SARA IRINA FABRIKANT[1],
STACY REBICH HESPANHA[2],
DANIEL R. MONTELLO[2]
GENNADY ANDRIENKO[3]
NATALIA ANDRIENKO[3]

VISUAL ANALYTICS

TO EVALUATE INFERENCE AFFORDANCE FROM ANIMATED MAP DISPLAYS

[1]UNIVERSITY OF ZURICH
[2]UNIVERSITY OF CALIFORNIA SANTA BARBARA
[3]FRAUNHOFER INSTITUTE FOR INTELLIGENT ANALYSIS & INFORMATION SYSTEMS

GEOVIS–GISCIENCE 08, 23/09/2008

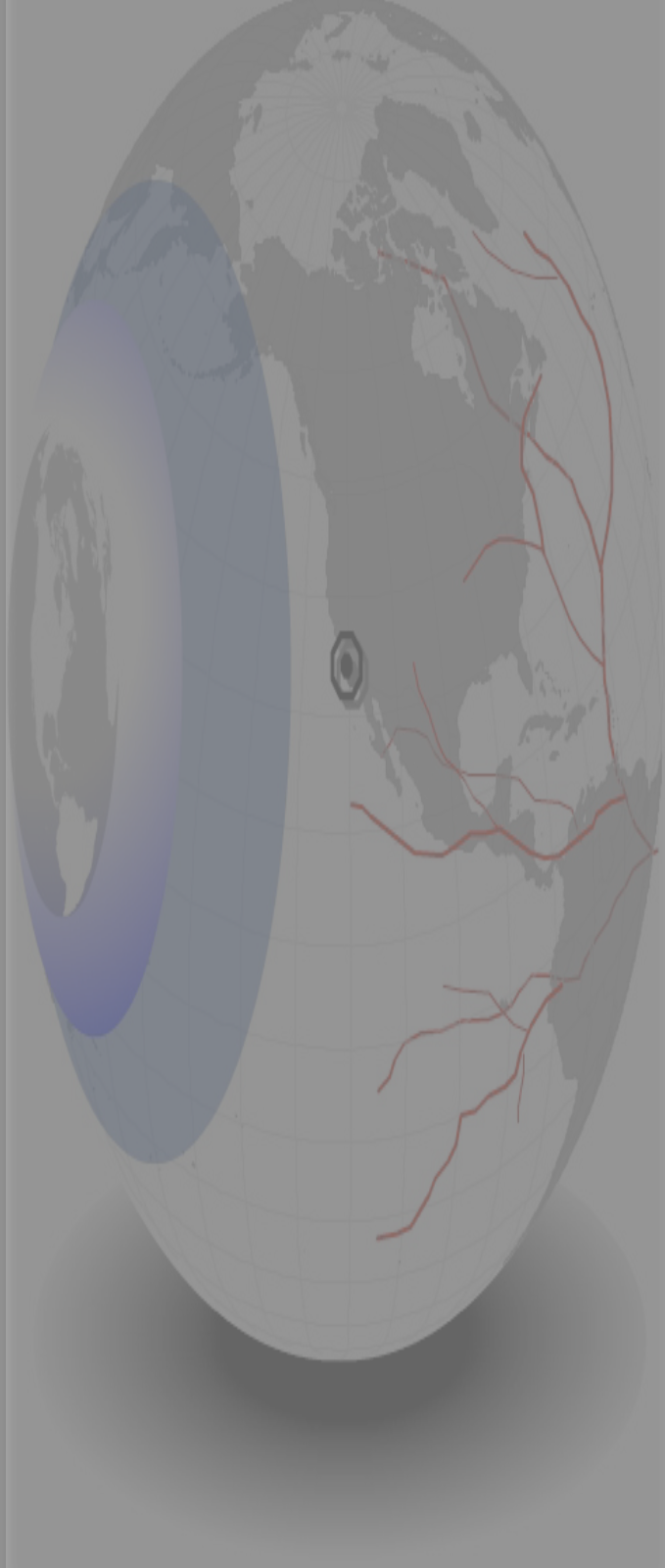
ACKNOWLEDGMENTS

U.S. National Science Foundation # 0350910
Canton of Zurich, Switzerland

collaborators:

Joao Hespana, Mary Hegarty,
Scott Prindle & Adeline Dougherty

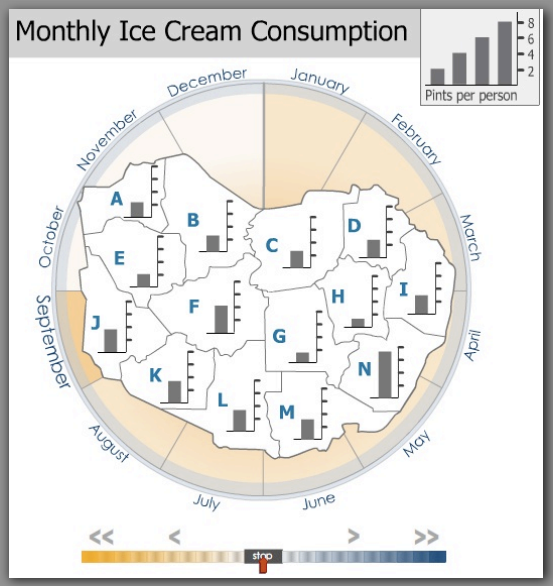
Thomas Grossmann, Jan Wilkening,
Marc Segarra Peña (ERASMUS: Jaume 1, Spain)

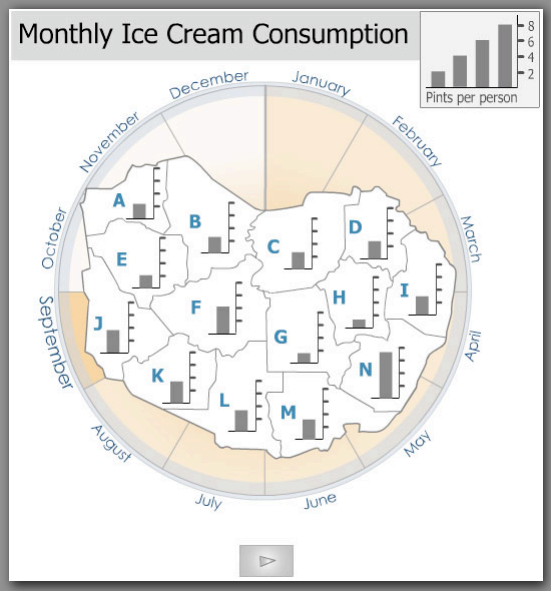


WHEN, HOW AND WHY DO ANIMATIONS WORK ?

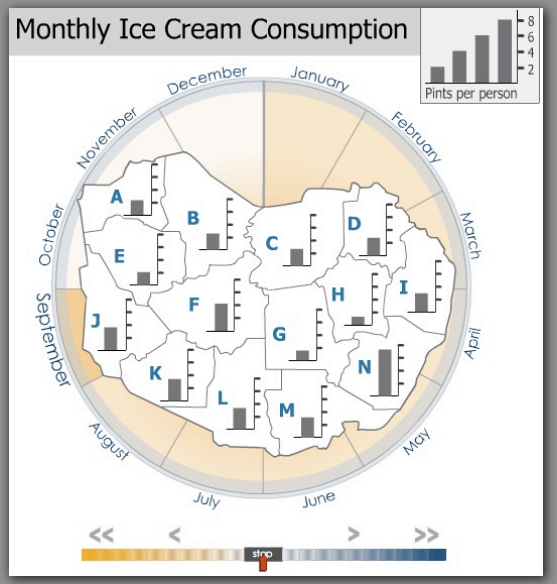
- inference affordance (Fabrikant et al., 2008)
  - informational equivalence (amount and quality of information content)
  - computational equivalence (quality and efficiency of inference making)
- research question:

How does design facilitate or hinder inference affordance from animated displays?



