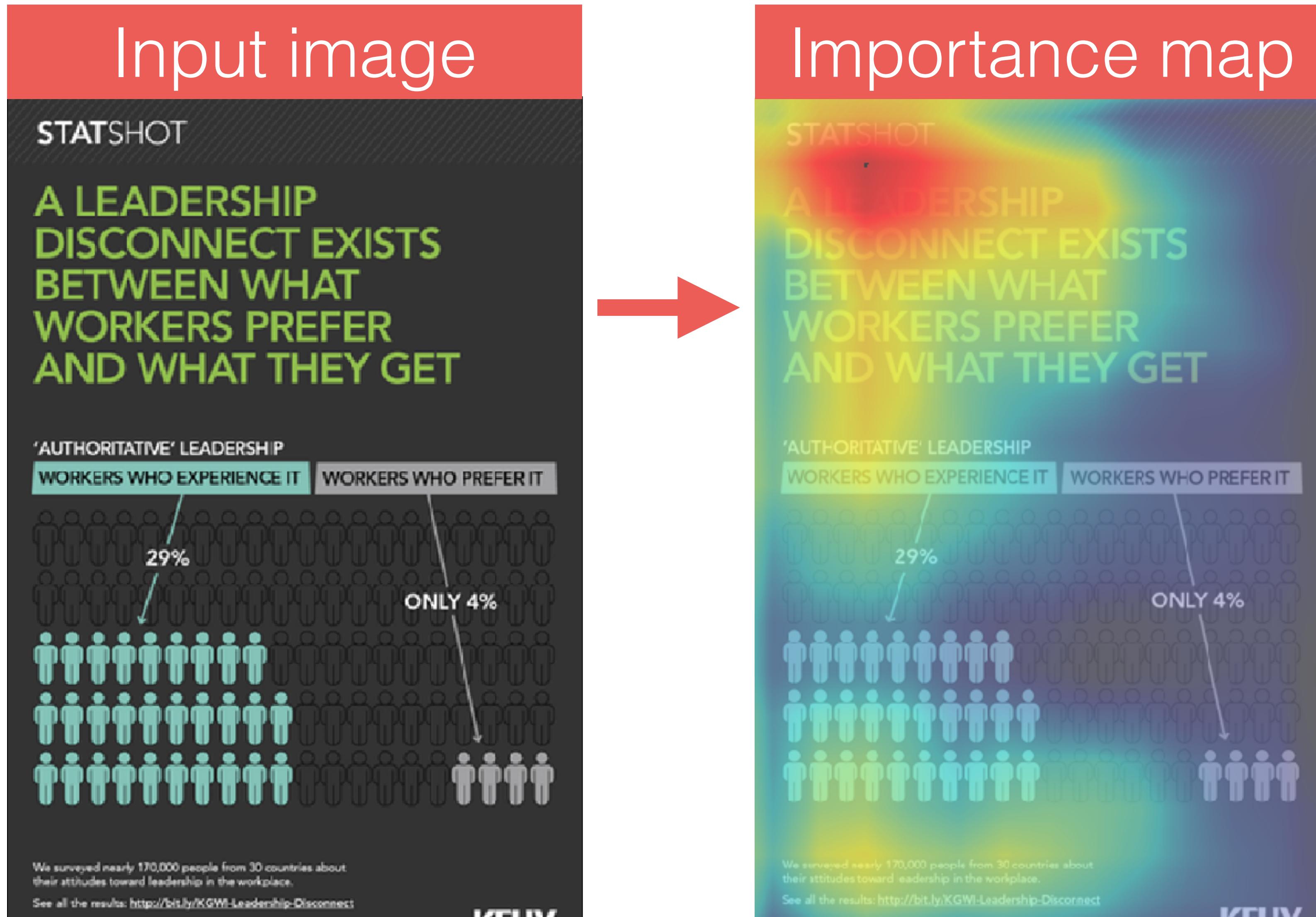
Experimental Results



Future Applications



