

Constraints and Opportunities for Expressive Information Design

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Why Visualization?

Data Visualization in a Societal Context

In journalism, education, public institutions, civic engagement, ...

Data Visualization in a Personal Context

In personal health, finance, resource conservation, ...

Visualization and Visual Analytics

How do I **situate my research** within the academic visualization community?

Let's consider applications of visualization beyond those in professional data analysis.

Why Expressivity?

What does expressivity mean in the context of visualization and information design?

Expressing Visualization Tasks

 *A Multi-Level Typology of Abstract Visualization Tasks*. Brehmer and Munzner.

In *IEEE Transactions on Visualization and Computer Graphics* (VIS 2013, InfoVis Track).

Icons by Eamonn Maguire (cc by) for Munzner's *Visualization Analysis & Design* (CRC Press 2014).

Expressing Visualization Tasks

Expressivity and Design Choices

Visual representation,

Interaction,

Highlighting and annotation, and

Ways to combine visual and textual content.

Across each of these, what is the appropriate **granularity**?

Constraints on Expressivity

Expertise Constraints

How can I empower non-programmers? Non-designers?

Limited Resource Constraints

How can I support visualization design for those on a deadline?

Context Constraints

What are the best practices for visualization design on mobile devices?

How can I improve data literacy among the audience for visualization content?

Democratizing Data Visualization

How can I enable more people to...

Expressively visualize their data?

Present compelling data-driven stories?

Make personal decisions grounded in data?

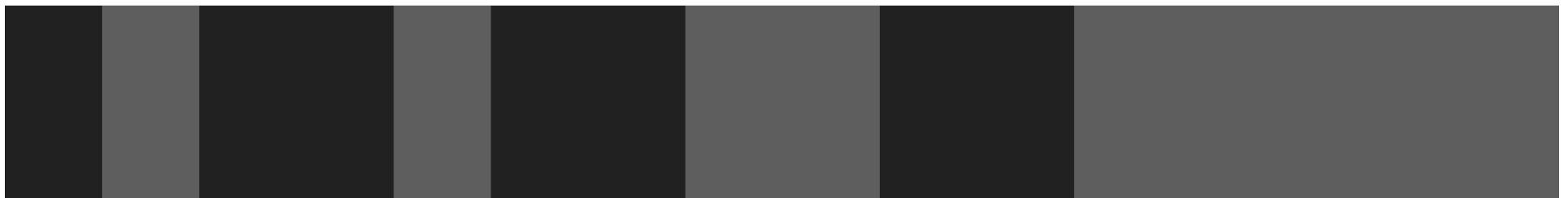
Connecting Visualization Research and Practice

Disseminating research into practice, and practice into research.

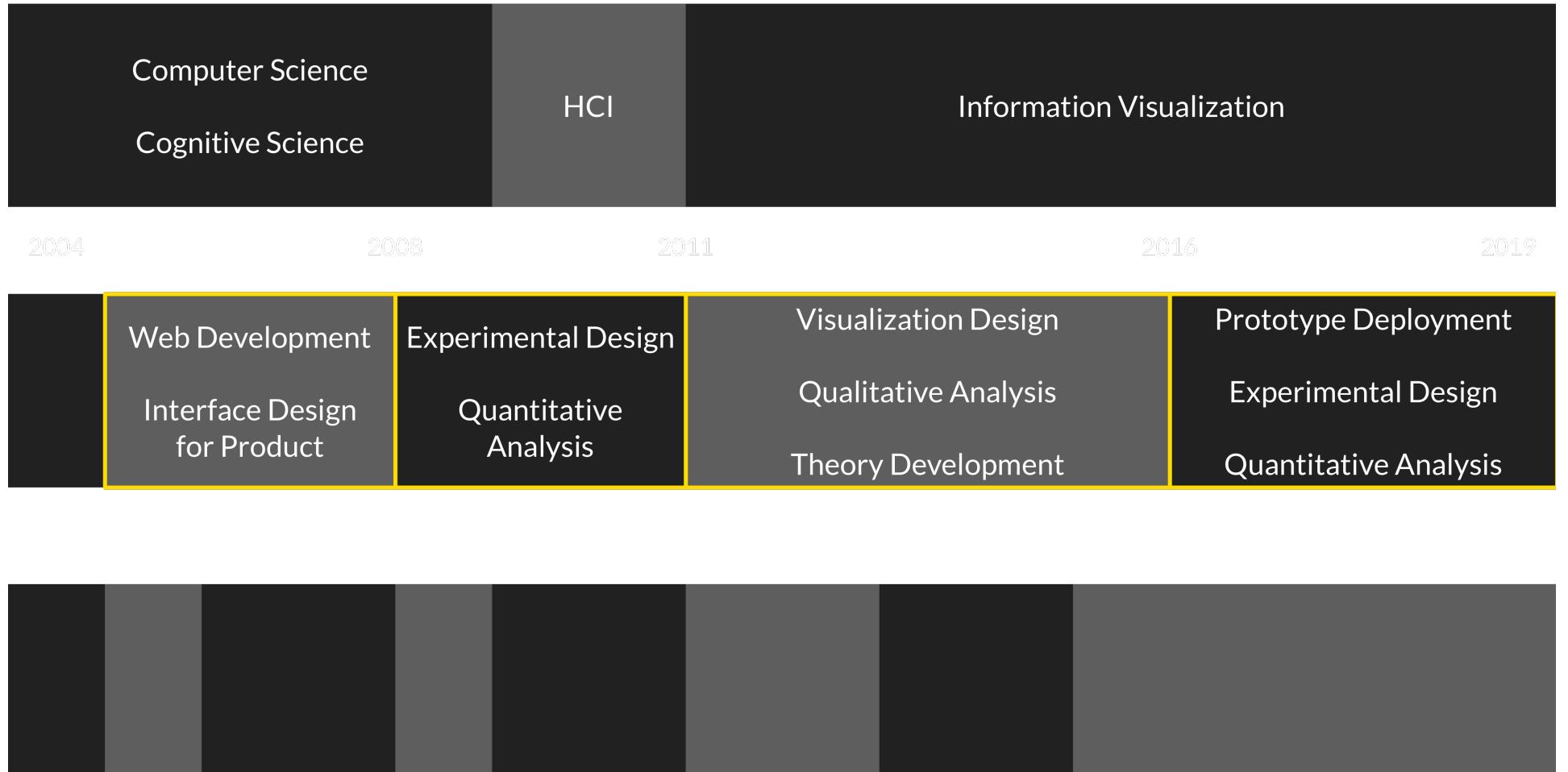
Why Me?