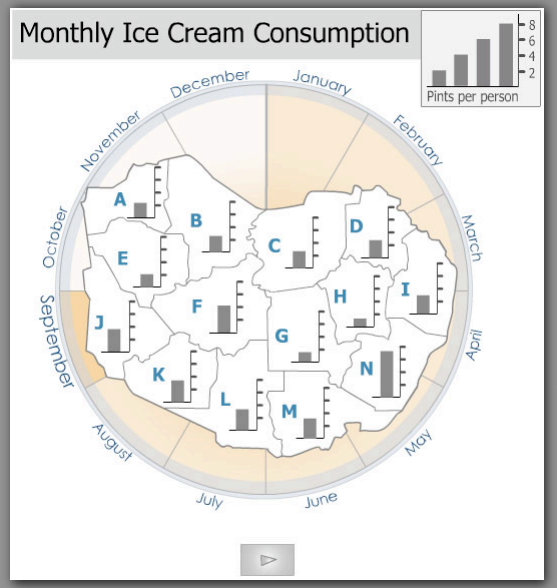


EXPERIMENTAL DESIGN



interactive

- independent variables (controlled)
  - animation types (between-subject)
    - simple (tweened, non-tweened)
    - interactive (tweened, non-tweened)
  - inference tasks (within-subject)
    - simple questions: location, theme, & time
    - complex questions: general patterns, what-if scenarios

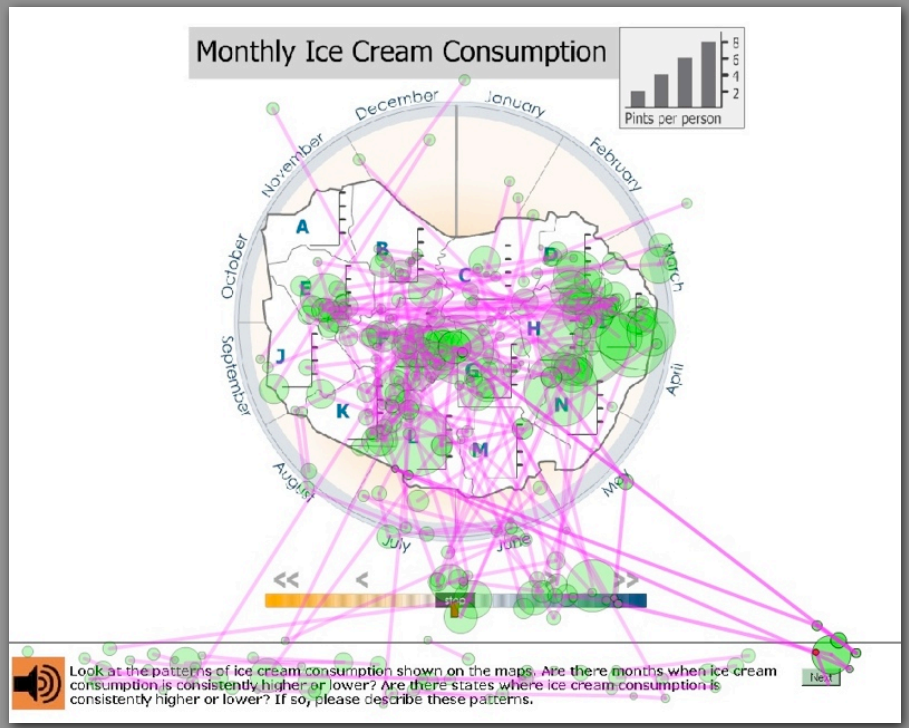


simple

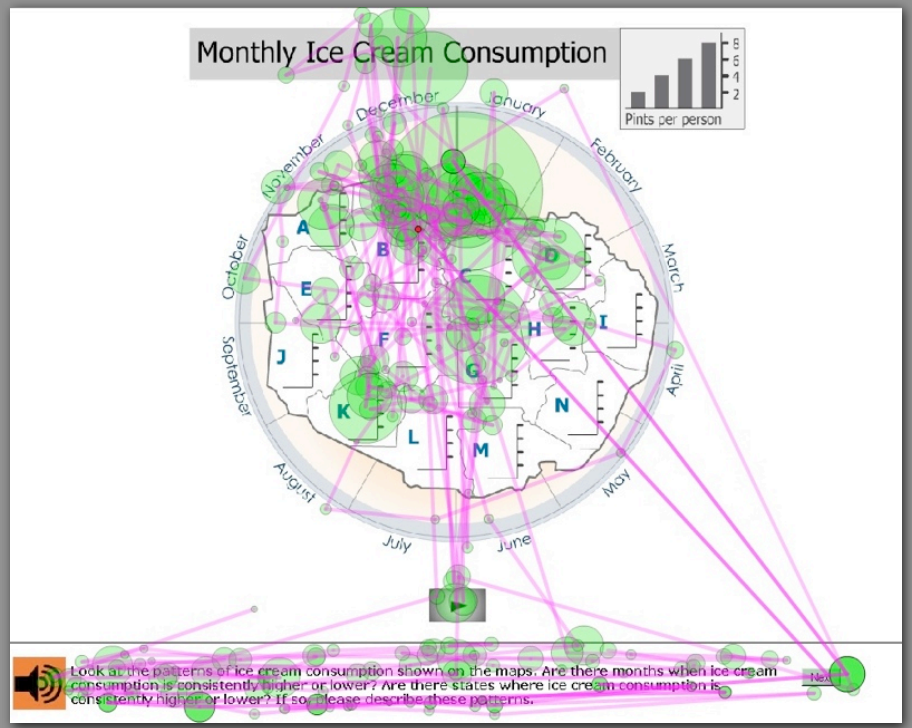
- dependent variables (measured)
  - eye movement pattern: AOIs, gaze paths
  - user interactions
  - verbal protocols
  - (accuracy of) response for inference task
  - response time (RT) for task completion

EYE MOVEMENT DATA

- "gaze plot" maps (fixations & saccades)



interactive

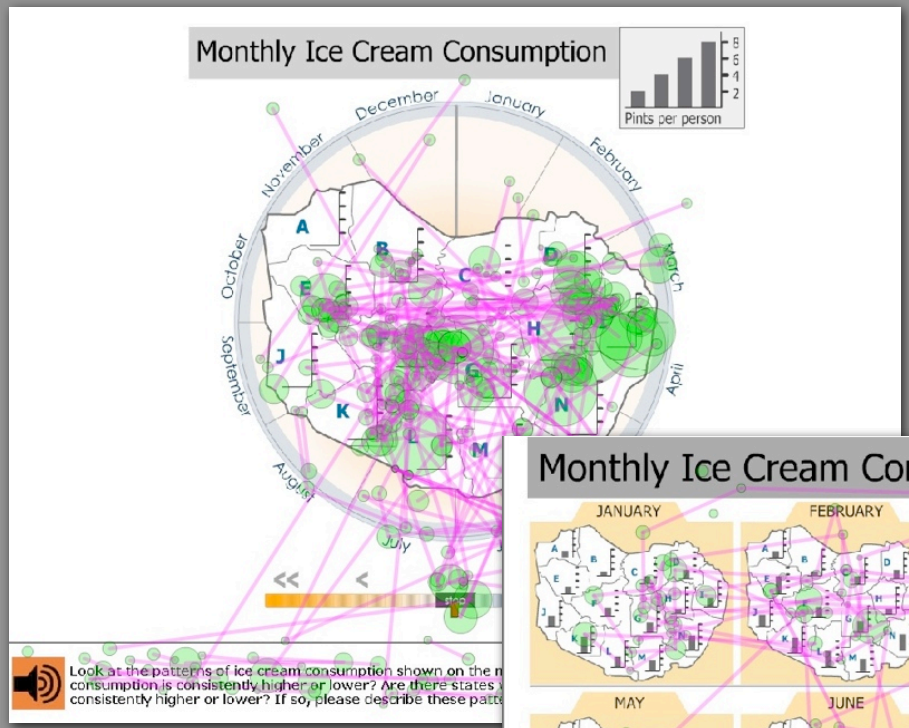


simple

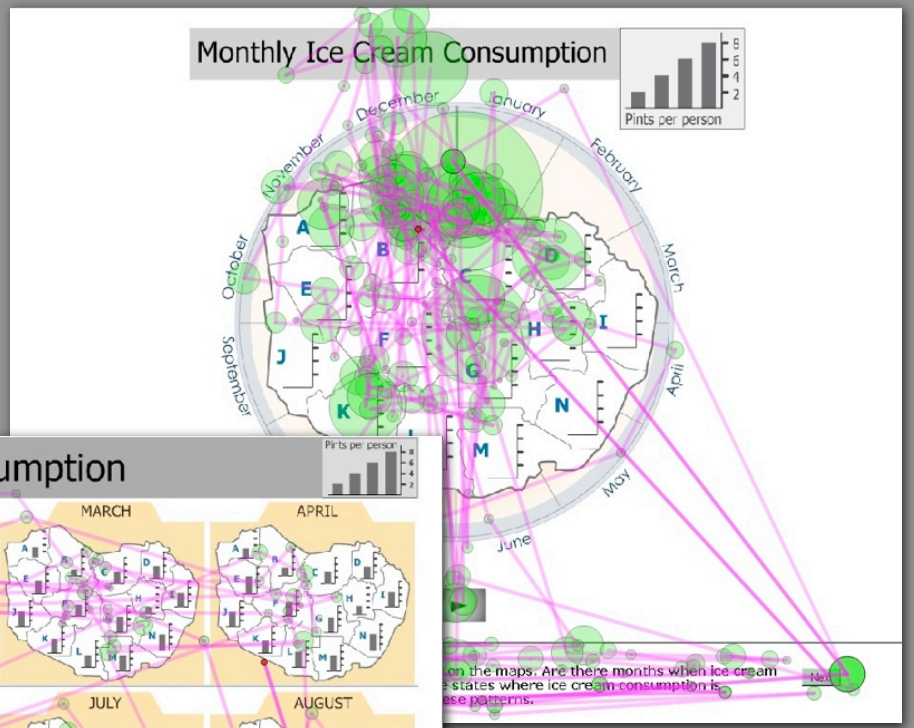
overall pattern question

EYE MOVEMENT DATA

- "gaze plot" maps (fixations & saccades)