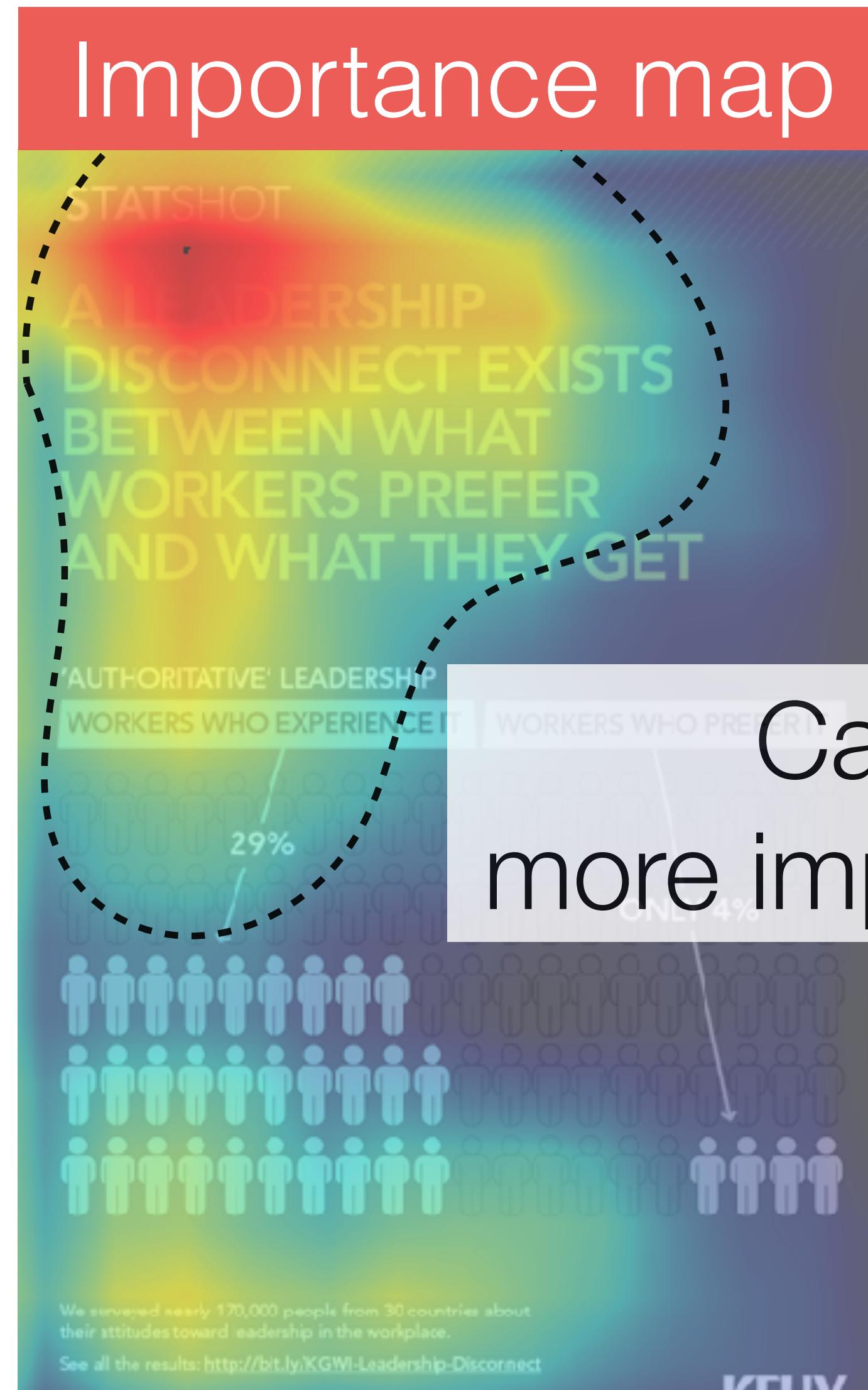
Retargeting & Thumbnailing



[Bylinskii et al. UIST 2017]