Fields of Study

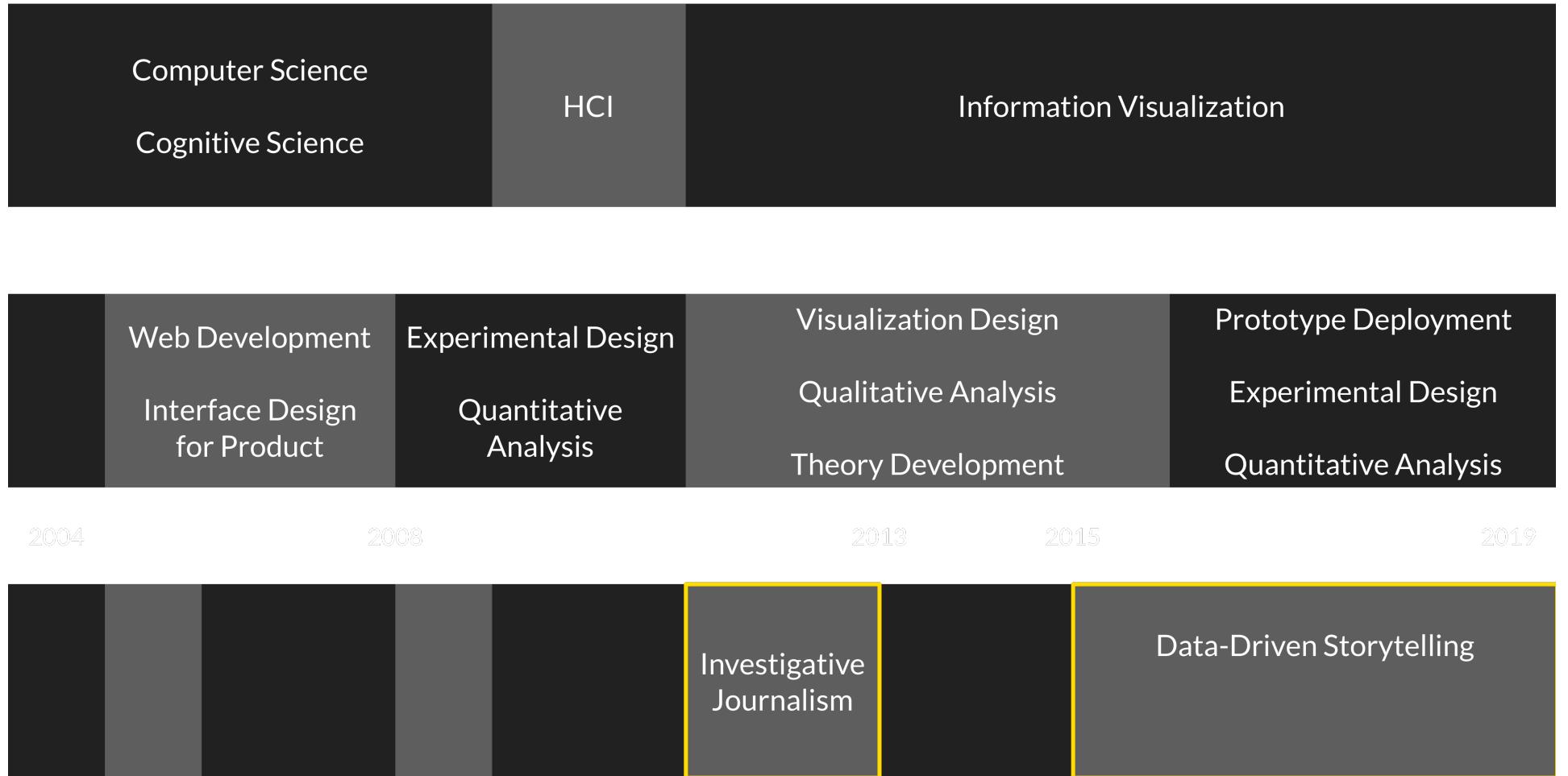
2004 2009 2011 2019



Methods



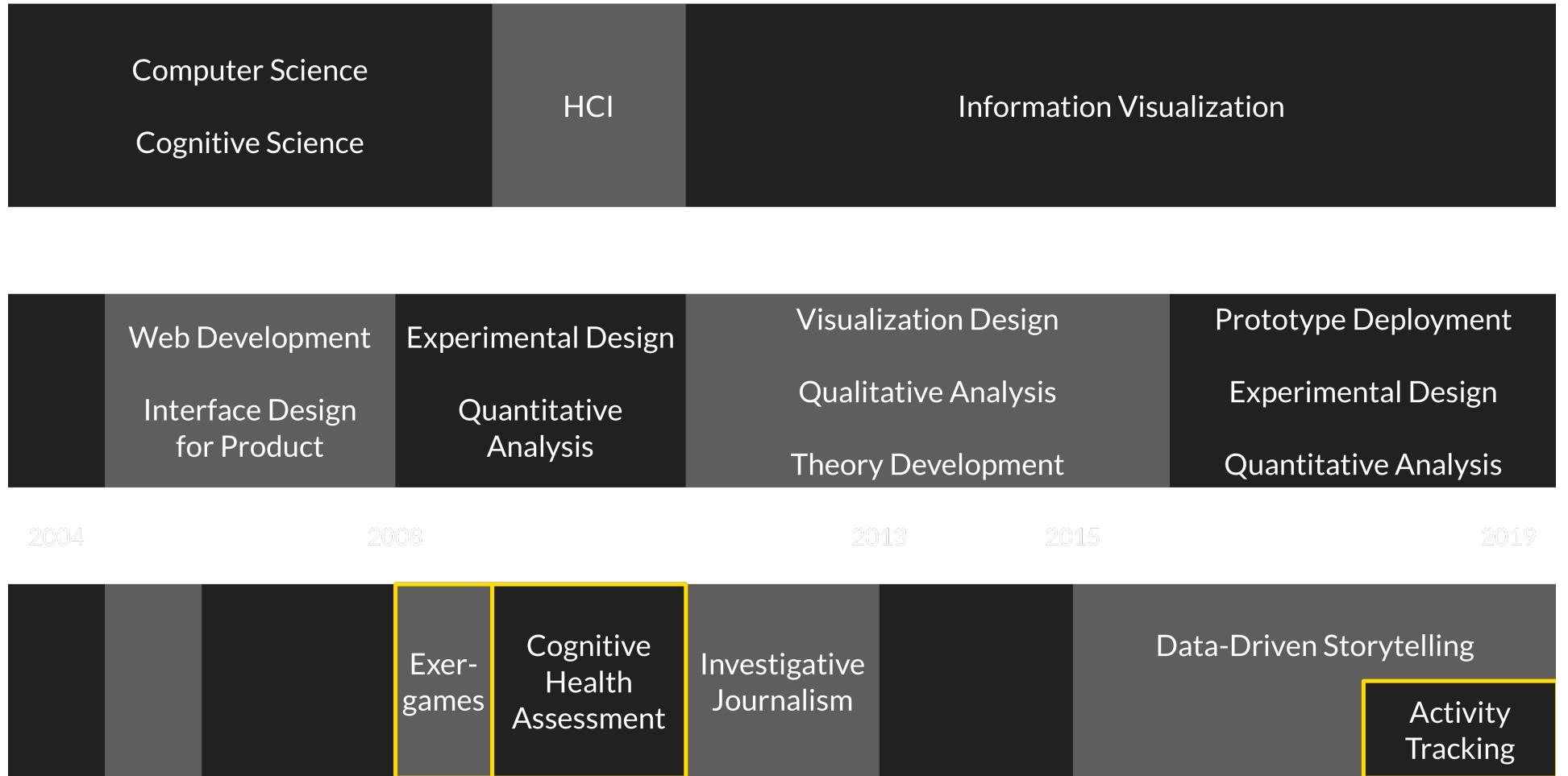
Application Domains: Journalism



❑ Overview: The Design, Adoption, and Analysis of a Visual Document Mining Tool For Investigative Journalists.
Brehmer, Ingram, Stray, and Munzner. In IEEE TVCG(VIS 2014, InfoVis Track).

❑ Timeline Storyteller. Brehmer, Lee, Riche, Tittsworth, Lytvynets, Edge, and White.
In Proc. 2019 Computation + Journalism Symp.