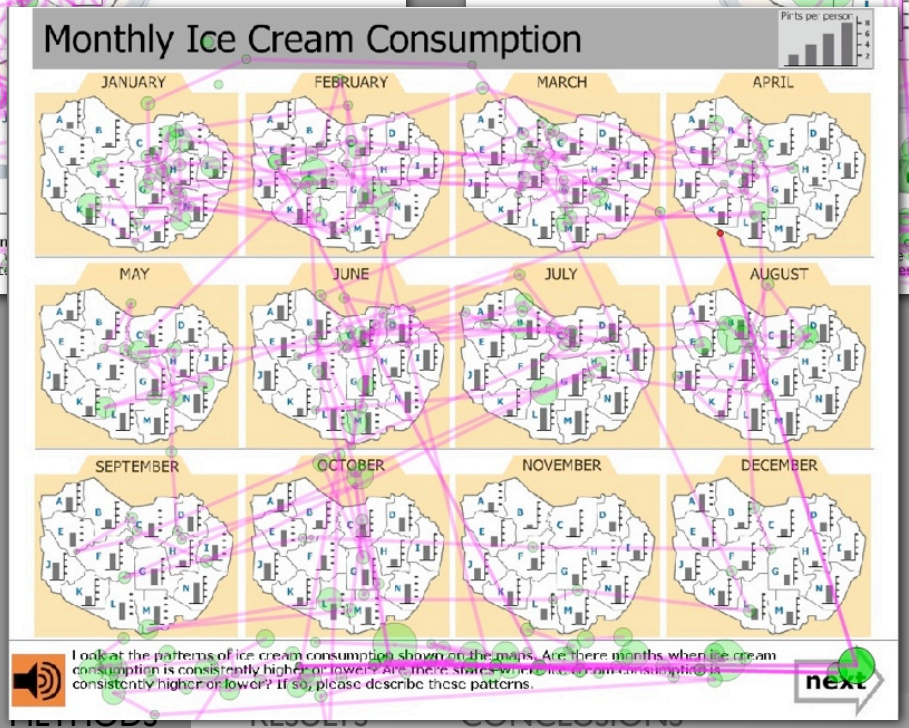


interactive



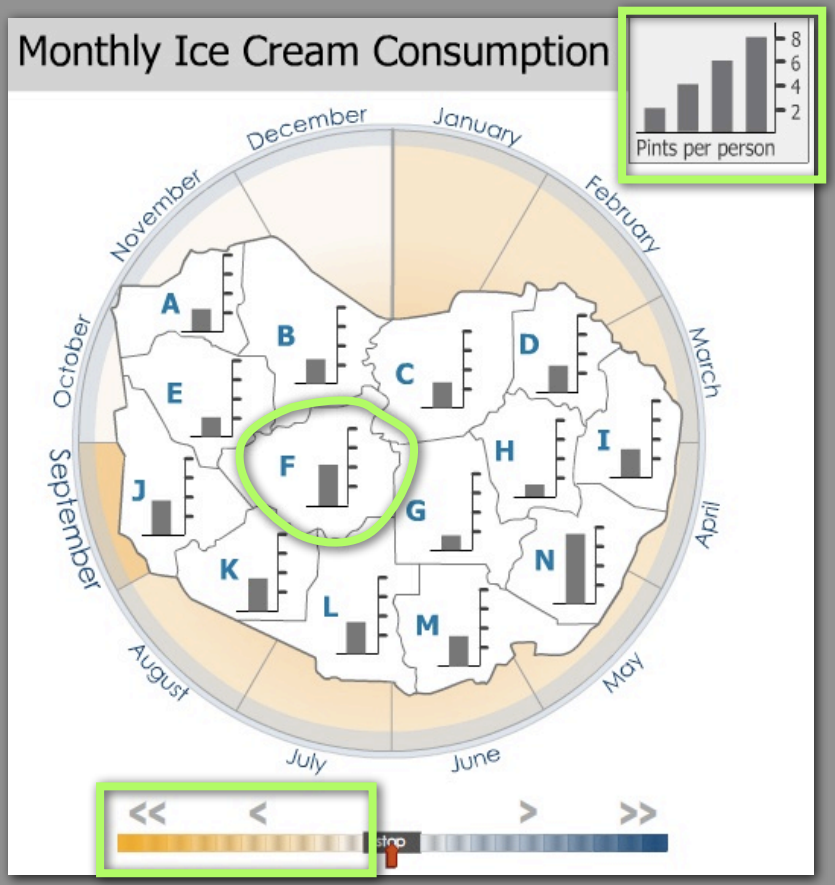
simple

small multiple design



ANALYSIS OF EYE MOVEMENTS

- questions:
  - *where* on the animation?
  - *when* looked at first, second...?
  - *for how long* in a particular location?

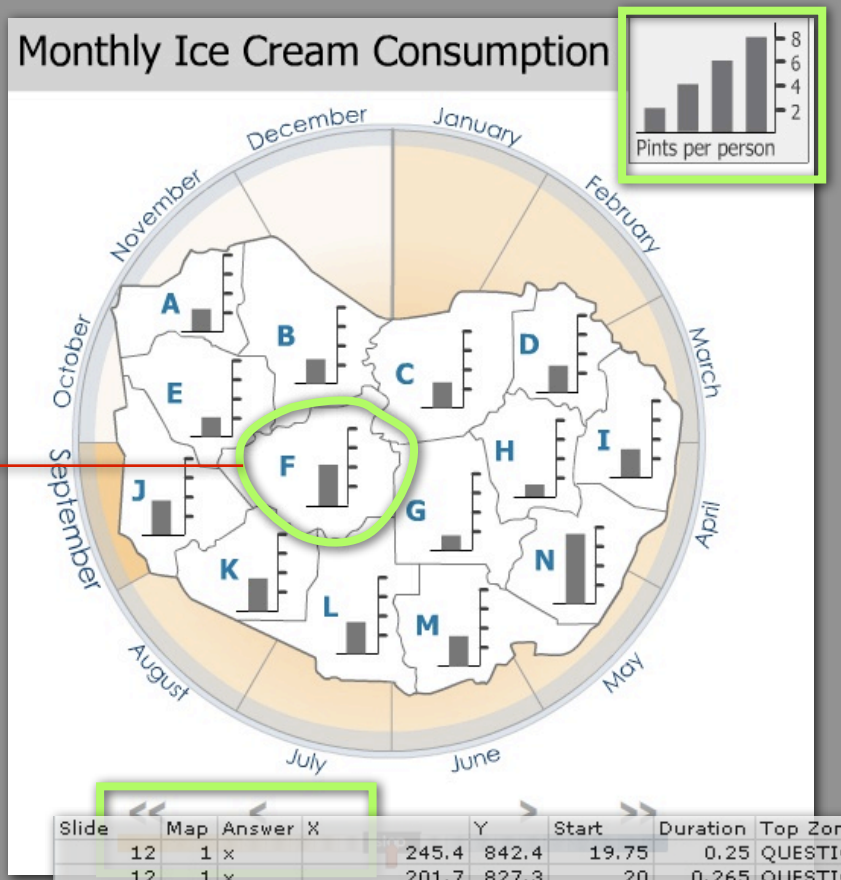


- measures (Goldberg & Kotval 1999)
  - fixation location
  - fixation: duration (e.g., >100 ms)
  - *sequence/order* of fixations
  - gaze path *similarities*
  - etc.

ANALYSIS OF EYE MOVEMENTS

- questions:
  - *where* on the animation?
  - *when* looked at first, second...?
  - *for how long* in a particular location?

- measures (Goldberg & Kotval 1999)
  - fixation location
  - fixation: duration (e.g., >100 ms)
  - *sequence/order* of fixations
  - gaze path *similarities*
  - etc.