Retargeting & Thumbnailing

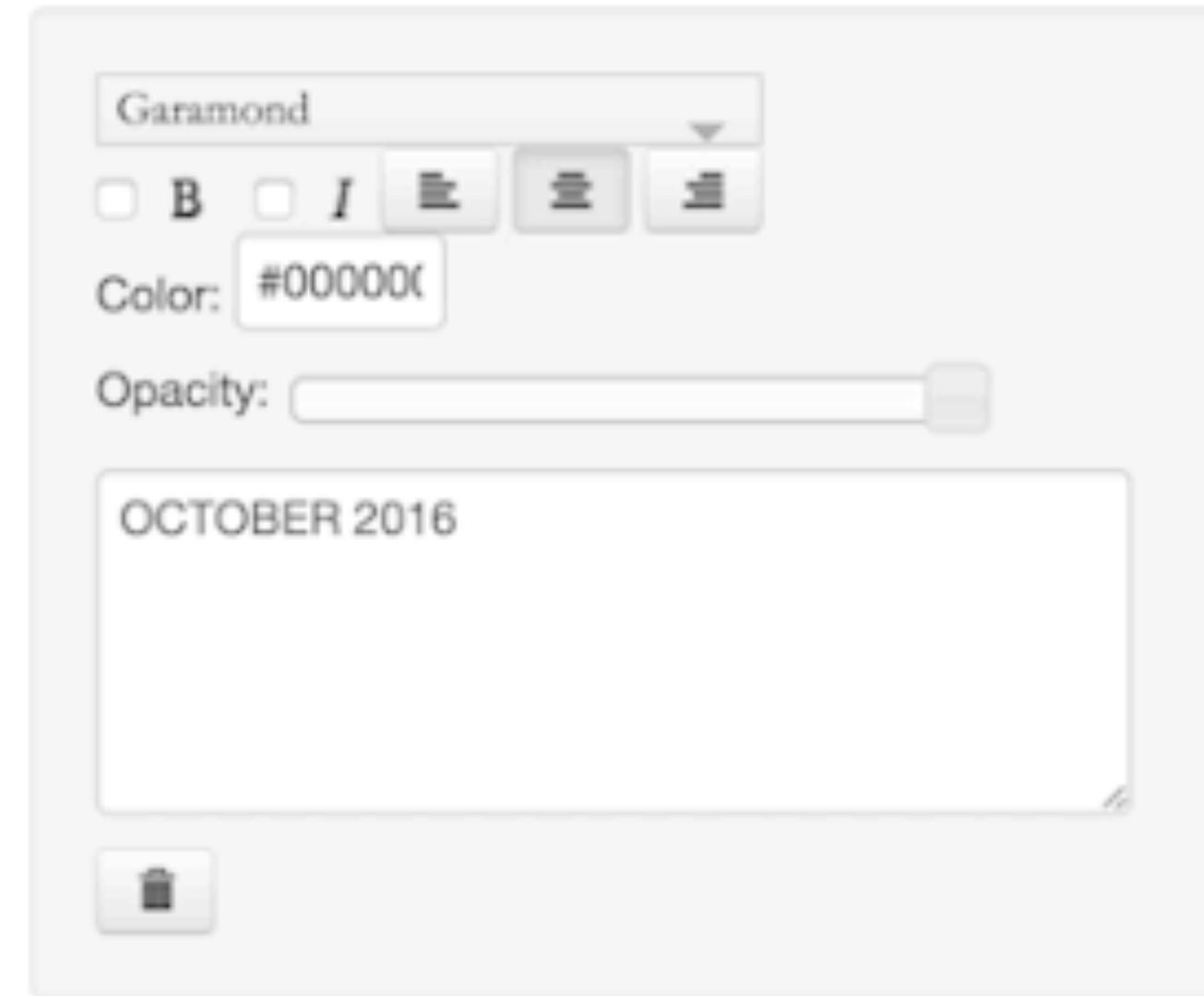


Carving out
more important regions

[Bylinskii et al. UIST 2017]



Prediction of Visual Importance



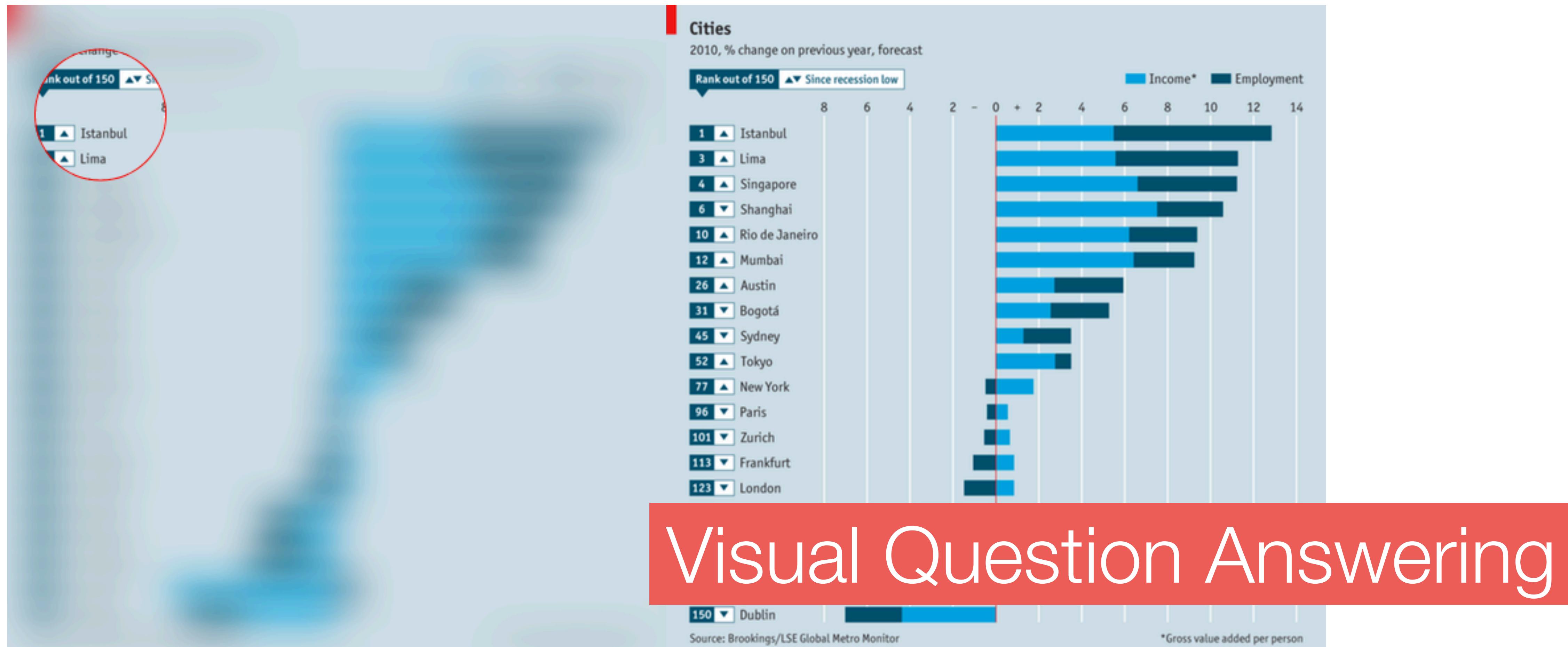
Providing real time feedback
based on importance predictions

