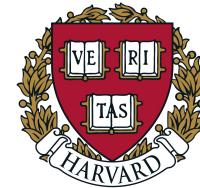




TurkEyes: A Web-Based Toolbox for Crowdsourcing Attention Data

Anelise Newman, Barry McNamara, Camilo Fosco, Yun Bin Zhang,
Pat Sukhum, Matthew Tancik, Nam Wook Kim, Zoya Bylinskii

TurkEyes.mit.edu



Applications of Attention

Applications of Attention



Automatic cropping

Applications of Attention



Automatic cropping

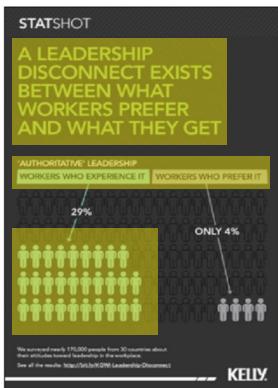


Graphic design retargeting

Applications of Attention

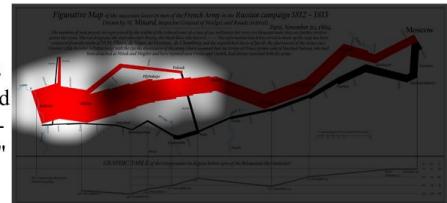


Automatic cropping

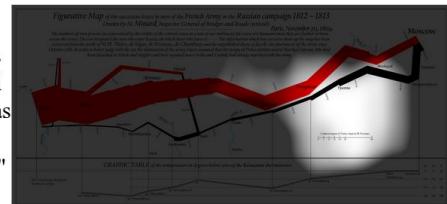


Graphic design retargeting

Viewers
who rated
as "well-
designed"



Viewers
who did
not rate as
"well-
designed"



Visualization debugging

Applications of Attention



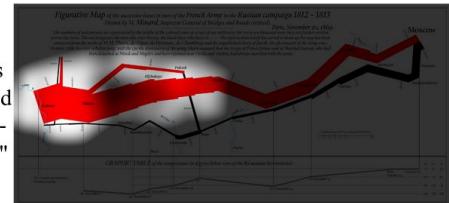
Automatic cropping



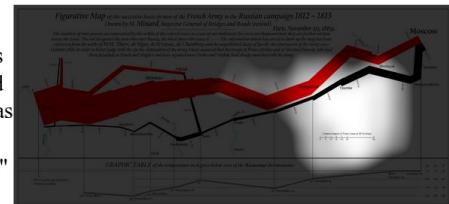
Graphic design retargeting



Viewers who rated as "well-designed"



Viewers who did not rate as "well-designed"



Visualization debugging

0.5s



3s



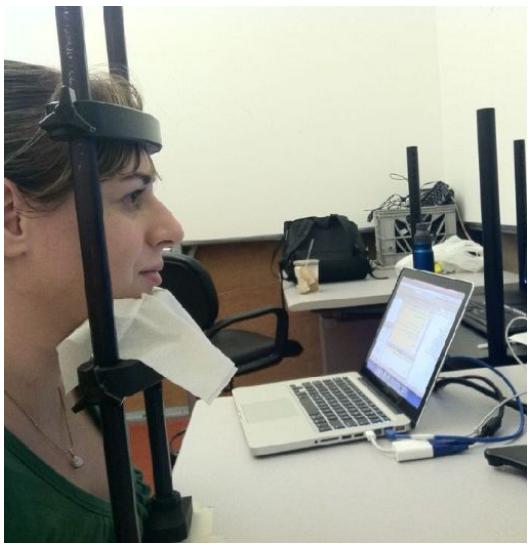
5s



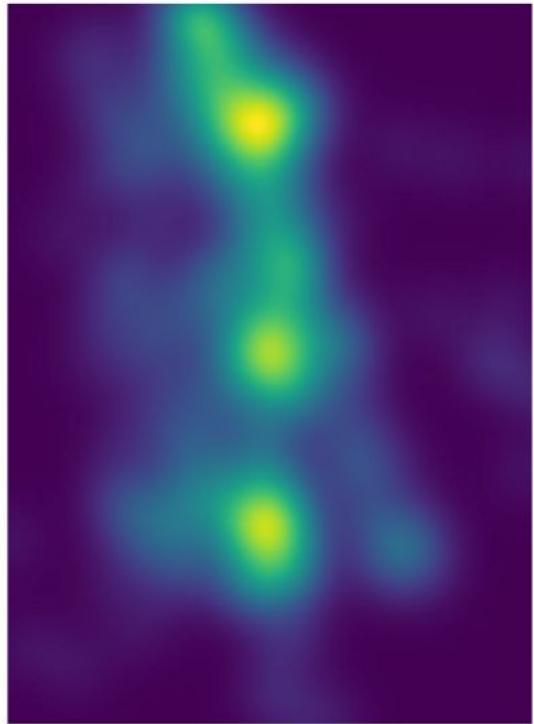
Gradual rendering

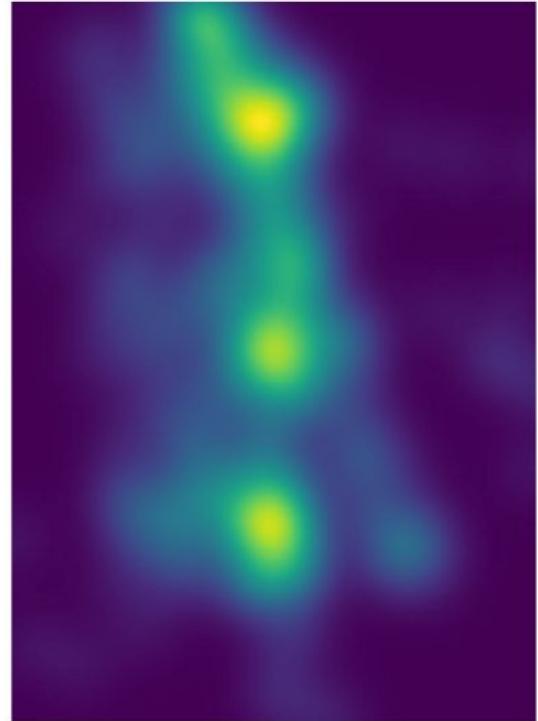
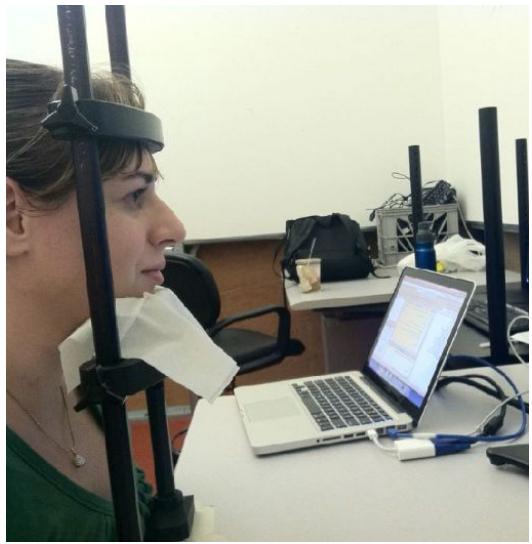






Attention heatmap





Eye tracking does not scale!



The TurkEyes Toolbox

ZoomMaps



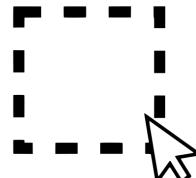
(Zoom-based)

CodeCharts

F37

(Self-report)

ImportAnnots



(Annotation)

BubbleView



(Cursor-based)



The TurkEyes Toolbox

ZoomMaps



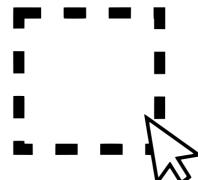
(Zoom-based)

CodeCharts

F37

(Self-report)

ImportAnnots



(Annotation)

BubbleView



(Cursor-based)



The TurkEyes Toolbox

ZoomMaps



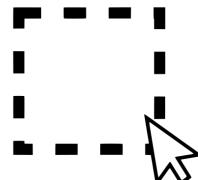
(Zoom-based)

CodeCharts

F37

(Self-report)

ImportAnnots



(Annotation)

BubbleView



(Cursor-based)



The TurkEyes Toolbox

ZoomMaps



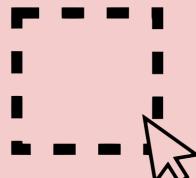
(Zoom-based)

CodeCharts

F37

(Self-report)

ImportAnnots



(Annotation)

BubbleView



(Cursor-based)



The TurkEyes Toolbox

ZoomMaps



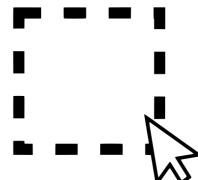
(Zoom-based)

CodeCharts

F37

(Self-report)

ImportAnnots



(Annotation)

BubbleView



(Cursor-based)



The TurkEyes Toolbox

ZoomMaps



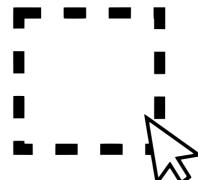
(Zoom-based)

CodeCharts

F37

(Self-report)

ImportAnnots



(Annotation)

BubbleView



(Cursor-based)



ZoomMaps (*zoom-based*)

Related Work



F37





ZoomMaps (zoom-based)

Related Work



Lagun et al., SIGIR '14
Li et al., 2017



F37





ZoomMaps (*zoom-based*)

Related Work

A screenshot of the Louvre Museum's official website. The top navigation bar includes links for Web, Images, Videos, News, and More. Below the navigation is a banner for 'Louvre Museum Official Website' with a link to 'www.louvre.fr/en'. A message from the Louvre thanking donors is displayed, followed by a link to 'Latest news from the Louvre on Twitter'. Below this is a section for 'Hours & Admission - Advance Tickets'. The main content area features a large image of a woman in a classical painting, with a heatmap overlay showing areas of high engagement. A 'More images' button is visible on the right.