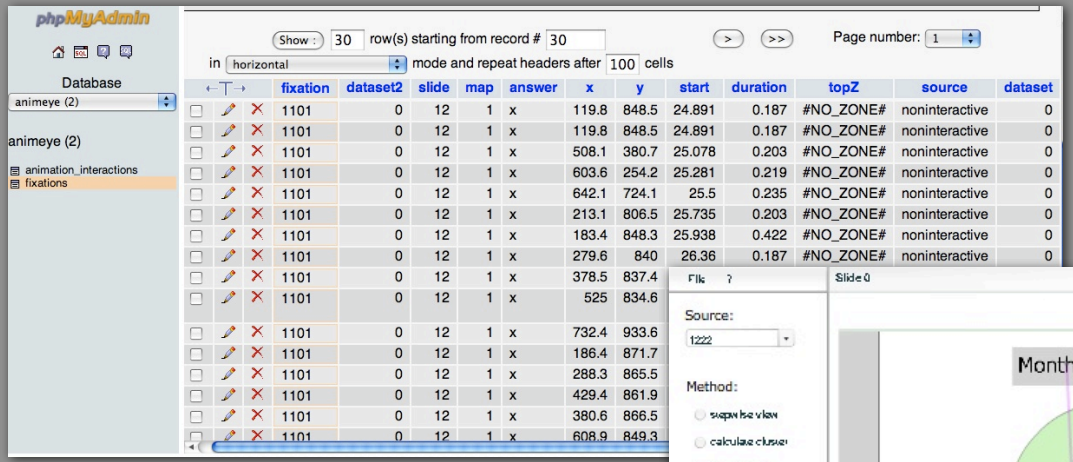
Slide	Map	Answer	X	Y	Start	Duration	Top Zones
12	1	x	245.4	842.4	19.75	0.25	QUESTION_01
12	1	x	201.7	827.3	20	0.265	QUESTION_01
12	1	x	263.5	815.3	20.265	0.172	QUESTION_01
12	1	x	366.5	813.5	20.437	0.297	QUESTION_01
12	1	x	282.2	825.3	20.734	0.328	QUESTION_01
12	1	x	342.3	816	21.062	0.125	QUESTION_01
12	1	x	401.6	817.7	21.187	0.141	QUESTION_01
12	1	x	476	817.8	21.328	0.297	QUESTION_01
12	1	x	596.1	815.8	21.625	0.25	QUESTION_01
12	1	x	682.8	804.7	21.875	0.187	QUESTION_01
12	1	x	778.8	801.1	22.062	0.219	NOVEMBER_01
12	1	x	882.4	811.6	22.281	0.219	QUESTION_01
12	1	x	800.4	823.9	22.5	0.843	QUESTION_01
12	1	x	919.2	826.5	23.343	0.422	QUESTION_01
12	1	x	964.4	820	23.765	0.532	QUESTION_01
12	1	x	1032.3	813.9	24.297	0.187	QUESTION_01
12	1	x	182.6	822.7	24.484	0.281	QUESTION_01
12	1	x	263.6	824.4	24.765	0.375	QUESTION_01
12	1	x	388.8	843.5	25.234	0.25	QUESTION_01
12	1	x	455.9	845.2	25.484	0.125	QUESTION_01
12	1	x	504.3	823.2	25.609	0.156	QUESTION_01
12	1	x	564.3	820.8	25.765	0.485	QUESTION_01
12	1	x	628.3	814.4	26.25	0.297	QUESTION_01
12	1	x	583.7	816.9	26.609	0.484	QUESTION_01
12	1	x	647.3	813.3	27.093	0.172	QUESTION_01
12	1	x	812.5	799.7	27.406	0.359	NOVEMBER_01

VISUAL ANALYTICS OF EYE MOVEMENTS

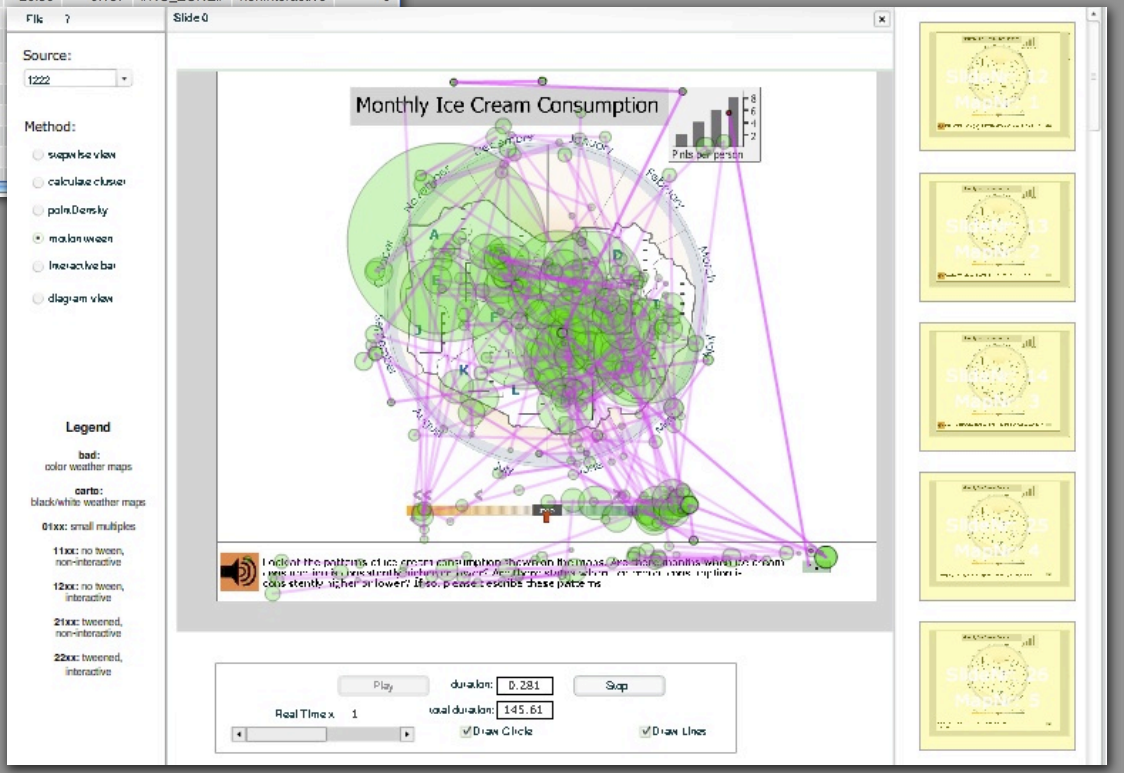
- information affordance is a *process !*
  - bottom line measures: accuracy & speed of response not enough
- pattern detection and analysis as a classic data mining problem !
  - fixation data (>173,000 records, ~ 10 MB)
  - interaction data (> 8,000 records, ~1 MB)
  - bottom line data: accuracy/speed, and user background information
- development of data handling solutions
  - scripted visual stimuli (control of every single drawn element)
  - database storage and access (Oracle, MySQL with PHP)
- development of visual front-ends
  - play-back of user-interactions and visualizations of eye movements