[visimportance.csail.mit.edu]



Task-specific attentional data

Which city is ranked first (find an extremum)?





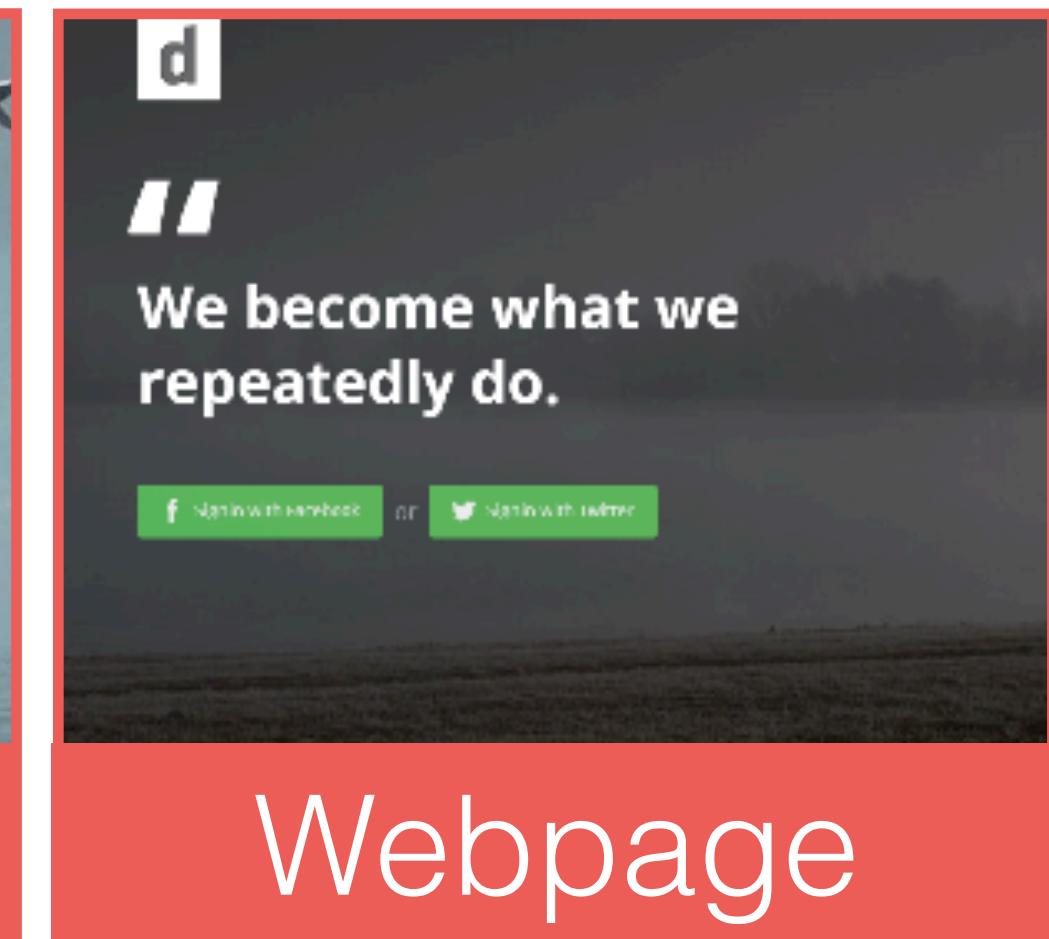
Other image domains & tasks