Lagun et al., SIGIR '14
Li et al., 2017

Huang and Diriye, HCIR '12

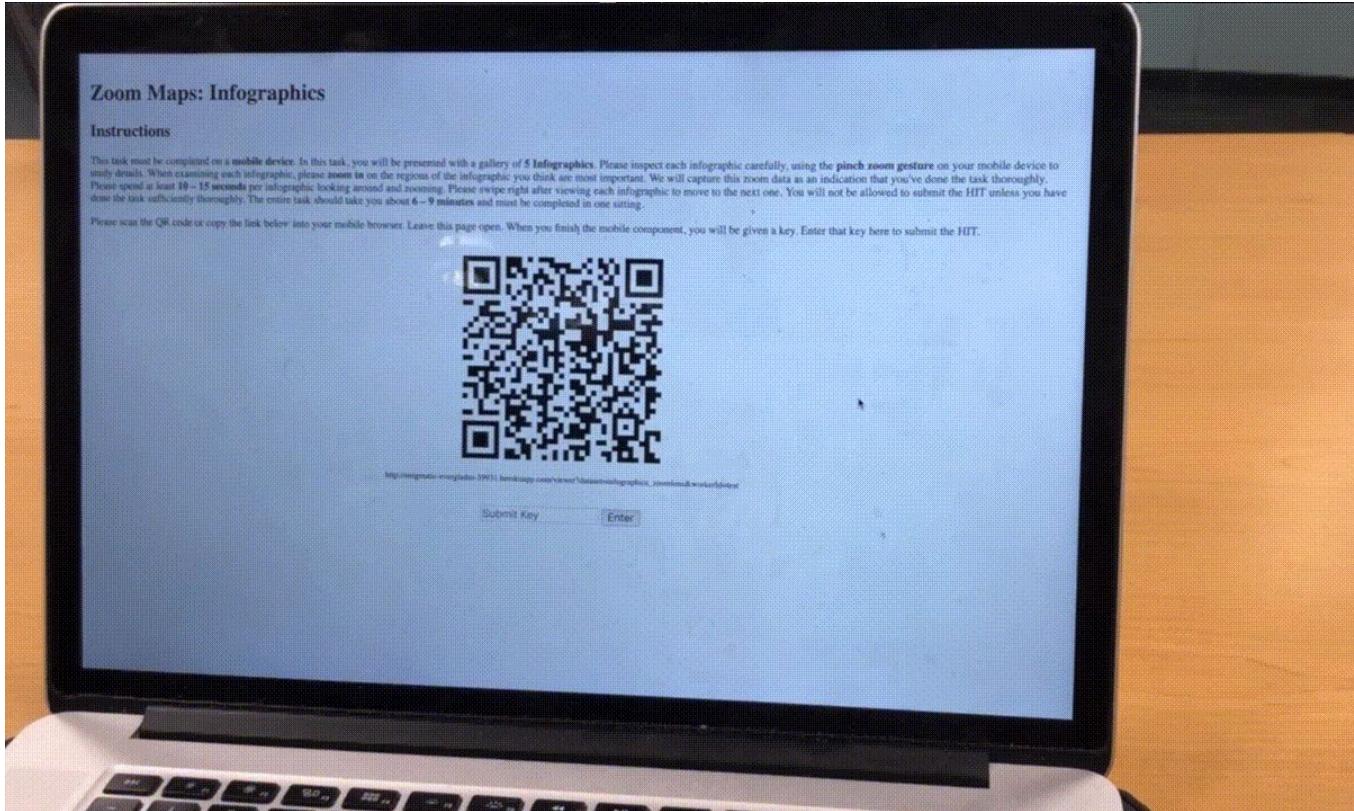


F3





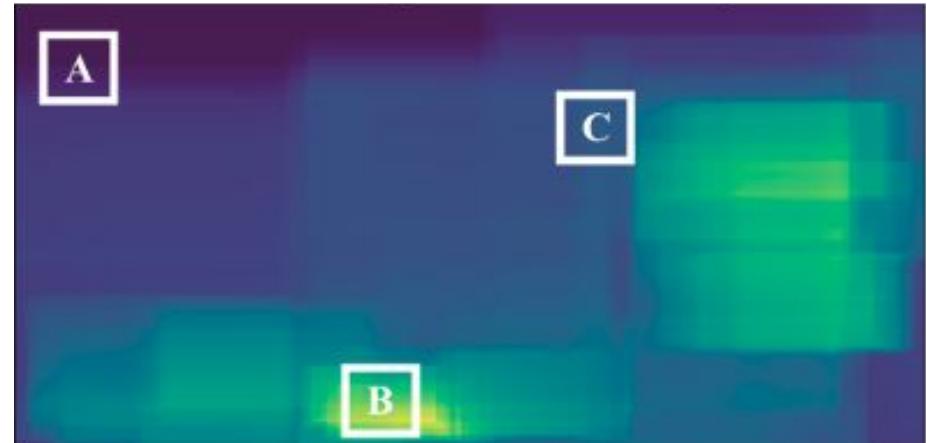
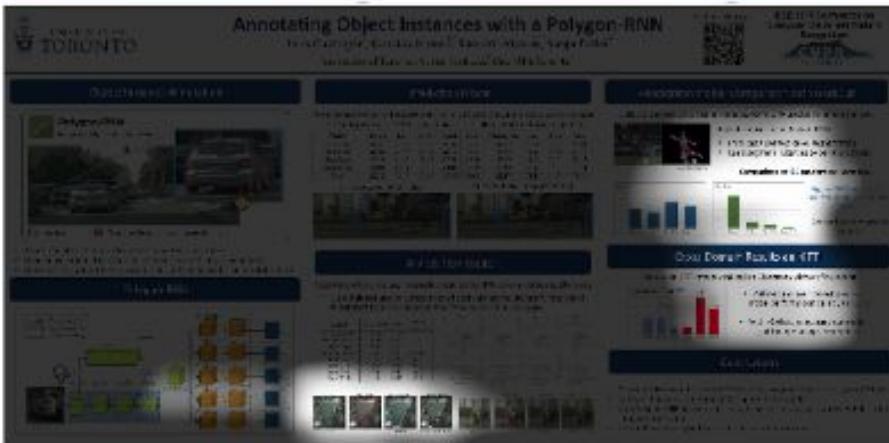
ZoomMaps (zoom-based)





ZoomMaps (*zoom-based*)

Making a heatmap



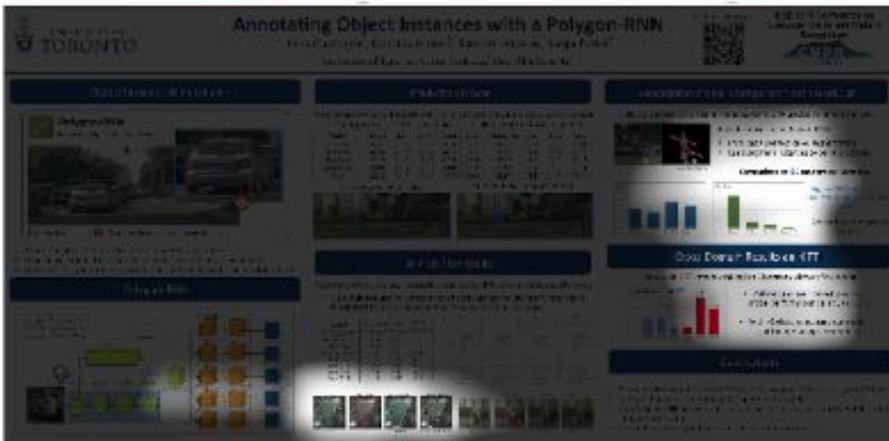


ZoomMaps (zoom-based)