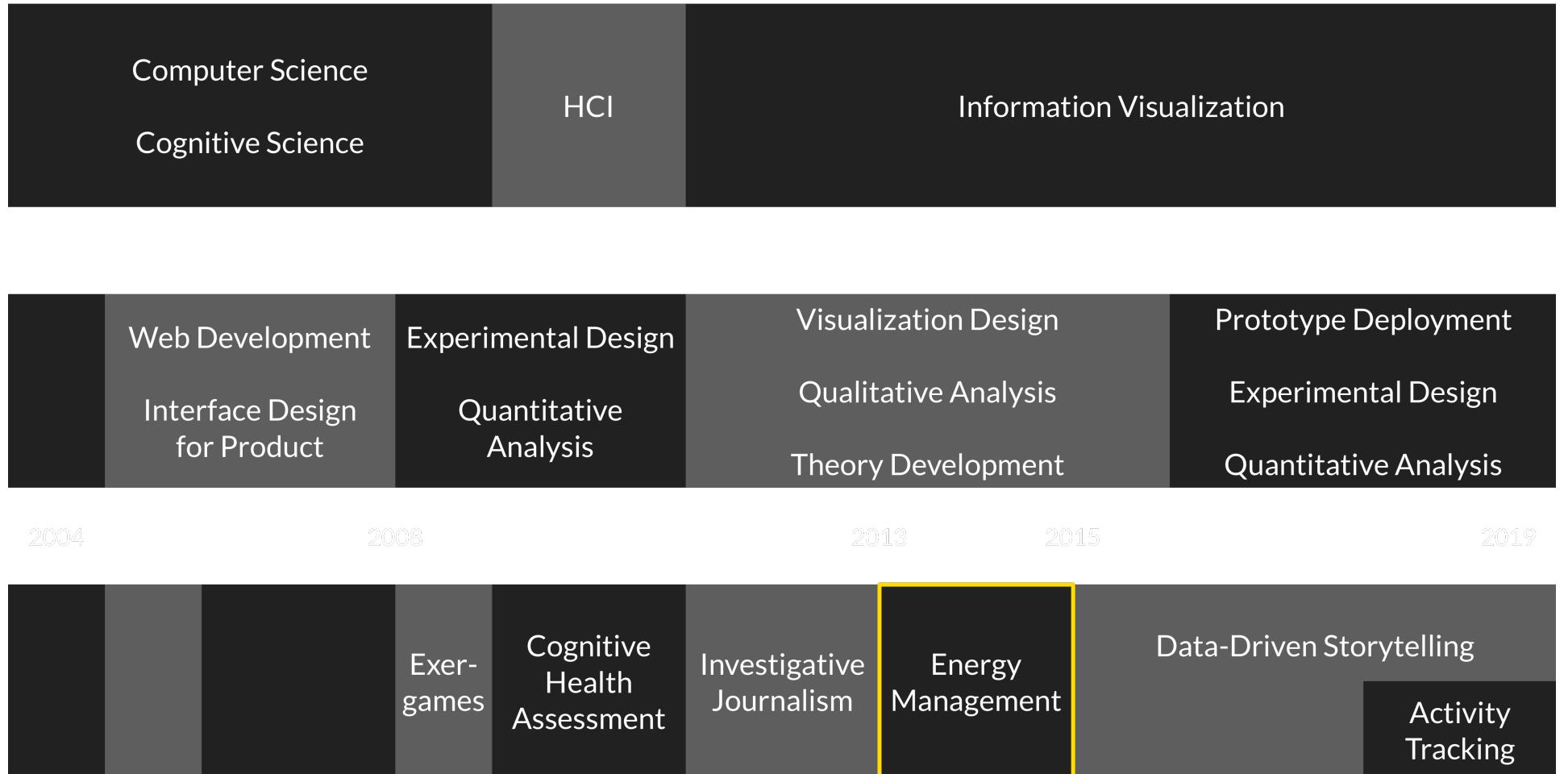
Application Domains: Personal Health



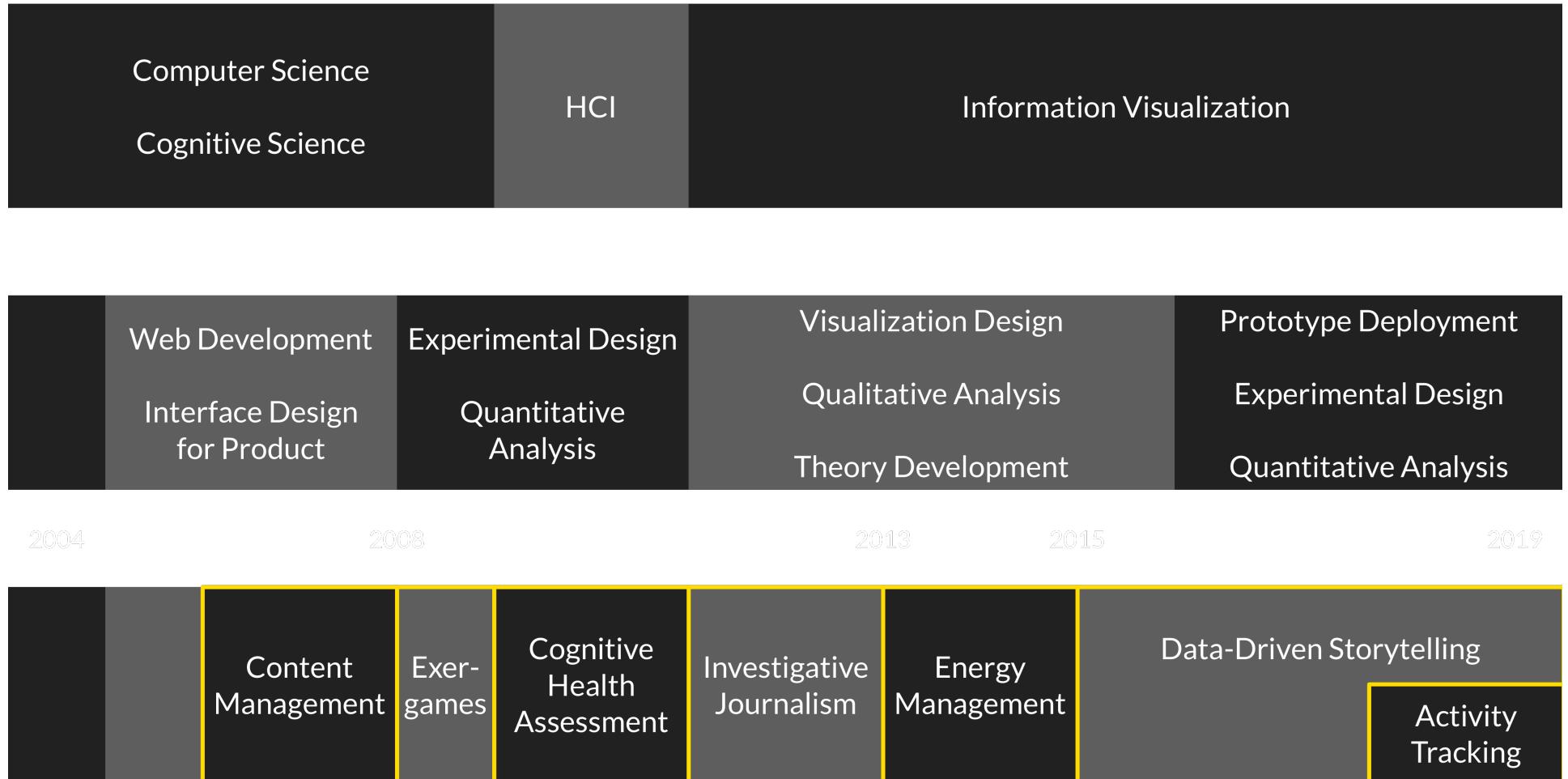
Activate Your GAIM: A Toolkit for Input in Active Games.
Brehmer, Graham, and Stach. In Proc. 2010 ACM Future PlayConf.

Investigating Interruptions in the Context of Computerized Cognitive Testing for Older Adults.
Brehmer, McGrenere, Tang, and Jacova. In Proc. 2012 ACM CHI Conf.

Application Domains: Energy Conservation



Application Domains



Outline

Why Visualization?

Why Expressivity? What are the Constraints?

Why Me?

Focus Section 1: Supporting Expressive Information Design

Focus Section 2: Expressive Information Design for Mobile Devices

Ongoing Work and Future Research Program

Why SIAT?

Focus Section 1

Supporting expressive information design, from guidance to authoring tools.