Visualization



Natural scene



Webpage



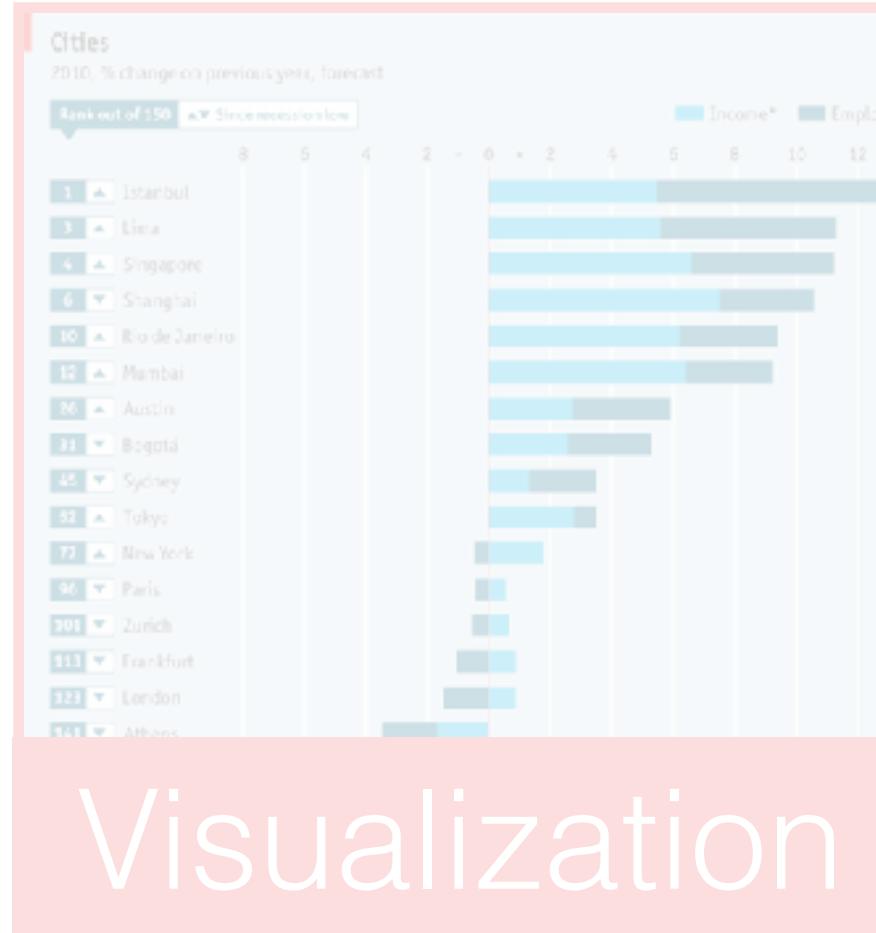
Graphic design

Tasks

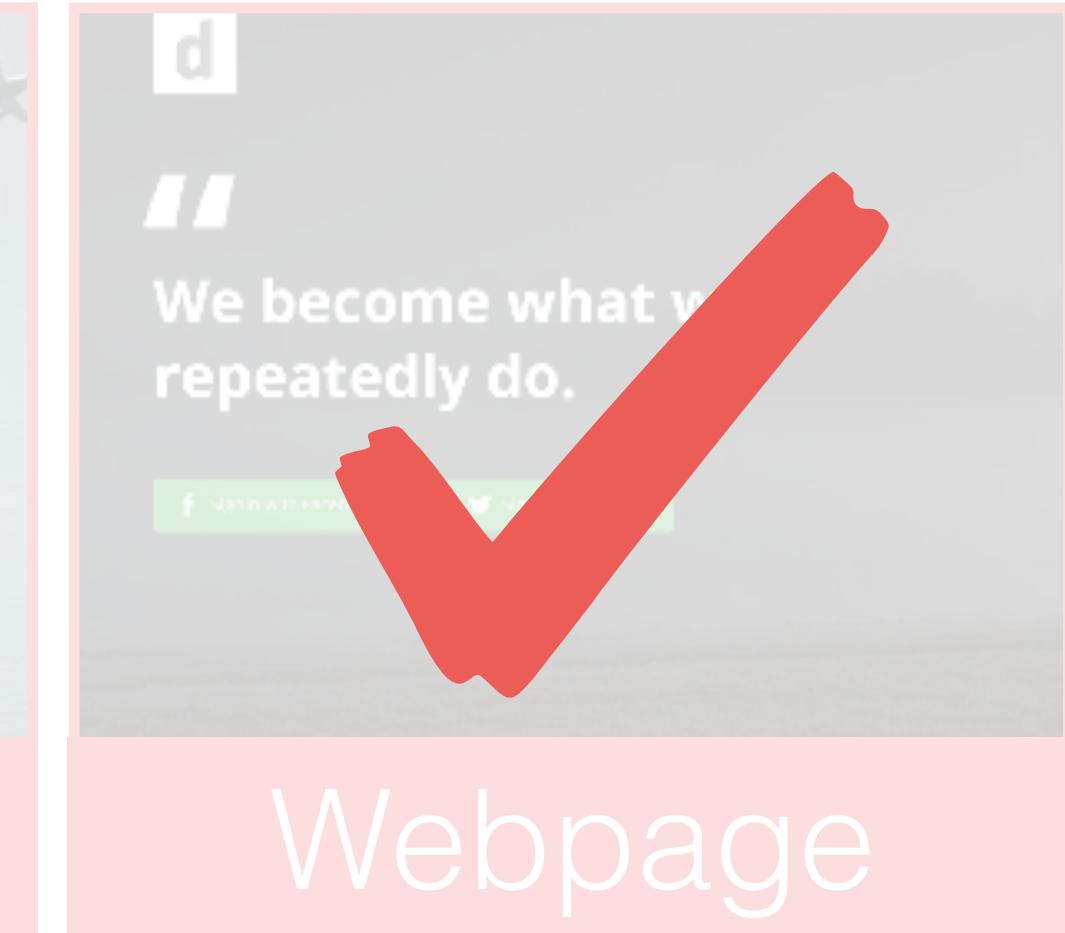
Free-viewing