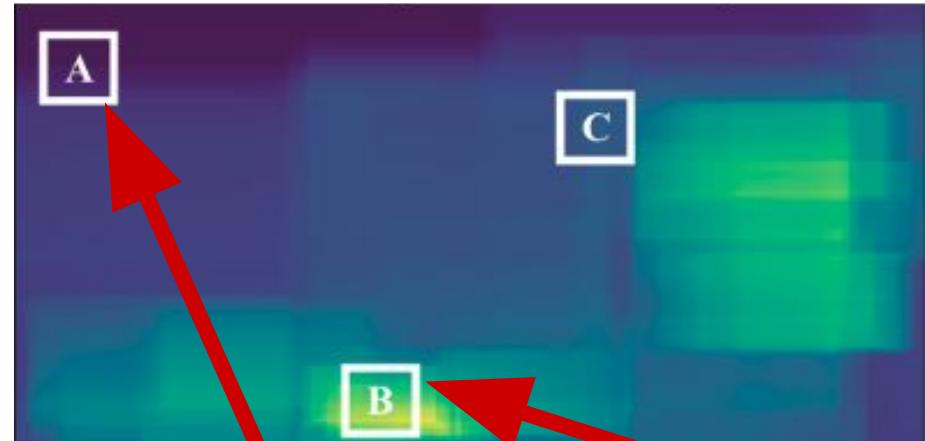
Making a heatmap



F37



$$\text{Zoom Level} = \frac{\text{full image area}}{\text{zoomed area}}$$



Zoom Level A

Zoom Level B



ZoomMaps (*zoom-based*)

Making a heatmap

Original



Individual Maps



F37



Zoom



F37

CodeCharts (*self-report*)

Related Work



F37



F37

CodeCharts (*self-report*)

Related Work



67	C36	R95	H56	U37	A94	G79	C42
61	H05	D28	N91	D93	Z07	A99	V11
74	H99	A60	L72	Z84	D09	X74	F23
62	W40	C97	N65	G30	K74	D41	F56
96	Z81	K51	B11	X07	E98	D88	K2
J23	F57	G87	G26	Y92	J86	X88	R65
59	T71	M55	J26	T84	V48	P05	R96
36	E00	C27	B16	B47	T47	D34	E19

Rudoy et al., '12



F37



F37

CodeCharts (*self-report*)

Related Work



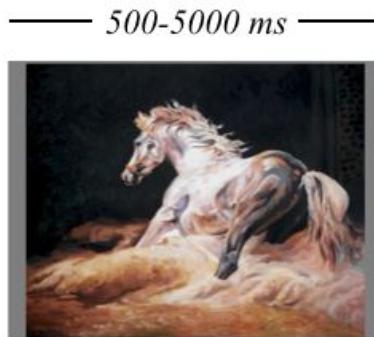
67	C36	R95	H56	U37	A94	G79	C42
61	H05	D28	N91	D93	Z07	A99	V11
74	H99	A60	L72	Z84	D09	X74	F23
62	W40	C97	N65	G30	K74	D41	F56
96	Z81	K51	B11	X07	E98	D88	K2
J23	F57	G87	G26	Y92	J86	X88	R65
59	T71	M55	J26	T84	V48	P05	R96
36	E00	C27	B16	B47	T47	D34	E19



F37



Rudoy et al., '12



a) image for viewing

E96	T26	W17	N95	B91	P21	I27	S91
G45	D79	U29	G40	I49	B97	I27	H98
T96	A28	H63	W63	J54	Z96	A48	Q75
V21	H79	H65	J29	E89	P79	J83	P94
A17	Y72	R14	P64	P24	V52	S41	T81
A82	C79	A67	C61	H74	T42	Q93	U54
T63	H42	R18	T94	W15	F25	S19	T58
X85	Y84	B41	L38	D69	C53	C16	T81
Z89	B24	W39	Z16	S84	Z29	P17	L47
D56	J69	C89	S82	G42	S61	F93	N18

b) codechart

Please enter the character code
you remember looking at last:

H35|

+



c) code entry

d) fixation cross

F37

CodeCharts (*self-report*)

Related Work



67	C36	R95	H56	U37	A94	G79	C42
61	H05	D28	N91	D93	Z07	A99	V11
74	H99	A60	L72	Z84	D09	X74	F23
62	W40	C97	N65	G30	K74	D41	F56
96	Z81	K51	B11	X07	E98	D88	K2
J23	F57	G87	G26	Y92	J86	X88	R65
59	T71	M55	J26	T84	V48	P05	R96
36	E00	C27	B16	B47	T47	D34	E19



F37



Rudoy et al., '12

500-5000 ms



a) image for viewing

400 ms

E96	T26	W17	N95	B91	P01	I27	P31	S91
O45	D79	U29	G40	I49	B97	I27	H98	Y93
T96	A28	H03	W63	J54	Z96	A48	Q75	U63
V21	H79	H06	J29	E93	P79	J83	P94	H94
A17	Y72	R14	P64	P74	V52	S41	Y73	S81
A82	C79	A67	C61	H74	T42	Q93	U54	N10
T63	H42	R18	T94	W15	F25	S19	T58	H80
X85	Y84	B41	L38	D69	C53	C16	T81	C83
Z89	B24	W38	Z16	S84	Z29	P17	L47	K93
D56	J69	C39	S82	G42	S61	F93	N18	J25

b) codechart

until response

Please enter the character code
you remember looking at last:

H35|

750 ms



c) code entry



d) fixation cross

F37

CodeCharts (*self-report*)

Related Work



67	C36	R95	H56	U37	A94	G79	C42
61	H05	D28	N91	D93	Z07	A99	V11
74	H99	A60	L72	Z84	D09	X74	F23
62	W40	C97	N65	G30	K74	D41	F56
96	Z81	K51	B11	X07	E98	D88	K2
J23	F57	G87	G26	Y92	J86	X88	R65
59	T71	M55	J26	T84	V48	P05	R96
36	E00	C27	B16	B47	T47	D34	E19



F37



Rudoy et al., '12

— 500-5000 ms —



— 400 ms —

E96	T26	W17	N95	B91	P01	N27	P31	S91
G45	D79	U29	G40	I49	B97	I27	H98	Y93
T96	A28	H63	W63	J54	Z96	A48	Q75	U63
V21	H79	H65	J29	E93	P79	J83	P94	H94
A17	Y72	R14	P64	P24	V52	S41	T73	S81
A82	C79	A67	C61	H74	T42	Q93	U54	N10
T63	H42	R18	T94	W15	F25	S19	T58	H80
X85	Y84	B41	L38	D69	C53	C16	T81	C83
Z89	B24	W39	Z16	S84	Z29	P17	L47	K93
D56	J69	C39	S82	G42	S61	F93	N18	J25

— until response —

Please enter the character code
you remember looking at last:

H35|

a) image for viewing

b) codechart

c) code entry

d) fixation cross

+

F37

CodeCharts (*self-report*)

Related Work



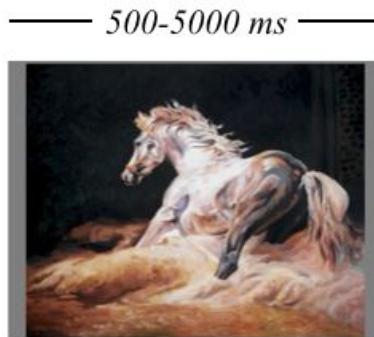
67	C36	R95	H56	U37	A94	G79	C42
61	H05	D28	N91	D93	Z07	A99	V11
74	H99	A60	L72	Z84	D09	X74	F23
62	W40	C97	N65	G30	K74	D41	F56
96	Z81	K51	B11	X07	E98	D88	K2
J23	F57	G87	G26	Y92	J86	X88	R65
59	T71	M55	J26	T84	V48	P05	R96
36	E00	C27	B16	B47	T47	D34	E19



F37



Rudoy et al., '12



a) image for viewing

E96	T26	W17	N95	B91	R21	I27	P31	S91
O45	D79	U29	G40	I49	B97	I27	H98	Y93
T96	A28	H63	W63	J54	Z96	A48	Q75	U63
V21	H79	H65	J29	E93	P79	J83	P94	H94
A17	Y72	R14	P64	P74	V52	S41	Y73	S81
A82	C79	A67	C61	H74	T42	Q93	U56	N10
T63	H42	R18	T94	W15	F25	S19	T58	H80
X85	Y84	B41	L38	D69	C53	C16	T81	C85
Z89	B24	W39	Z16	S84	Z29	P17	L47	K93
D56	J69	C89	S82	G42	S61	F93	N18	J25

b) codechart

Please enter the character code you remember looking at last:

c) code entry



d) fixation cross

F37

CodeCharts (*self-report*)