The "Timeline Saga"

❑ **TimeLineCurator.** Fulda, Brehmer, and Munzner.
In *IEEE TVCG* (MS 2015, VAST Track). timelinecurator.org

❑ **Timelines Revisited.** Brehmer, Lee, Bach, Riche, and Munzner.
In *IEEE TVCG* 2017. timelinesrevisited.github.io

❑ **Timeline Storyteller.** Brehmer, Lee, Riche, Tittsworth, Lytvynets, Edge, and White.
In Proc. 2019 *Computation + Journalism Symp.* timelinestoryteller.com

Timelines Revisited

Timelines tell stories about sequences of events.

How have people drawn timelines over the course of history?

The research community has focused on their use in data analysis.

I focused on their use in **presentation** and **storytelling**,

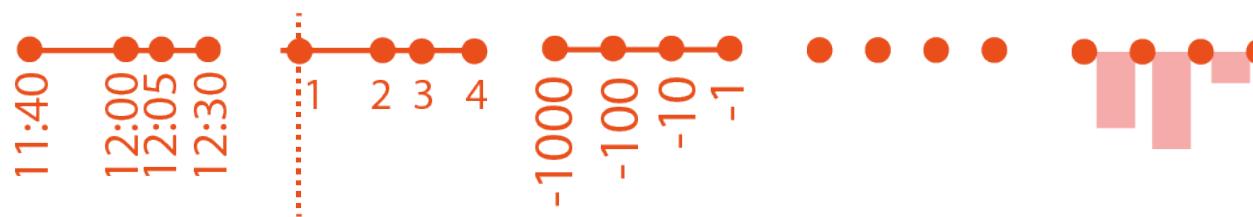
Where the palette of design choices in use was notably larger.