VISUAL ANALYTICS OF EYE MOVEMENTS

- database-driven visualization & exploration of eye movements & interactions



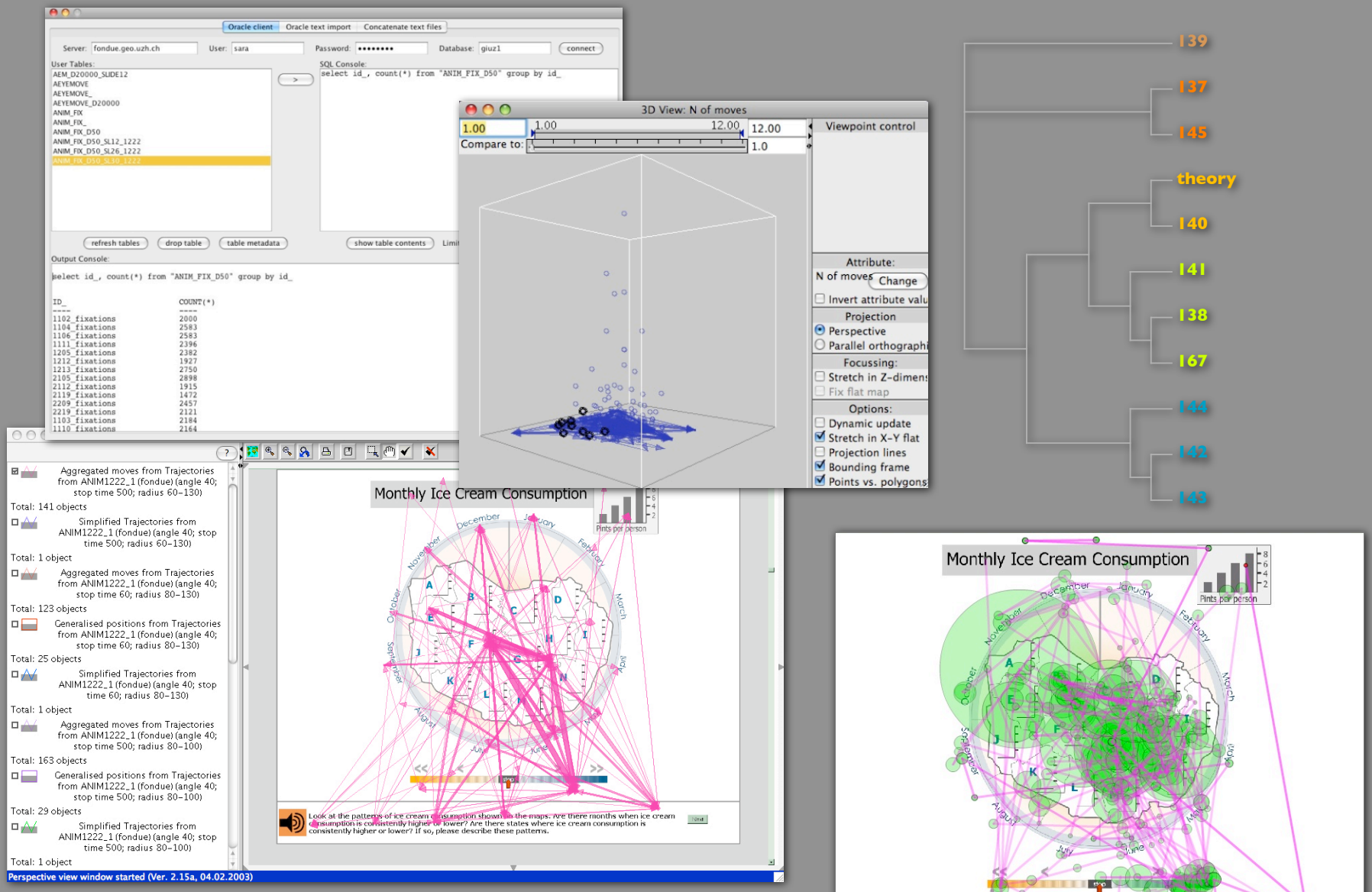
MySQL/PHP



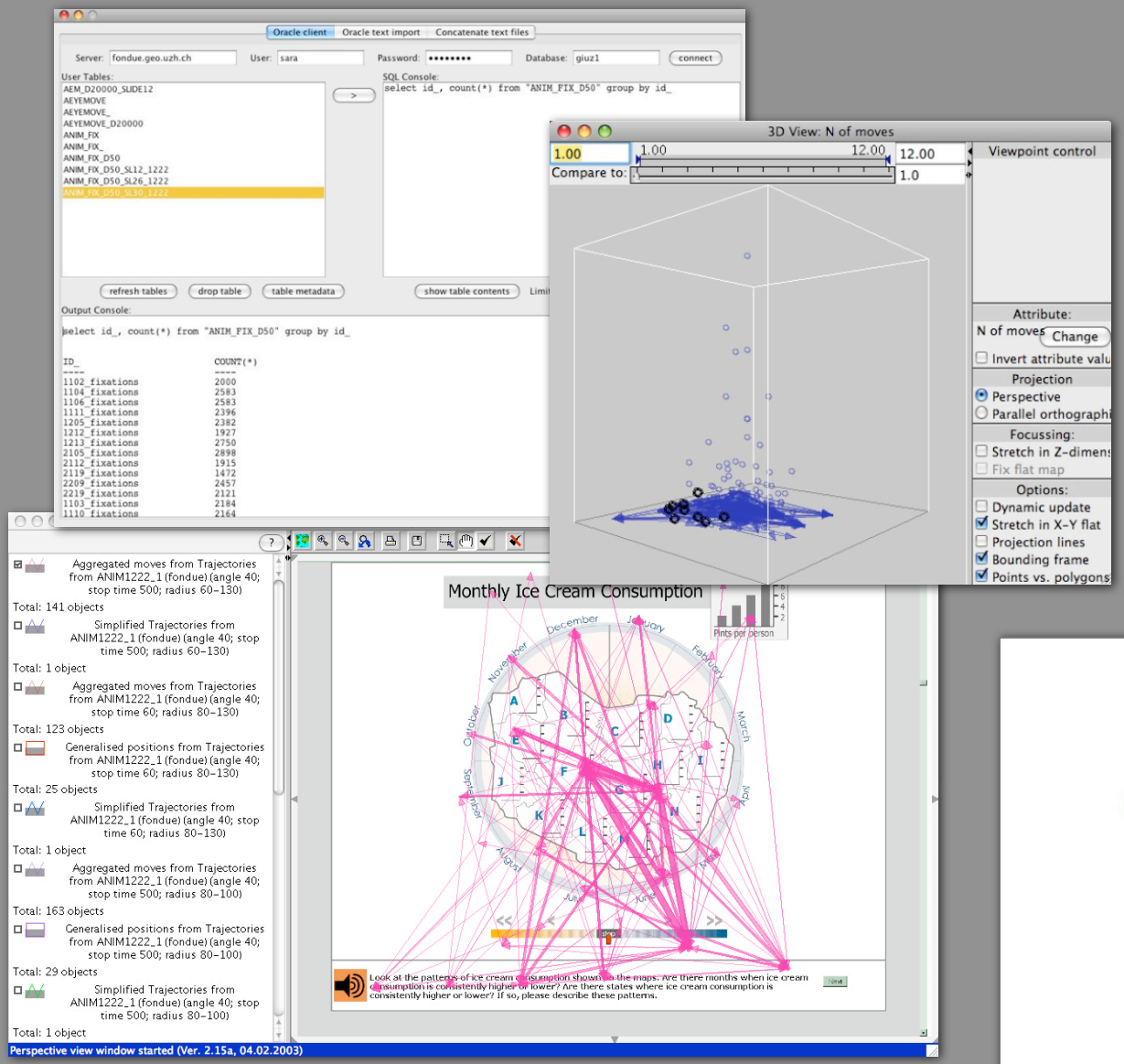
eyeview (Flash)

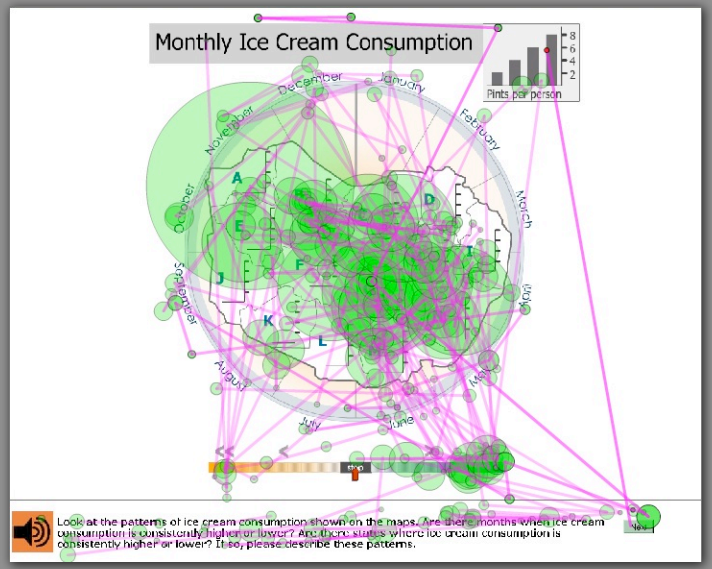
Grossmann (2007)

VISUAL ANALYTICS ALL THE WAY DOWN



VISUAL ANALYTICS ALL THE WAY DOWN

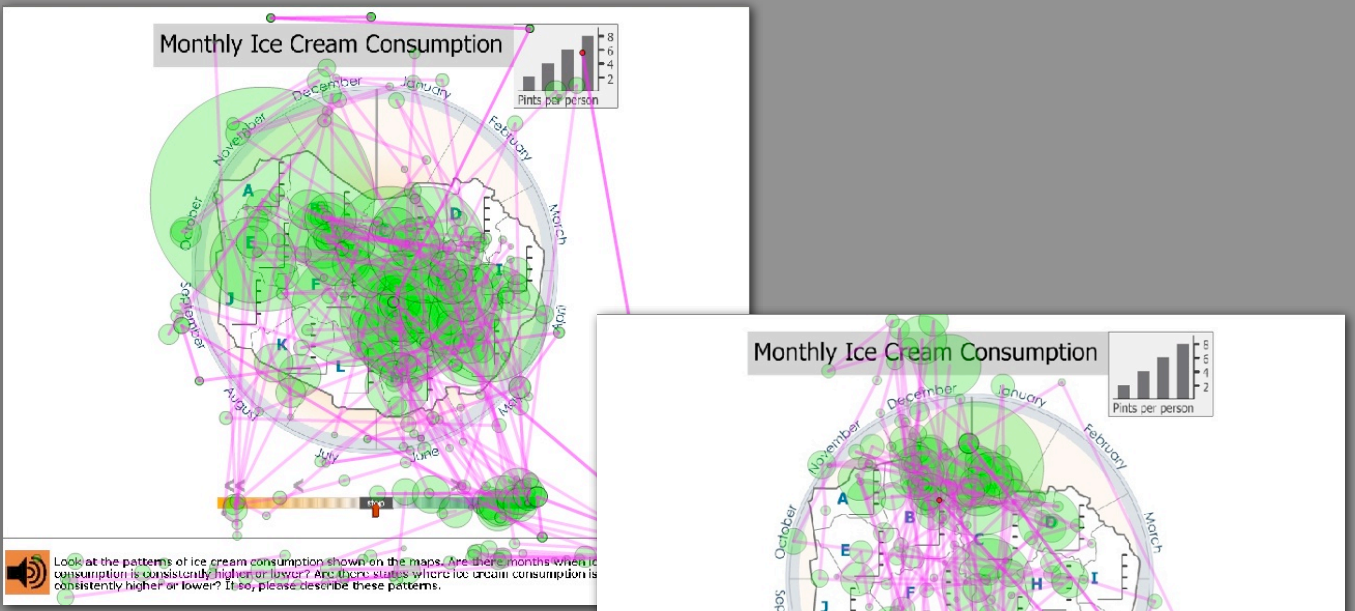




PRELIMINARY RESULTS

qualitative analysis:

- inference making patterns influenced by:
  - design & task

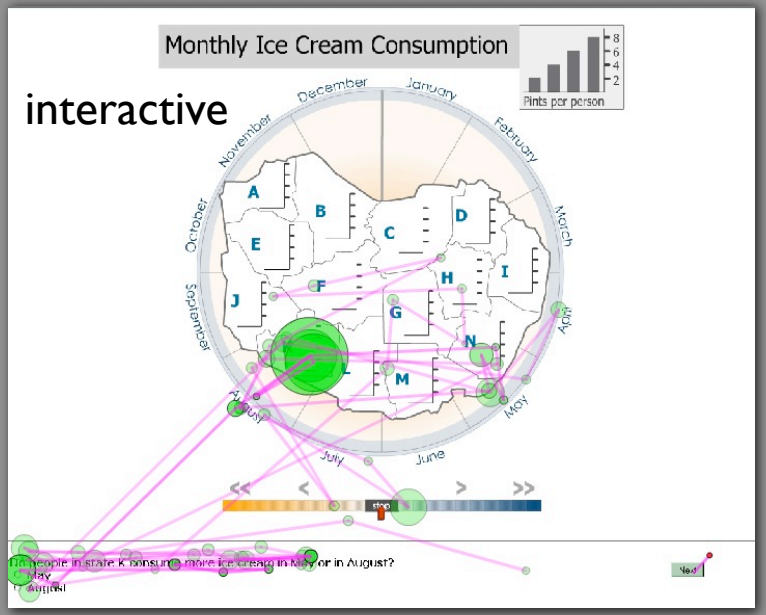


overall pattern question

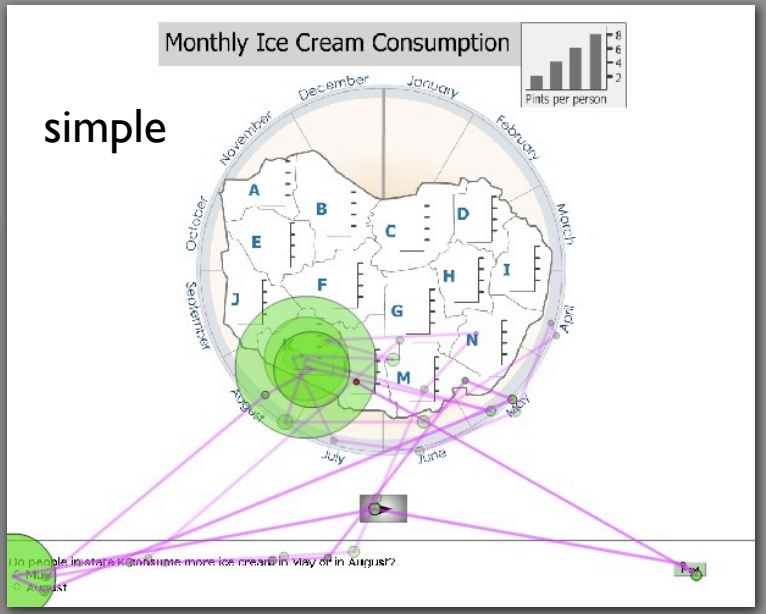
PRELIMINARY RESULTS

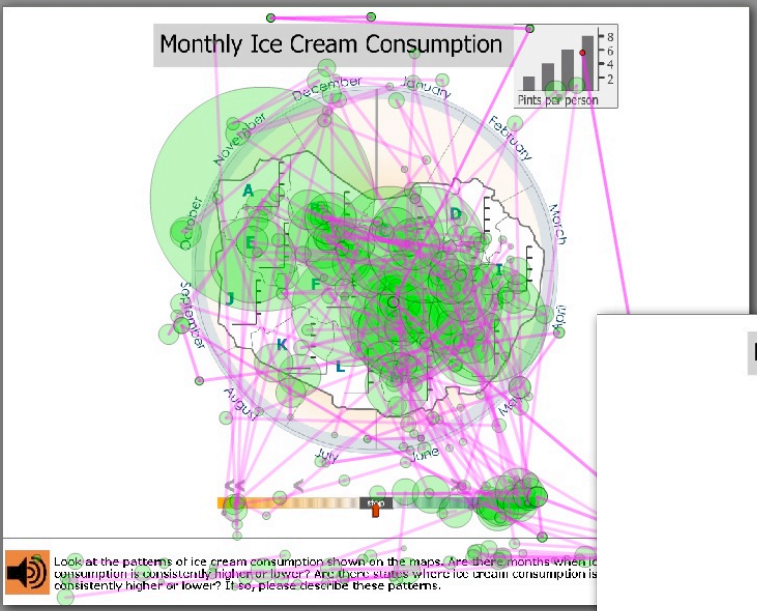
qualitative analysis:

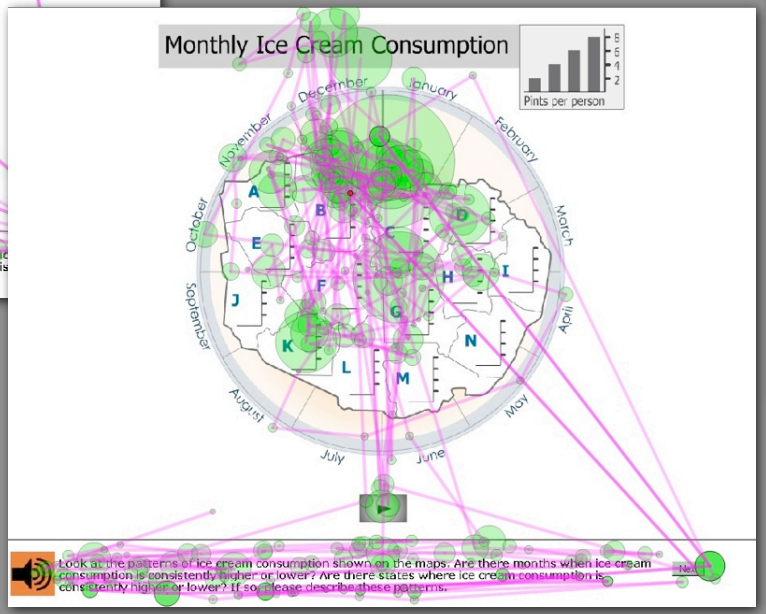
- inference making patterns influenced by:
  - design & task