Image Attention



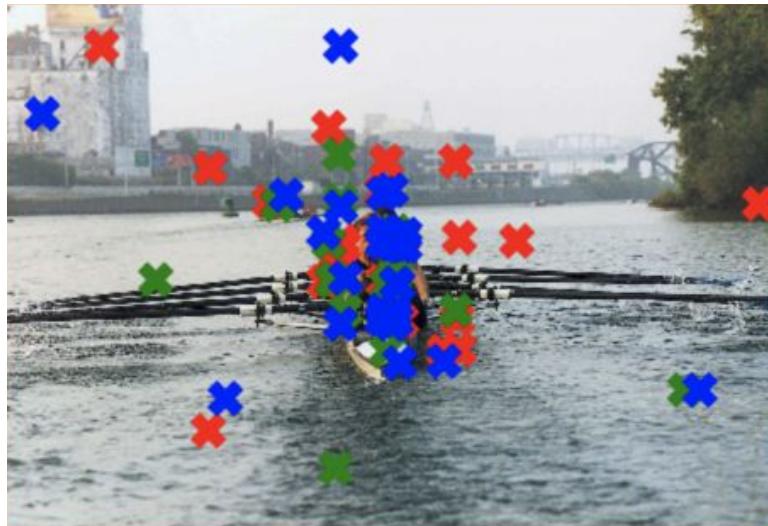
F37

CodeCharts (*self-report*)

Making a heatmap



F37



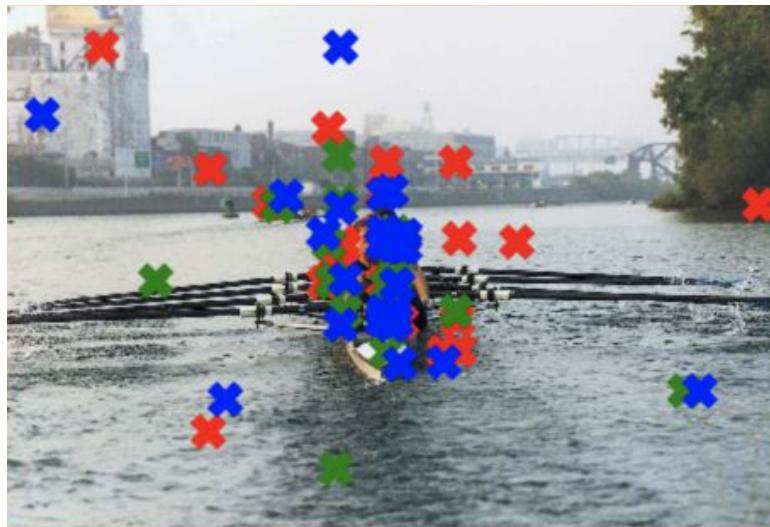
F37

CodeCharts (*self-report*)

Making a heatmap



F37





ImportAnnots (*annotation*)

Related Work



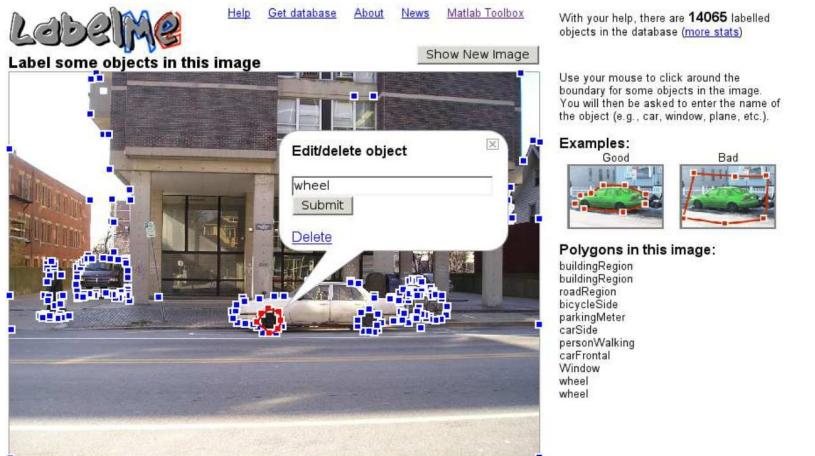
F37





ImportAnnots (*annotation*)

Related Work

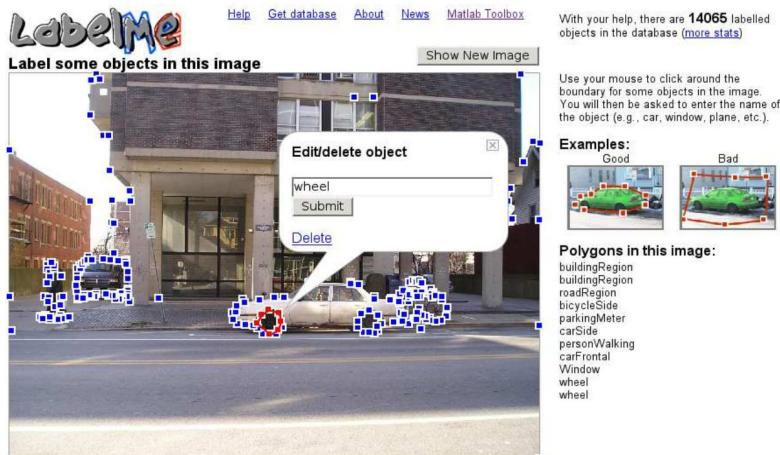


LabelMe: Russell et al., IJCV '08

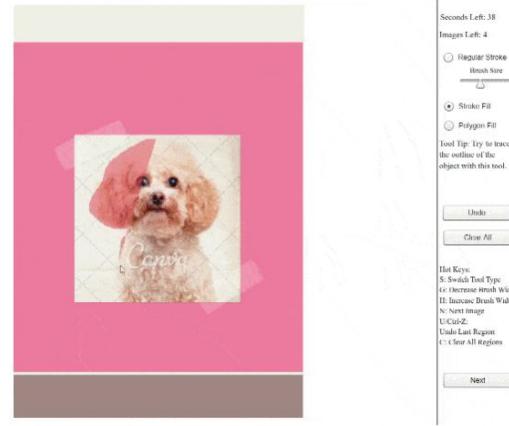


ImportAnnots (*annotation*)

Related Work



LabelMe: Russell et al., IJCV '08



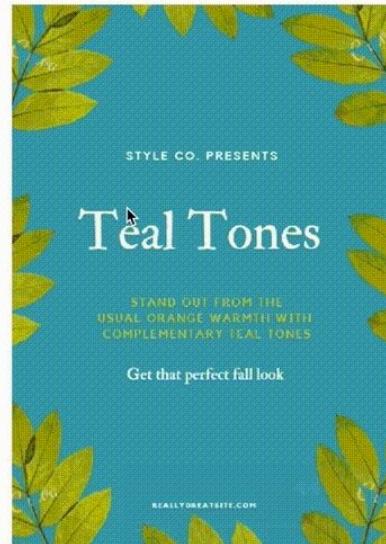
ImportAnnots: O'Donovan et al., TVCG '14



ImportAnnots (*annotation*)

Annotate the most important regions on graphic designs

Press 'Start' when you are ready to begin.



Second Left: 110
Images Left: 13
 Regular Stroke
Brush Size
 Stroke Fill
 Polygon Fill

Tool Tip: Try to trace the outline of the object with this tool.

Undo
Clear All

Hot Keys:
S: Switch Tool Type
G: Decrease Brush Width
H: Increase Brush Width
N: Next Image
U/Cut-Z:
Undo Last Region
C: Clear All Regions

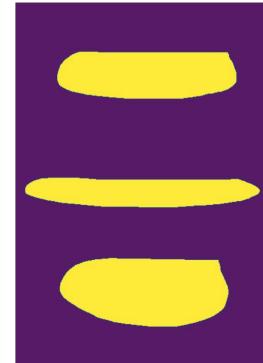
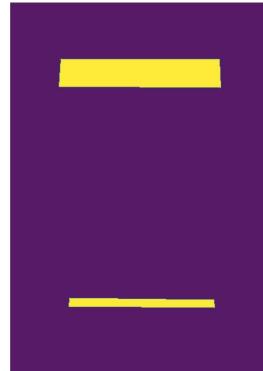
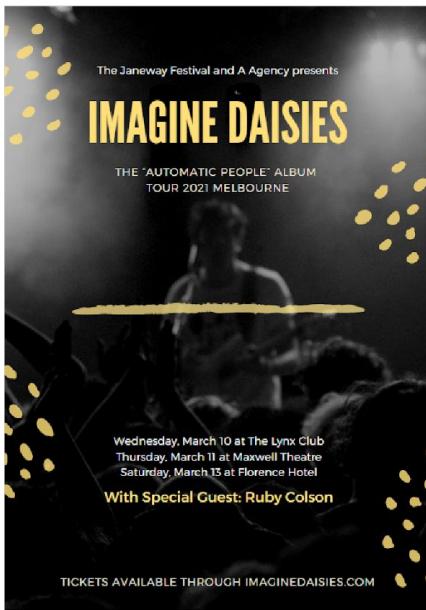
Next

Show instructions



ImportAnnots (*annotation*)