A Timeline Design Space

REPRESENTATION



SCALE



LAYOUT



A Timeline Design Space

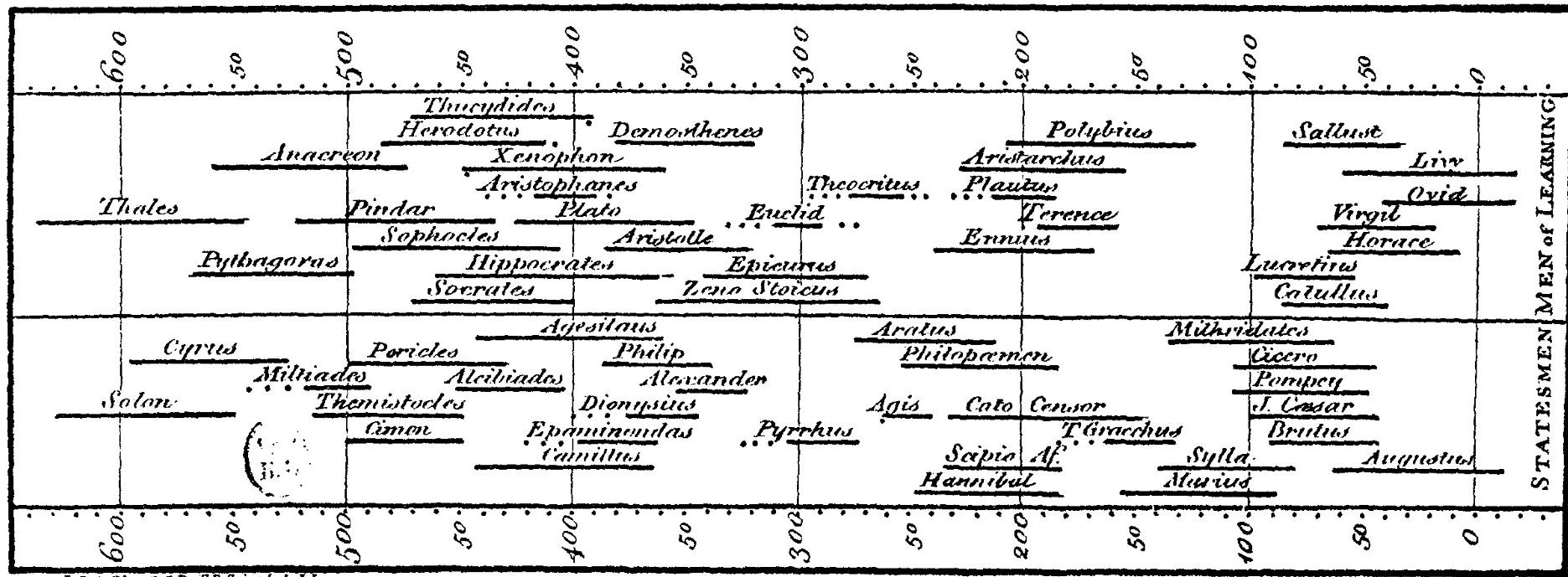
REPRESENTATION



SCALE

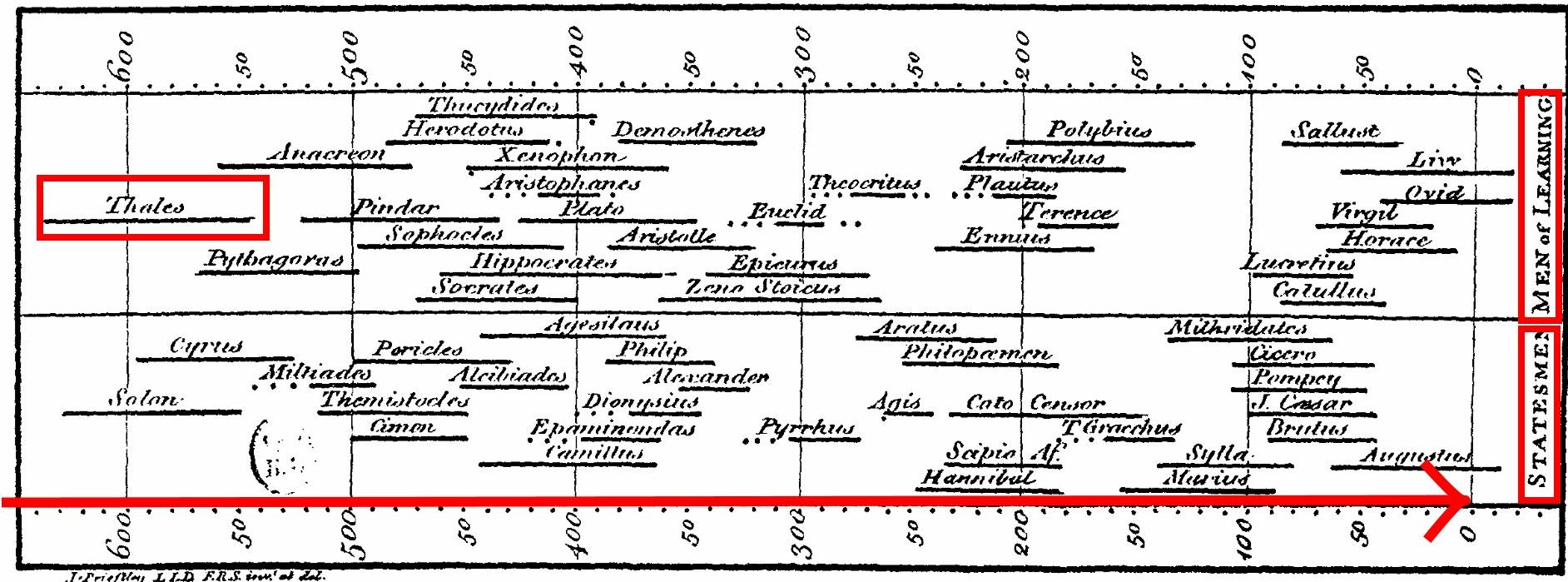