simple mag. comparison



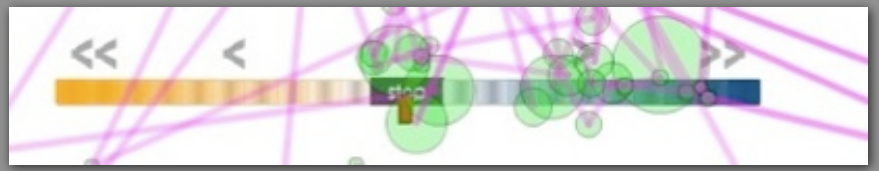


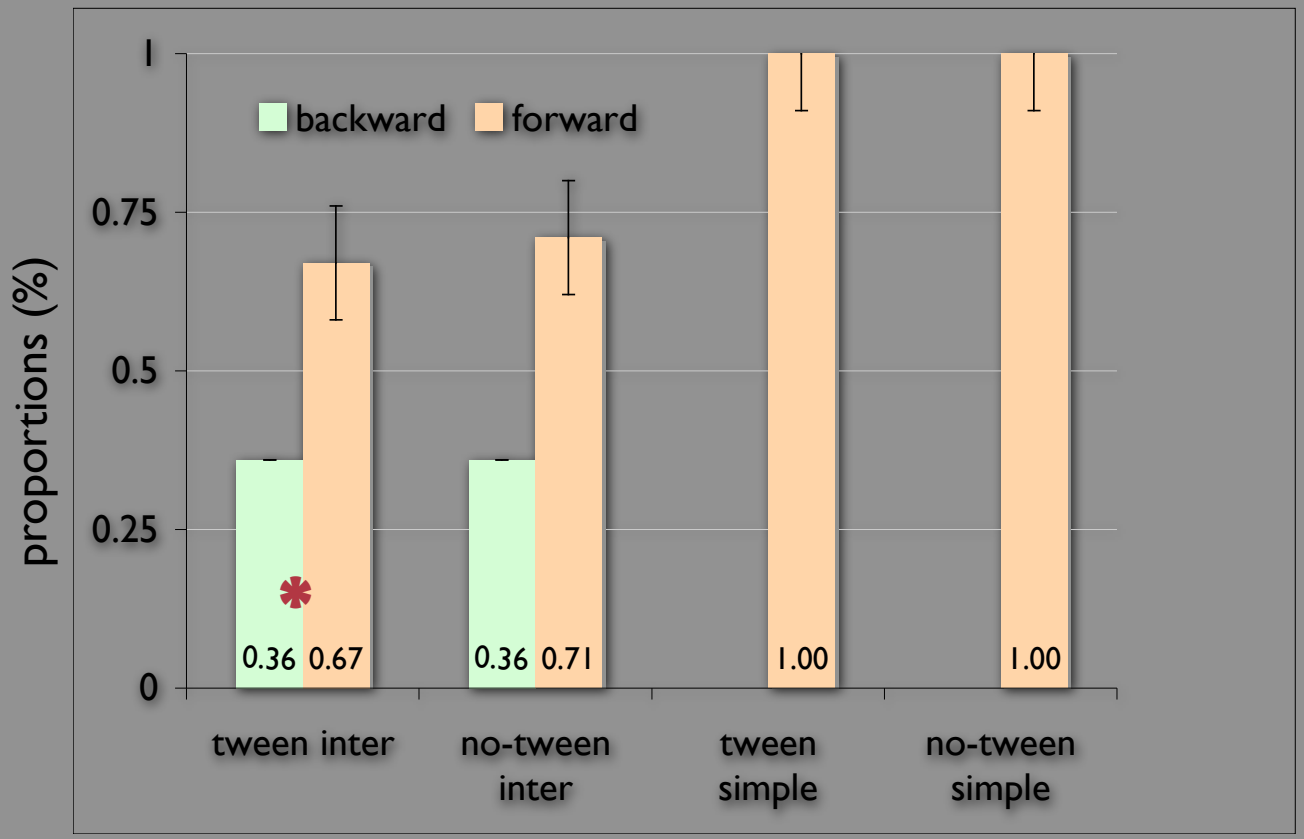


overall pattern question

PRELIMINARY RESULTS: INTERACTION PATTERNS

- direction & speed of animation

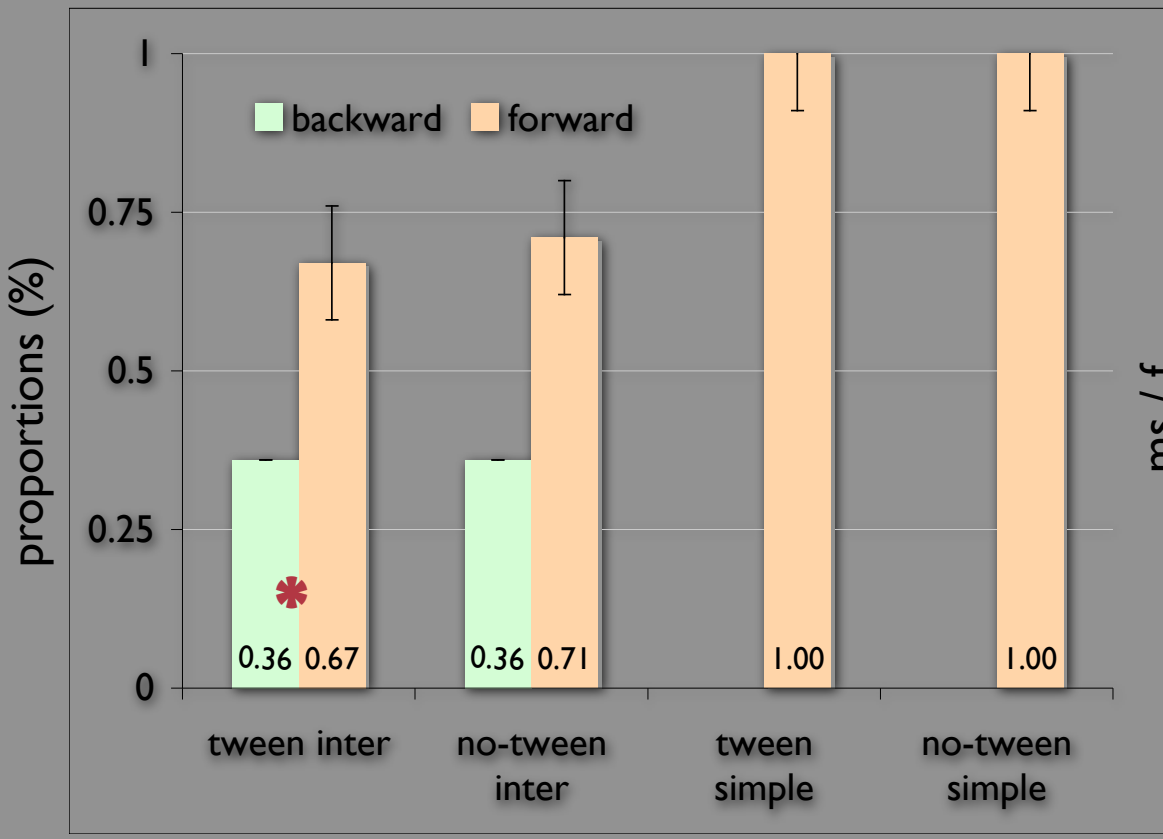


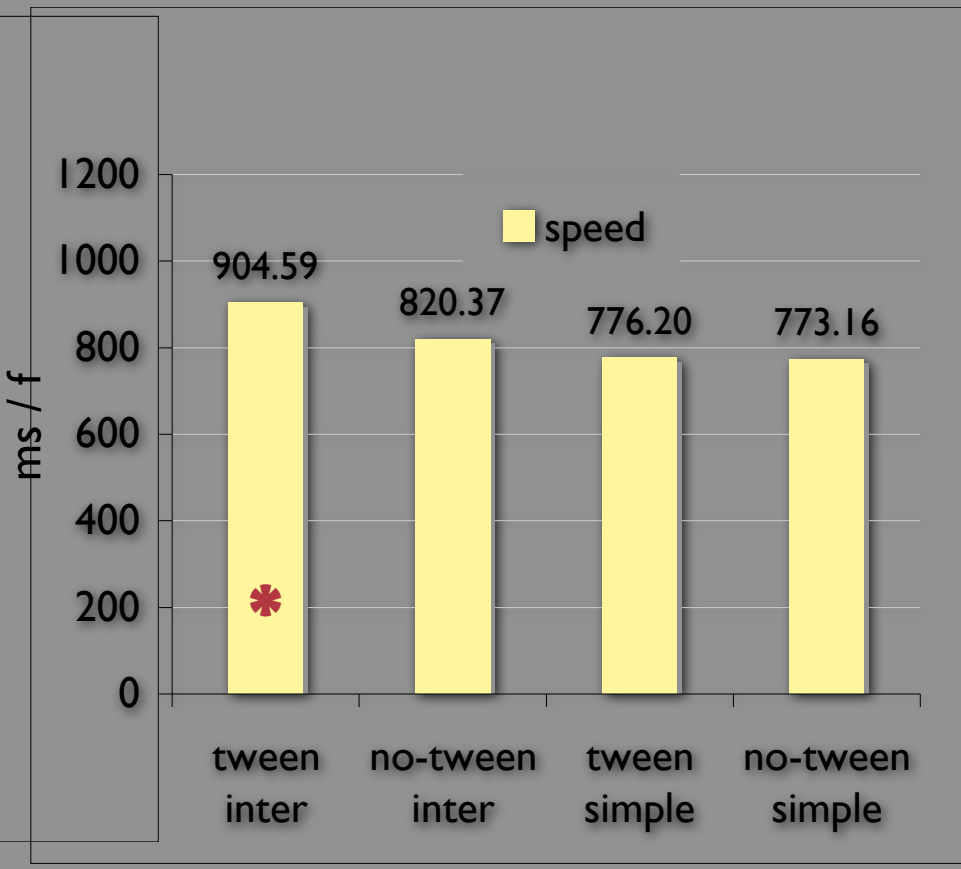


* significant

PRELIMINARY RESULTS: INTERACTION PATTERNS

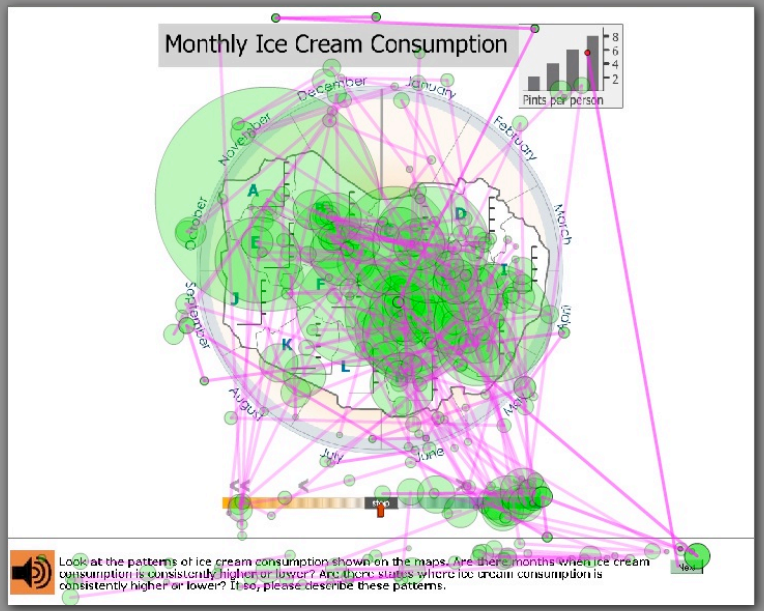
- direction & speed of animation

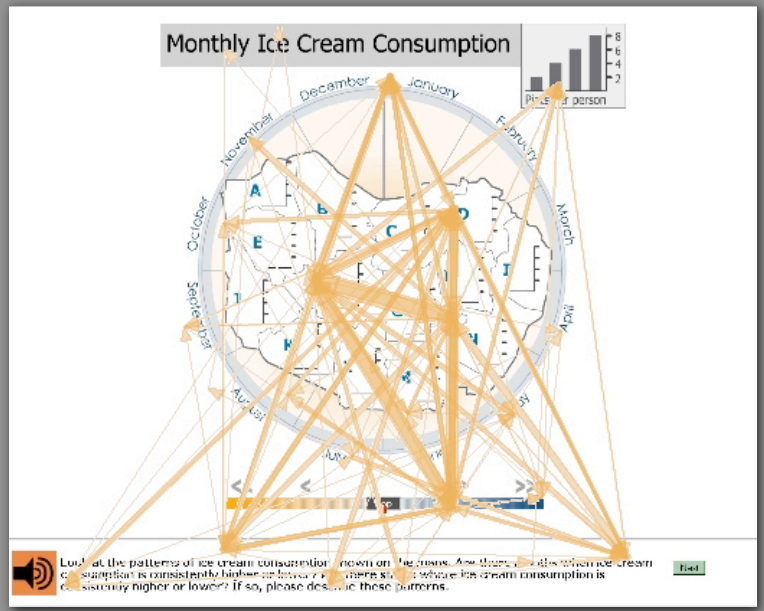




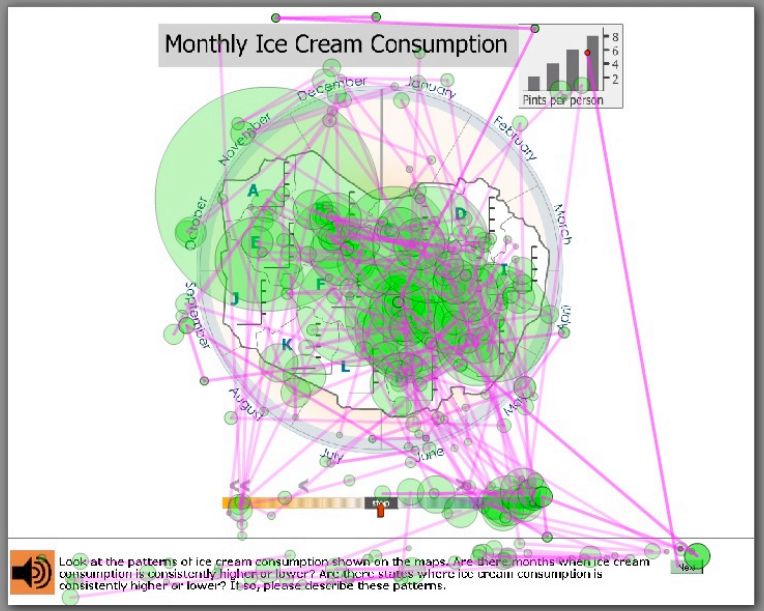
* significant

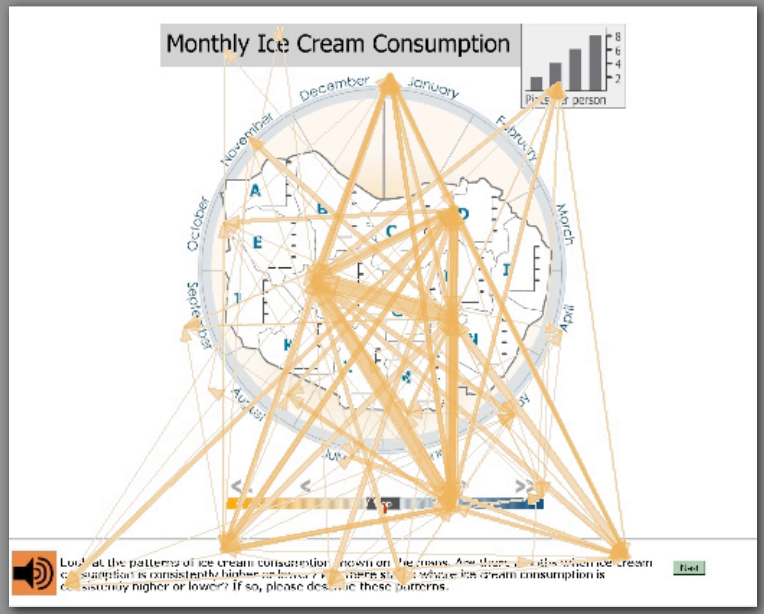
GENERALIZATION OF GAZE PLOTS

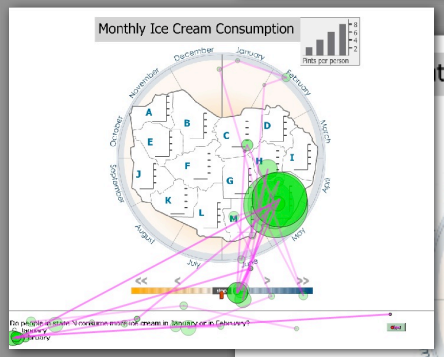


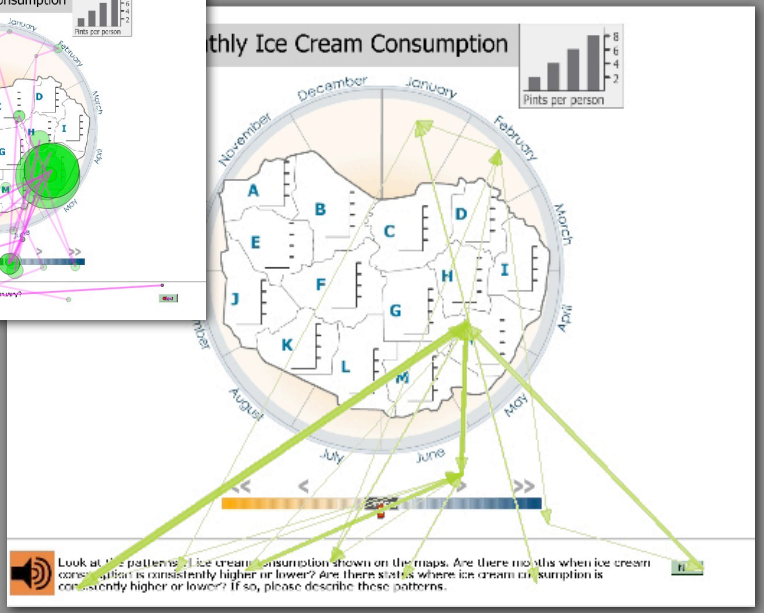


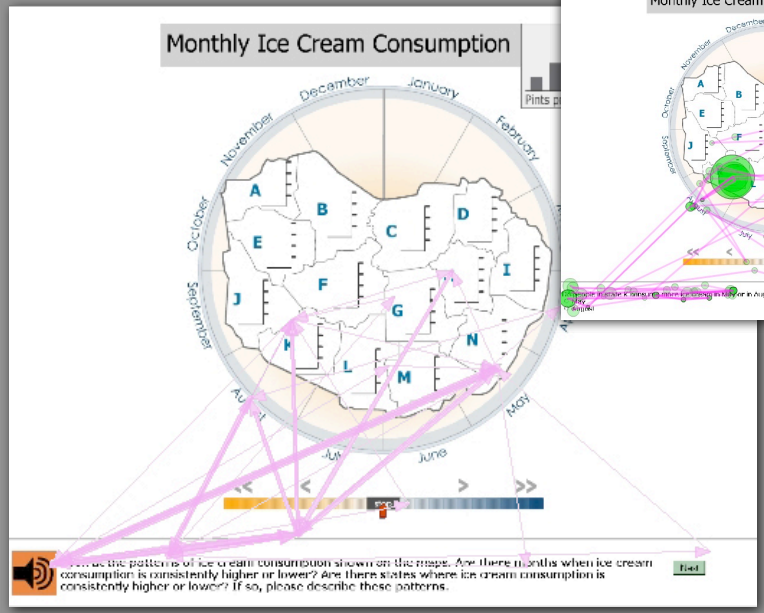
GENERALIZATION OF GAZE PLOTS

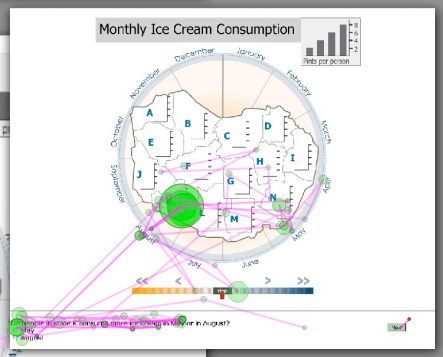












SUMMARY & OUTLOOK

- empirical evaluation of inference affordance from animated map displays
- inference affordance influenced by inferece tasks & display designs
  - i.e., simple or complex tasts
  - i.e., interactivity, animation speed, or tweening
- animation types **cannot** be informationally / computationally equivalent
  - context dependent trade-off !

OUTLOOK

- further quantitative analyses
  - i.e., sequence analysis of AOIs
  - summarizations across participants based on similarity measures
  - verbal protocol analysis

SARA IRINA FABRIKANT[1],
STACY REBICH HESPANHA[2],
DANIEL R. MONTELLO[2]
GENNADY ANDRIENKO[3]
NATALIA ANDRIENKO[3]

VISUAL ANALYTICS

TO EVALUATE INFERENCE AFFORDANCE FROM ANIMATED MAP DISPLAYS

¿ Questions ?

[1]UNIVERSITY OF ZURICH
[2]UNIVERSITY OF CALIFORNIA SANTA BARBARA
[3]FRAUNHOFER INSTITUTE FOR INTELLIGENT ANALYSIS & INFORMATION SYSTEMS

GEOVIS–GISCIENCE 08, 23/09/2008