Making a heatmap



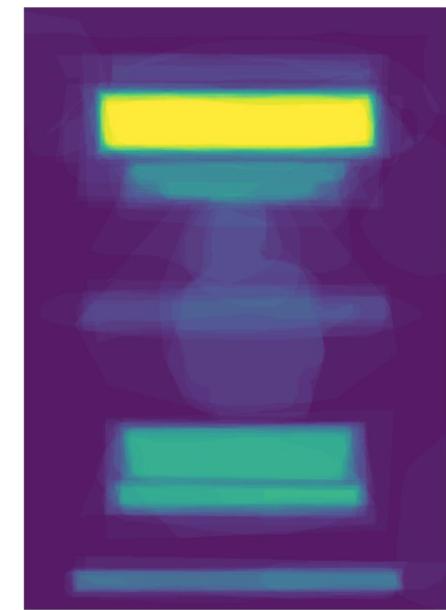
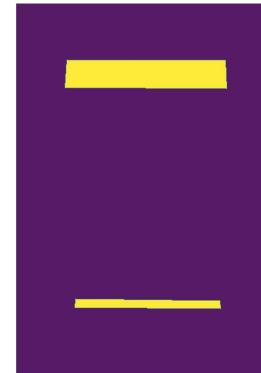
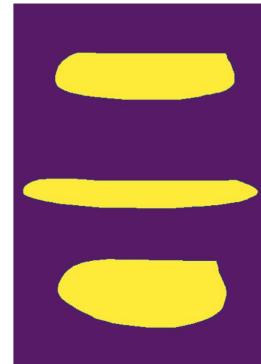
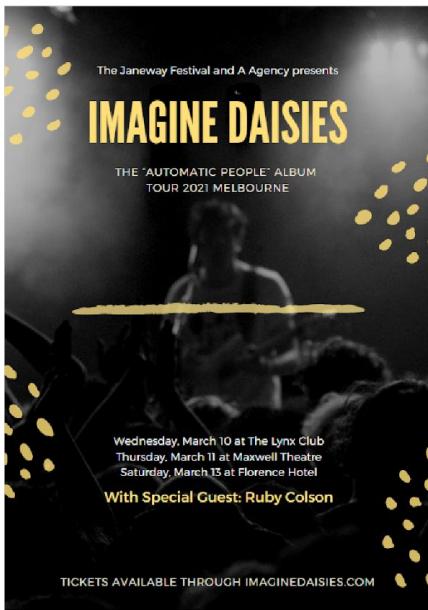
F37





ImportAnnots (*annotation*)

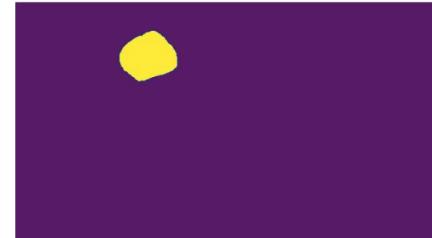
Making a heatmap



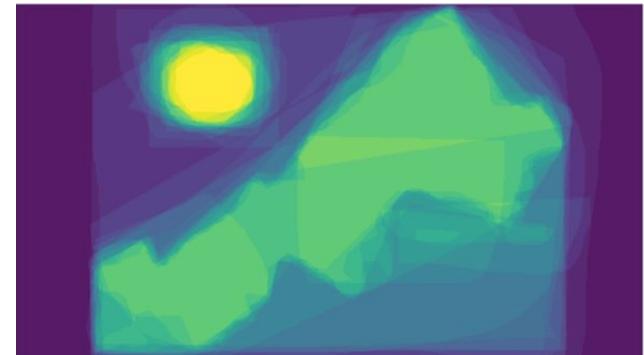


ImportAnnots (*annotation*)

Making a heatmap



F37





BubbleView (*cursor-based*)

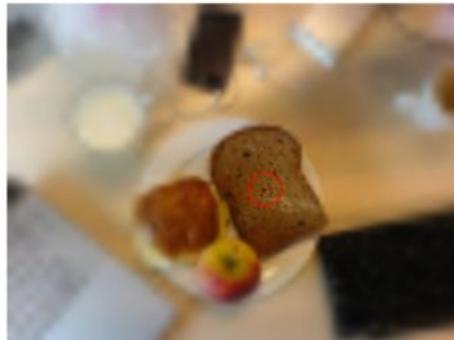
Related Work





BubbleView (*cursor-based*)

Related Work



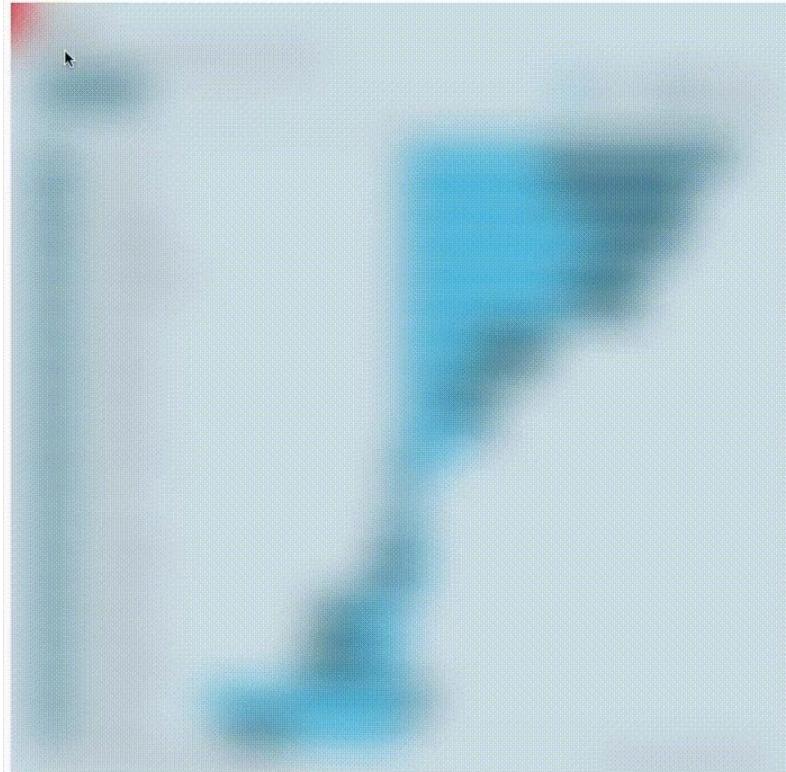
SALICON: Jiang et al., CVPR '15



BubbleView: Kim et al., TOCHI '17



BubbleView (*cursor-based*)



0 clicks 0 characters

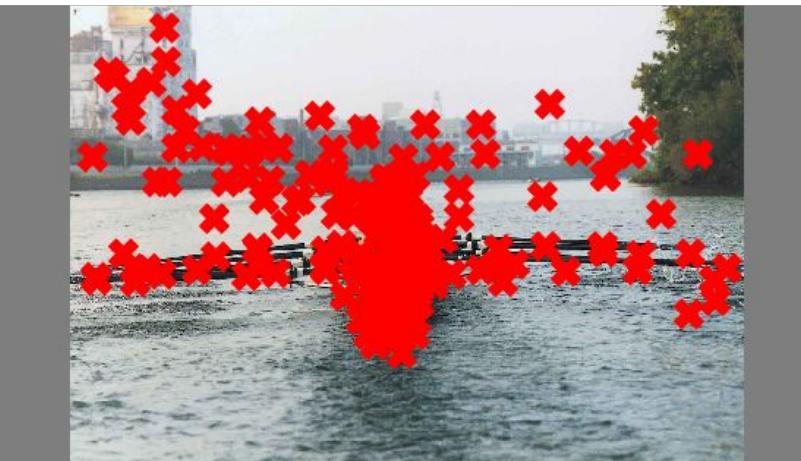
Describe the image in as much detail as possible...

NEXT



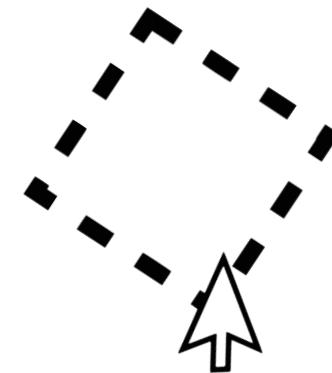
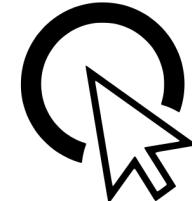
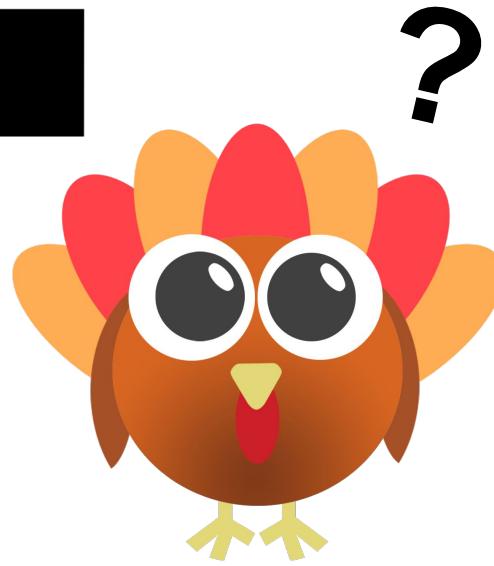
BubbleView (*cursor-based*)

Making a heatmap



Which tool should I use?