Description



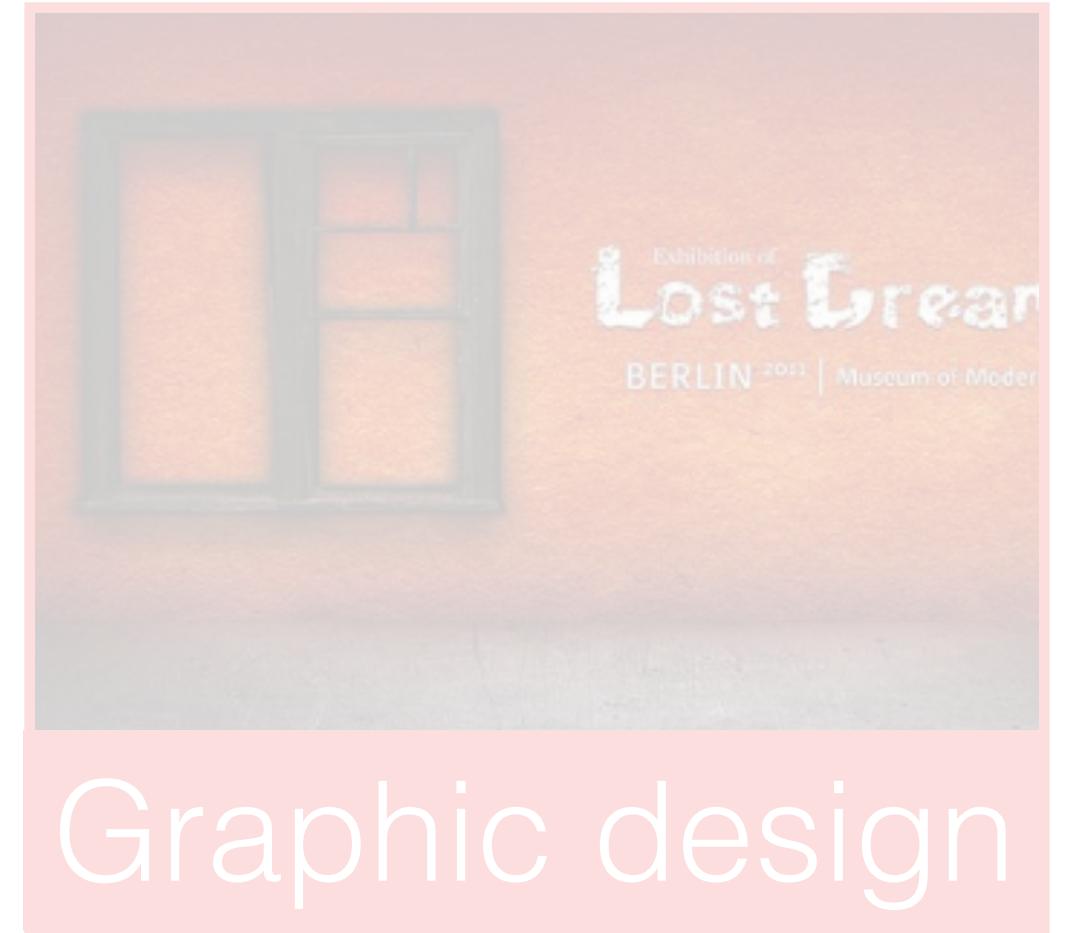
Other image domains & tasks



Visualization



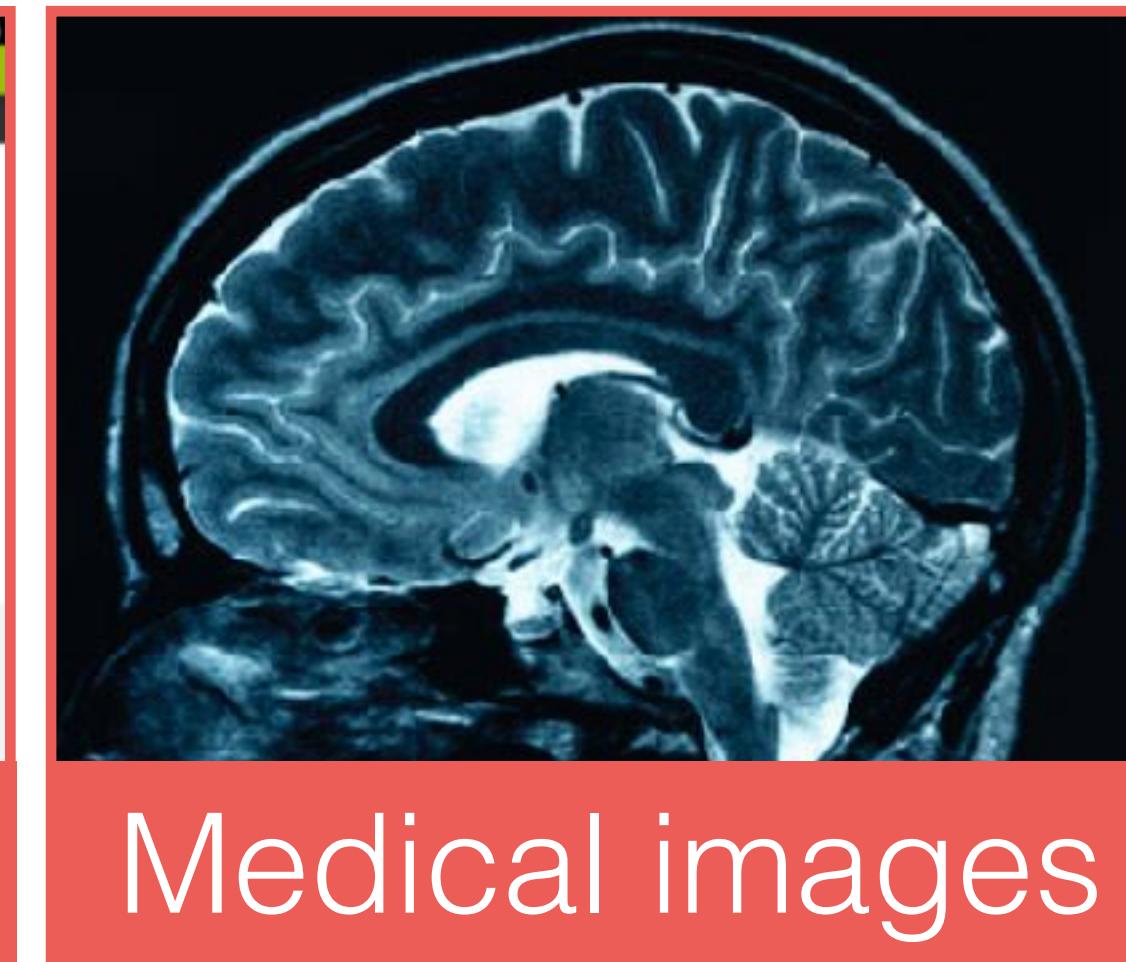
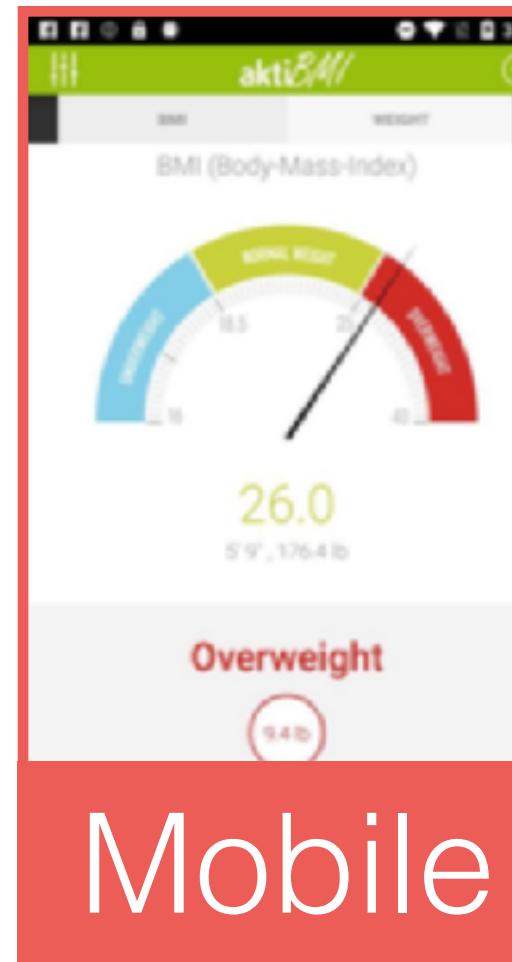