LAYOUT

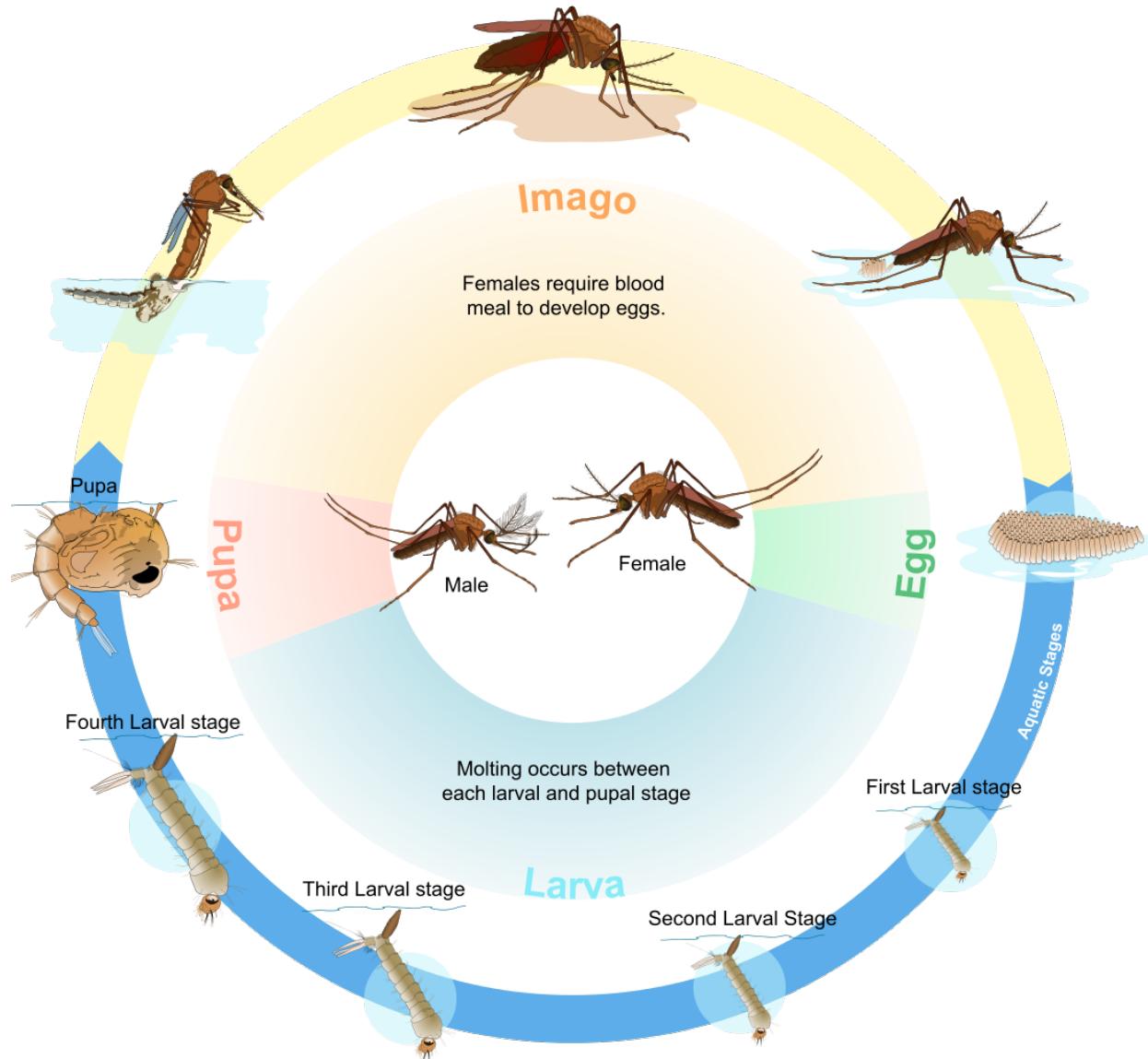
A Specimen of a Chart of Biography.



J. Priestley L.L.D. F.R.S. inv'td. 2d.

A Specimen of a Chart of Biography.