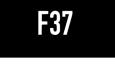
F37



Type of Stimuli

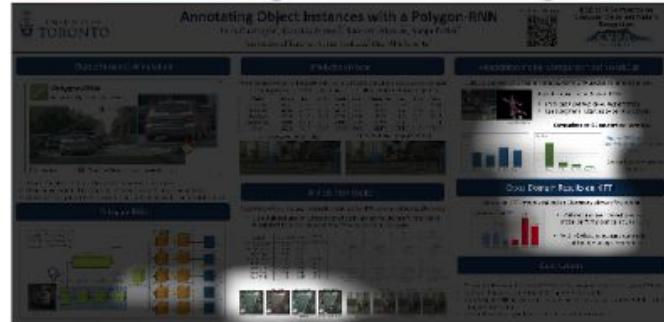
	 Zoom Maps	F37	 Import Annots	 Bubble View
Big / multiscale images	✓	✗	—	—
Natural images	✓	✓	—	✓
Non-natural images	✓	✓	✓	✓
Dynamic content	✗	✓	✗	✗

Type of Stimuli

	 Zoom Maps	 F37	 Import Annots	 Bubble View
Big / multiscale images	✓	✗	—	—
Natural images	✓	✓	—	✓
Non-natural images	✓	✓	✓	✓
Dynamic content	✗	✓	✗	✗

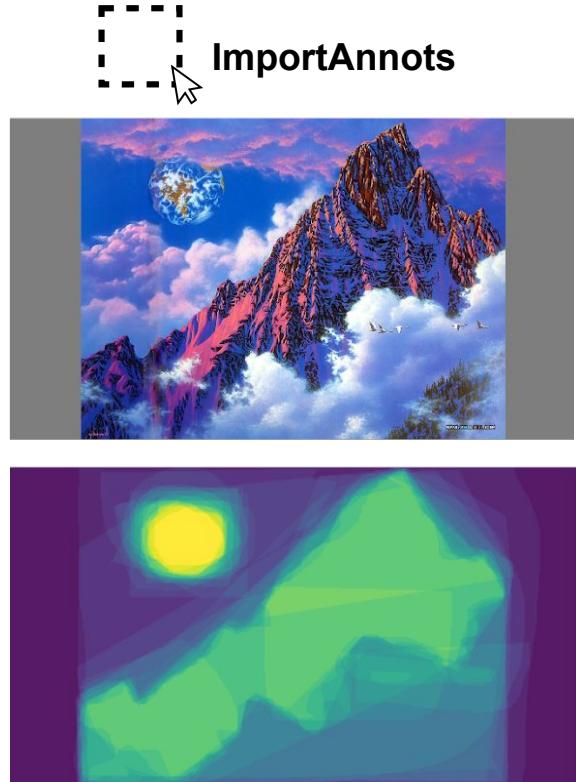


ZoomMaps



Type of Stimuli

	 Zoom Maps	F37	 Import Annots	 Bubble View
Big / multiscale images	✓	✗	—	—
Natural images	✓	✓	—	✓
Non-natural images	✓	✓	✓	✓
Dynamic content	✗	✓	✗	✗



Type of Stimuli

	 Zoom Maps	F37	 Import Annots	 Bubble View
Big / multiscale images	✓	✗		
Natural images	✓	✓		✓
Non-natural images	✓	✓	✓	✓
Dynamic content	✗	✓	✗	✗



ImportAnnots



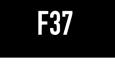
ZoomMaps

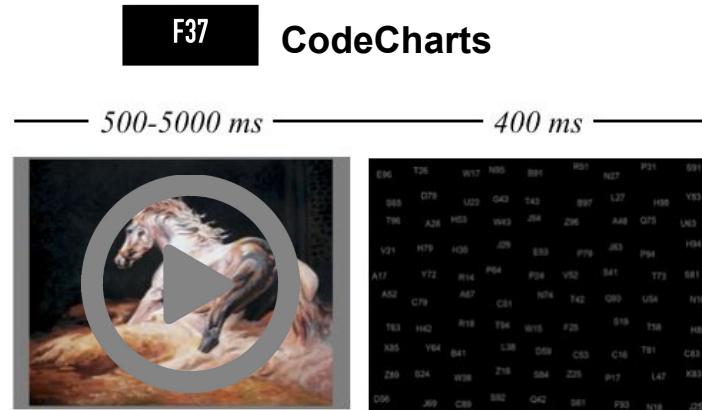


F37 CodeCharts



Type of Stimuli

	 Zoom Maps	 F37	 Import Annots	 Bubble View
Big / multiscale images	✓	✗	—	—
Natural images	✓	✓	—	✓
Non-natural images	✓	✓	✓	✓
Dynamic content	✗	✓	✗	✗



Cost

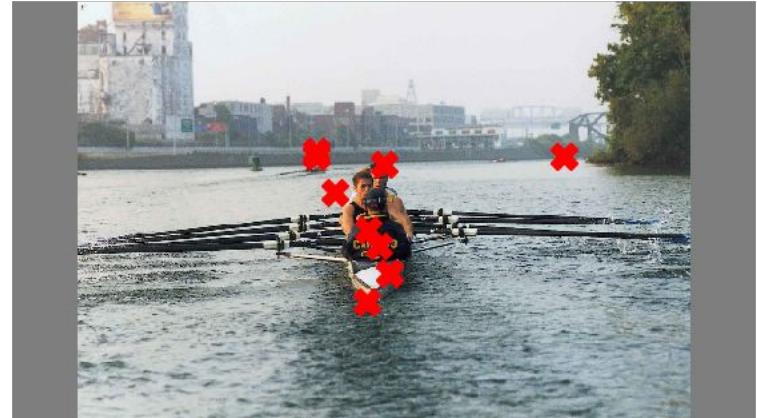
- How much data per participant?
- How much work is it?

Cost

- How much data per participant?
- How much work is it?



BubbleView



Cost

- How much data per participant?
- How much work is it?



BubbleView



15+ clicks/participant

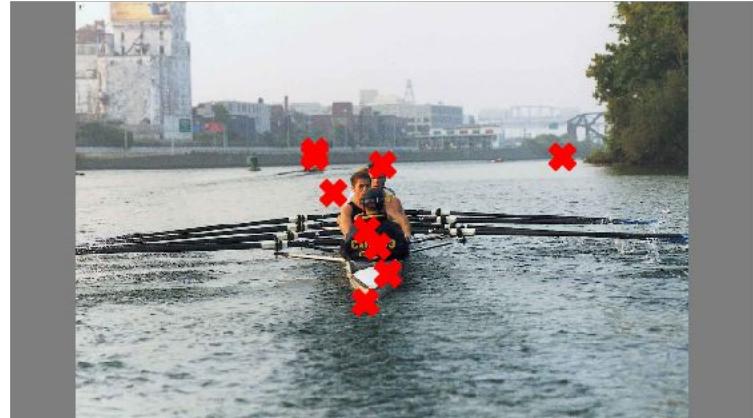


Cost

- How much data per participant?
- How much work is it?



BubbleView



15+ clicks/participant
15 participants/image

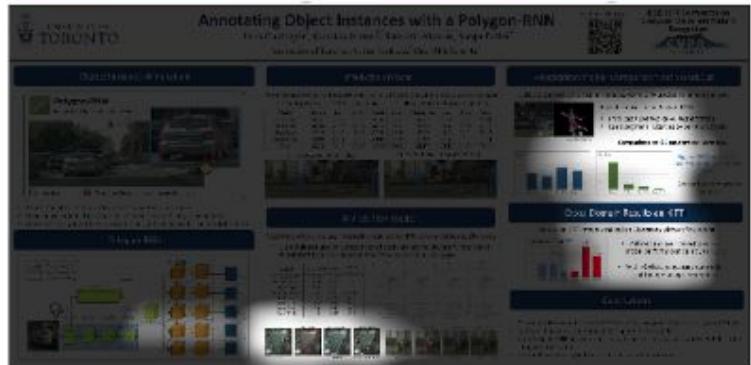


Cost

- How much data per participant?
- How much work is it?



ZoomMaps



20 participants/image

Cost

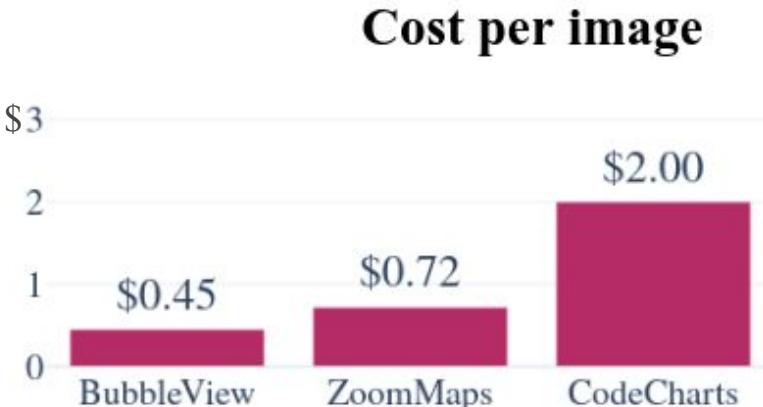
- How much data per participant?
- How much work is it?