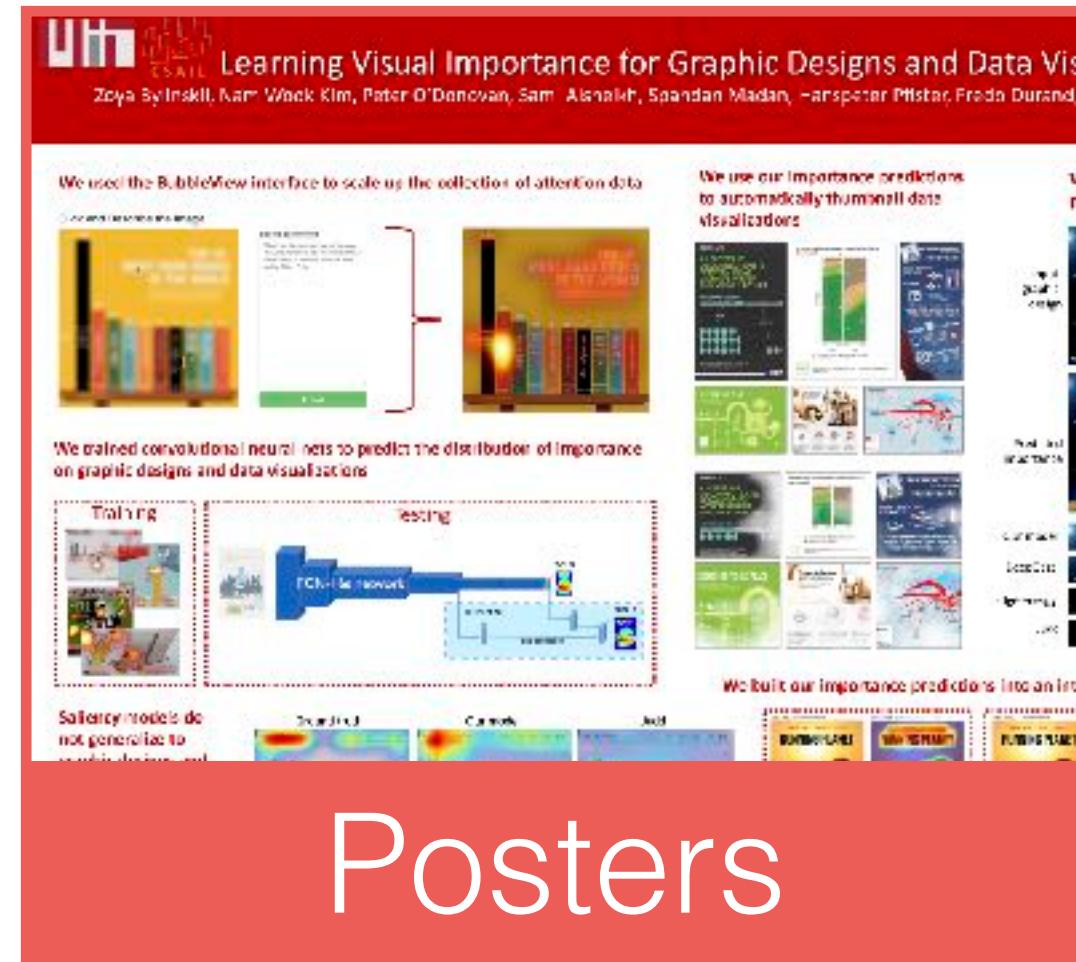
Webpage



Graphic design

Tasks

Free-viewing
Description



Visual search
Q & A
Analysis tasks

Posters

Mobile

Medical images

Satelite images

0 clicks 0 characters

Describe the image in as much detail as possible...

<http://bubbleview.namwkim.org>



Paper



Code



Demo

>> 2x

NEXT