Cost per image

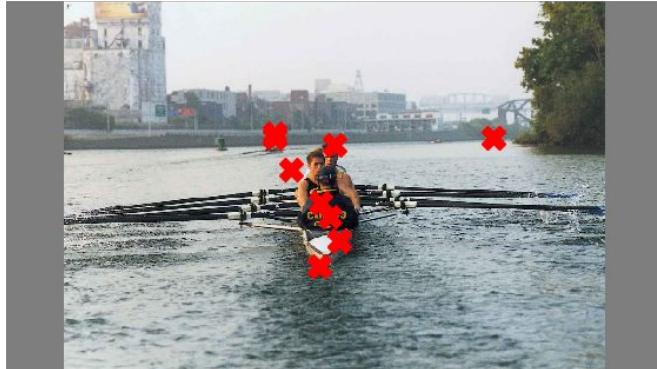


Cost

- How much data per participant?
- How much work is it?



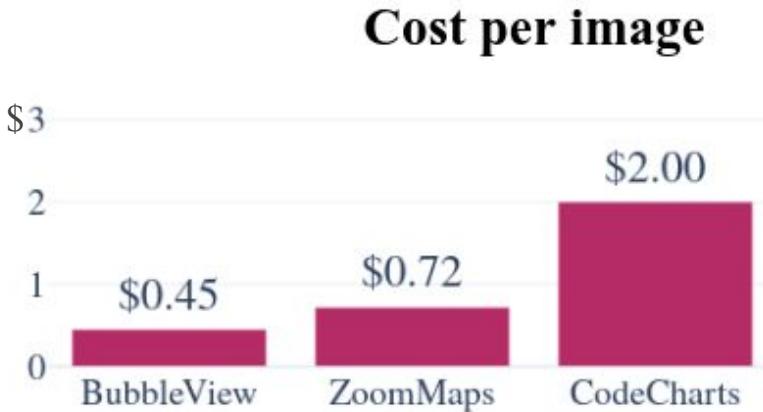
BubbleView



F37

Cost

- How much data per participant?
- How much work is it?



F37



BubbleView



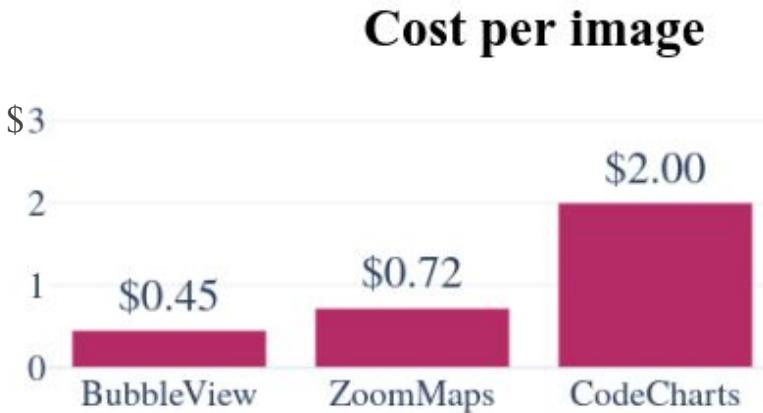
F37

CodeCharts



Cost

- How much data per participant?
- How much work is it?



F37



BubbleView



15 participants/image

F37

CodeCharts

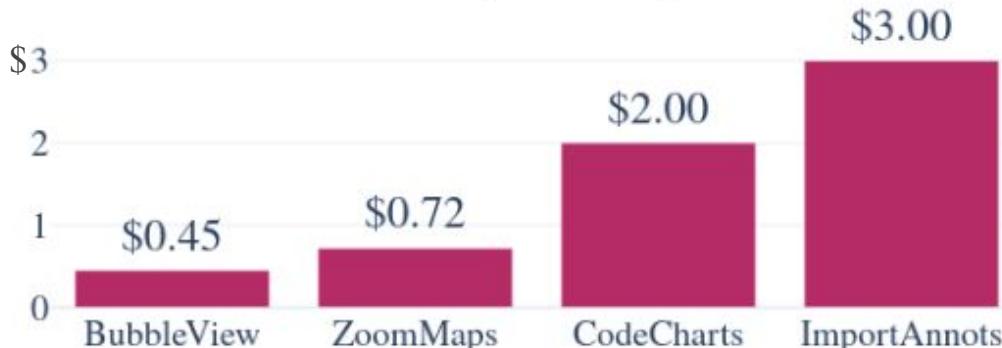


50 participants/image

Cost

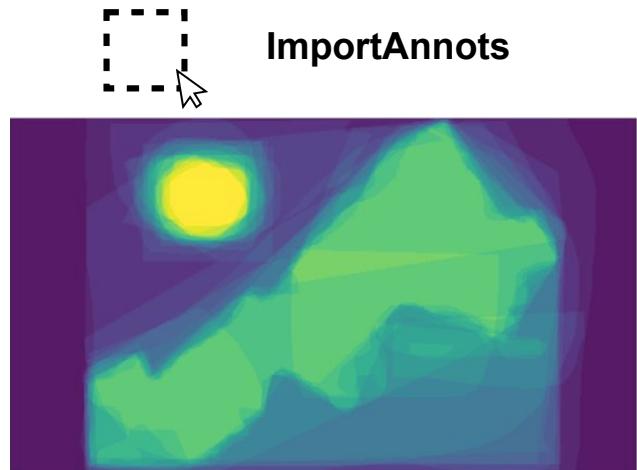
- How much data per participant?
- How much work is it?

Cost per image



Cost

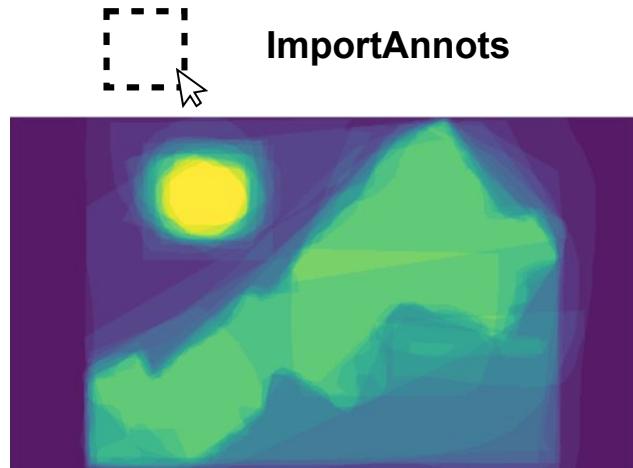
- How much data per participant?
- How much work is it?



30 participants/image

Cost

- How much data per participant?
- How much work is it?

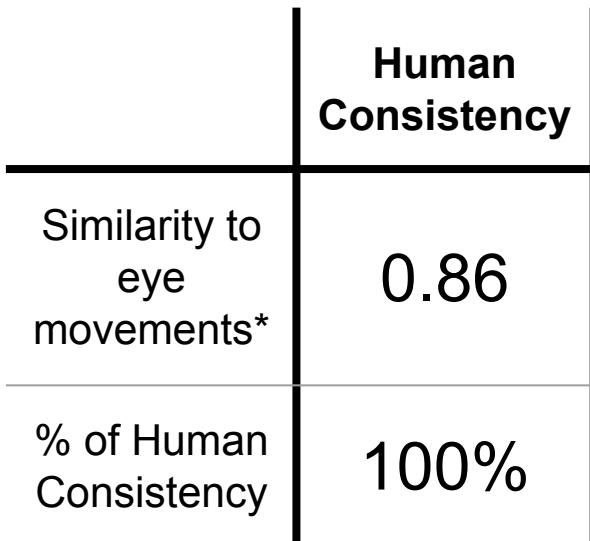


30 participants/image



Similarity to Eye Movements

Similarity to Eye Movements



*Similarity measured using Pearson's Correlation Coefficient comparing ground-truth to generated heatmaps

Similarity to Eye Movements

	Human Consistency	CodeCharts
Similarity to eye movements*	0.86	0.76
% of Human Consistency	100%	88%

F37

*Similarity measured using Pearson's Correlation Coefficient comparing ground-truth to generated heatmaps

Similarity to Eye Movements

	Human Consistency	F37	BubbleView	ZoomMaps	ImportAnnots
Similarity to eye movements*	0.86	0.76	0.62	0.59	0.51
% of Human Consistency	100%	88%	72%	69%	59%

*Similarity measured using Pearson's Correlation Coefficient comparing ground-truth to generated heatmaps

Similarity to Eye Movements

 Eye movements



 F37 CodeCharts



 BubbleView



 ZoomMaps



 ImportAnnots



Similarity to eye movements

Similarity to Eye Movements

 Eye movements



 F9 CodeCharts



 BubbleView



 ZoomMaps



 ImportAnnots



Similarity to eye movements

Similarity to Eye Movements

 Eye movements



 F37 CodeCharts



 BubbleView



 ZoomMaps



 ImportAnnots



Similarity to eye movements

Similarity to Eye Movements

 Eye movements



 CodeCharts



 BubbleView



 ZoomMaps



 ImportAnnots



Similarity to eye movements

Similarity to Eye Movements

 Eye movements



 F37 CodeCharts



 BubbleView



 ZoomMaps



 ImportAnnots



Similarity to eye movements

Saliency vs. Intentionality



Saliency vs. Intentionality

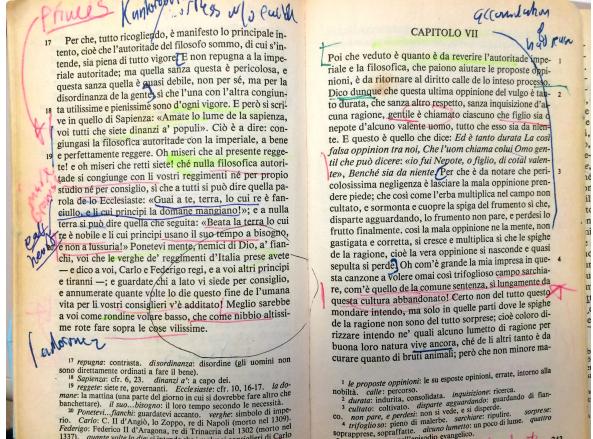


Saliency

Intentionality

Importance

Saliency vs. Intentionality



Per che tutto riconosce, e manifesto lo principale intendere, cioè che l'autorità del filosofo somma, di cui s'intende, sia piena di tutto vigore¹⁷ E non repugna a la imperiale autorità; ma quella senza questa è pericolosa, e questa senza quella è quasi debole, mentre s'è, ma per la discordianza de la gente¹⁸ che non con la ragione si utilissimo, e perciò d'ogni vigore. E però si scrive in quello de Sapienza: «Amate lo lume de la sapienza, voi tutti che siete dinanzi¹⁹ ai popoli». Ciò è dire: congiungete la filosofia autoritade con la imperiale, a bene e perfettamente regger. Oh miseri che al presente reggendo si congiunge con li vostri reggimenti per proprio scame per consiglio, e non si può dire di cosa. La parola de li vostri reggimenti: «Quai a te, terra, tu cui è famiglio». A li cui principi la domande mancano²⁰; è a nulla terra si può dire quella che seguita: «Beata la terra lo cui se è nobile e li cui principi usano il suo tempo a bisogno, e non a lussureggiare, non a feste, nemmeno Dio, ma che non le regole dei reggimenti. Italia, tu cose avete» — diceva a sei, Carlo o Federigo regi, e a voi altri principi tiranni —, e guardate chi a lato vi si stede per consiglio, e numerante quante volte lo dite questo fine de l'umana vita per li vostri consiglieri v'è additato! Meglio sarebbe a voi come rondine volare basso, che come nibbio altissime rote far sopra le cose vilissime.

Salomon

ed ecco

principio

<

Saliency vs. Intentionality

Eye
tracking



Intentionality

Saliency

Importance

Saliency vs. Intentionality

Eye
tracking

Code
Charts



F37

Saliency

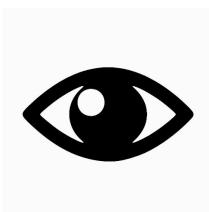
Intentionality

Importance



Saliency vs. Intentionality

Eye
tracking



Code
Charts



Bubble
View



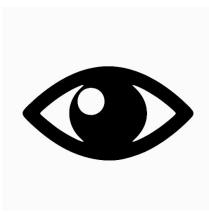
Saliency

Importance

Intentionality

Saliency vs. Intentionality

Eye
tracking



Code
Charts



Bubble
View



Zoom
Maps



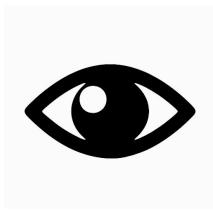
Saliency

Intentionality

Importance

Saliency vs. Intentionality

Eye
tracking



Code
Charts



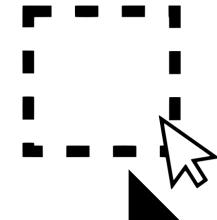
Bubble
View



Zoom
Maps



Import
Annots



Saliency

Intentionality

Importance

Saliency vs. Intentionality

 Eye movements

 F37 CodeCharts

 ImportAnnots

Different



Similar





Which tool should I use?



Which tool should I use?



ZoomMaps

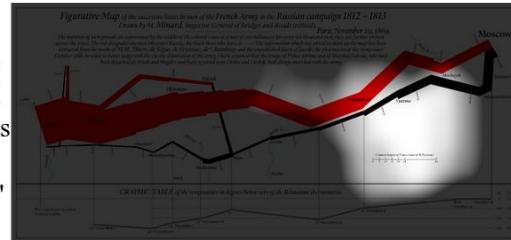
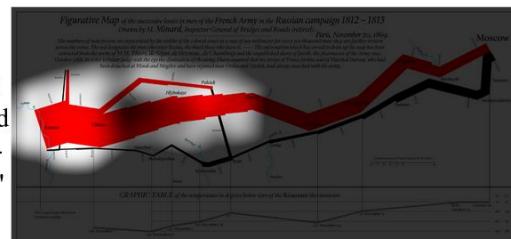


Which tool should I use?

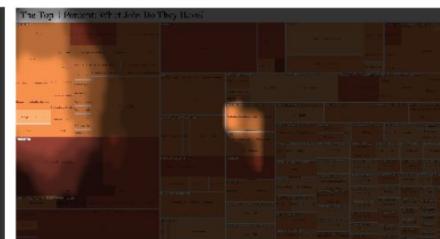


ZoomMaps

Viewers
who rated
as "well-
designed"



Viewers
who did
not rate as
"well-
designed"



Visualization debugging



Which tool should I use?

F37

CodeCharts



Which tool should I use?



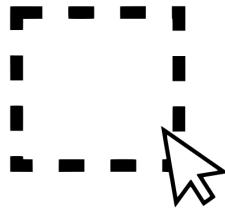
F37

CodeCharts

Gradual rendering



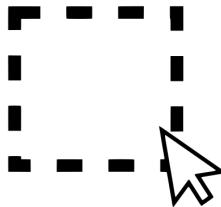
Which tool should I use?



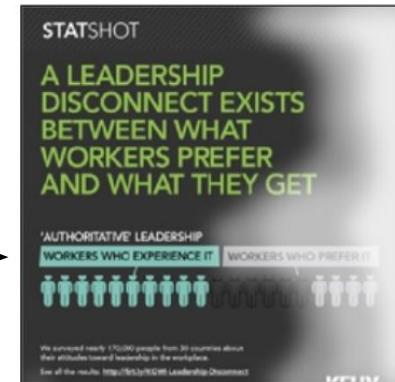
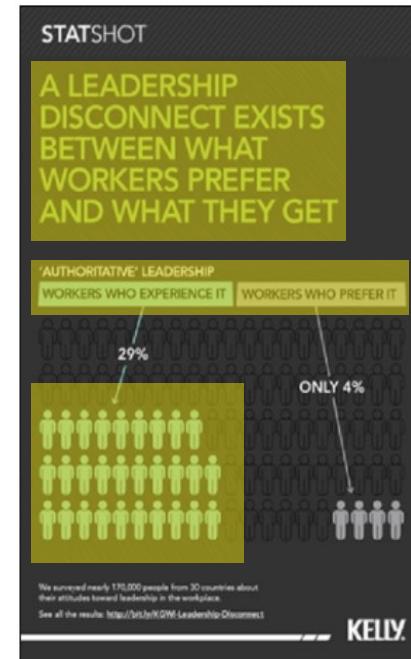
ImportAnnots



Which tool should I use?



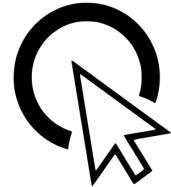
ImportAnnots



Graphic design retargeting



Which tool should I use?



BubbleView



Which tool should I use?



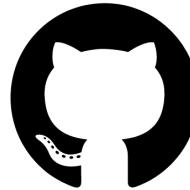
BubbleView



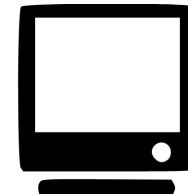
Automatic cropping



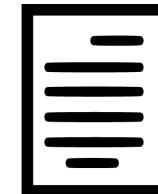
TurkEyes.mit.edu



Code



Demos



More details



TurkEyes.mit.edu



ZoomMaps

Works on multi-scale content,
natural form of interaction

Coarse approximation of
attention

F37

CodeCharts

Doesn't distort stimuli,
approximates eye movements

Expensive, images must fit on
screen



ImportAnnots

Produces clean segmentations,
captures importance

Not ideal for natural images,
importance > attention



BubbleView

Versatile, cheap

Distorts stimuli and timing