HARPER'S MONTHLY MAGAZINE

Vol. cxxx December, 1914. No. DCCCLXXV

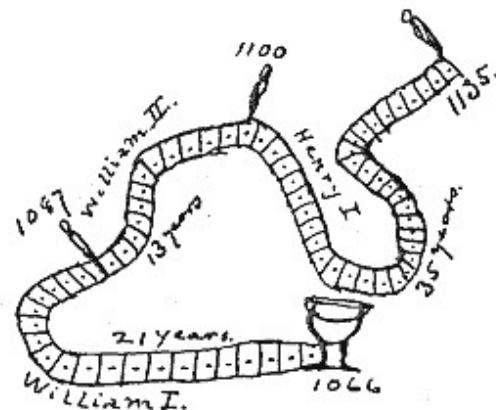
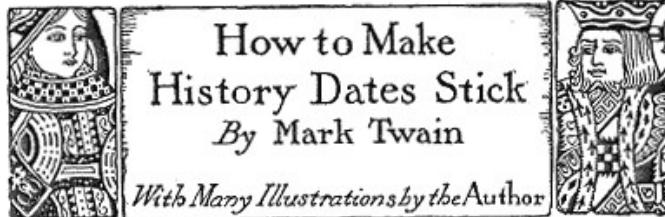


FIG. 2

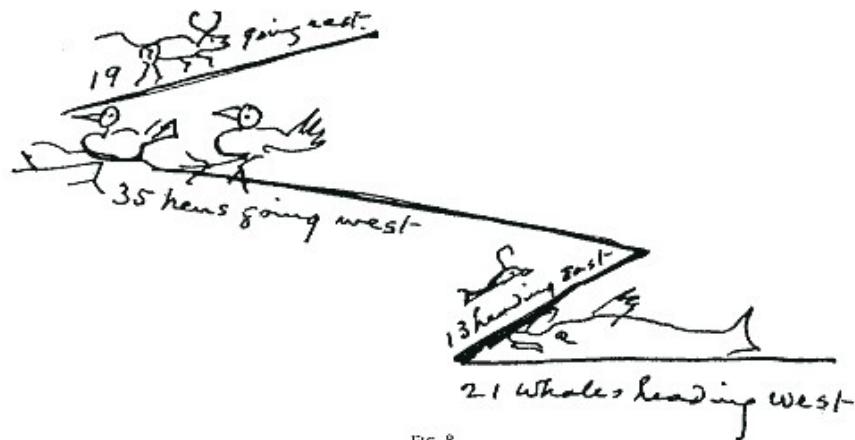


FIG. 8

Common Visual Representations of Time



What is a Timeline For?

What Happened When?

In what sequence did the events occur?

How long did the events last?

How long between event **A** and event **B**?

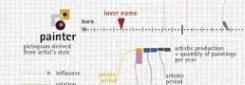
Did **A** and **B** co-occur?

When did **A** and **B** occur relative to event **C**?

Visualising painters' lives

a project by Accurat www.accurat.it/
directed by Giorgia Lupi and Matteo Buttafoglio

how to read it:
shape, elements, lines



Pollock

1912
Jan 25

Cody, United States

1956
Aug 11

Springs, United States

43 y. o.

“What can I say in my paintings? Period. I want to do this as it is now after a sort of ‘get acquainted’ period that I am what I am. I have no desire to change, to change destroying the image, etc. because the painting has a life of its own.”



Dali

1904
May 11

Figueres, Spain

1989
Jan 23

Prats, Majorca, Spain

84 y. o.

“I destroyed half of my work and I wanted to do the same thing for the other half.”



Miro

1893
Apr. 20

Bartolomé, Spain

1983
Dec. 25

Palma, Majorca, Spain

90 y. o.

“You must often wait for the sky on the ground if you want to jump into the air. The fact that I come down to earth again is important to me, because I have to go higher.”



Boccioni

1882
Oct. 19

Reggio Calabria, Italy

1916
Aug. 17

Venice, Italy

33 y. o.

“As I realize when I experimentally, in the living environment, for example, that the subject moves from the regular to the irregular, I feel the need to move more freely to draw inspiration from the irregular movement around me.”



Picasso

1881

Malaga, Spain

1973
Apr. 8

France

91 y. o.

“My mother used to me tell me one of a kind, about her parents. They were a monk, a priest and a Pope. I went to school with them and became Picasso.”



Klee

1879
Dec. 18

Märchenbuch der Bern, Switzerland

1940
Mar. 29

Murten, Switzerland

60 y. o.

“In the large fields of memory, now, when one memory comes, they provide the material for the others.”



Mondrian

1872
July 7

Amerongen, Netherlands

1944
Feb. 11

New York, United States

71 y. o.

“Nature is that which / need inspirer me just as it is with any painter. It is an environment that I have to live in to meet something that will fit into me. I have to live in nature to meet everything that suits / meets the needs of the soul and environment / boundary of things.”



Matisse

1869
Dec. 31

Dauvignac, France

1954
Nov. 3

Vence, France

84 y. o.

“There is nothing more difficult for a painter than to know that he is finished. Because before he can do it he has to find the right of the voice that were his painter.”



Kandinsky

1866
Dec. 16

Moscow, Russia

1944
Dec. 13

Paris-sur-Seine, France

78 y. o.

“The secret heart of Moscow allows to a simple soul, that is a mad, like that of the hawk and all of the birds of prey, to be born in the heart of Moscow, and it is not the most beautiful heart. It is the heart of the hawk, that is to say, it has more relation to the events of the sky than to the events of the earth. In Moscow, the hawk is born, it is born complete and pleased by Moscow, borned.”

Source:
Wikispaces,
Wikpedia,
Britannica,
Google
(April 2013)

01:06

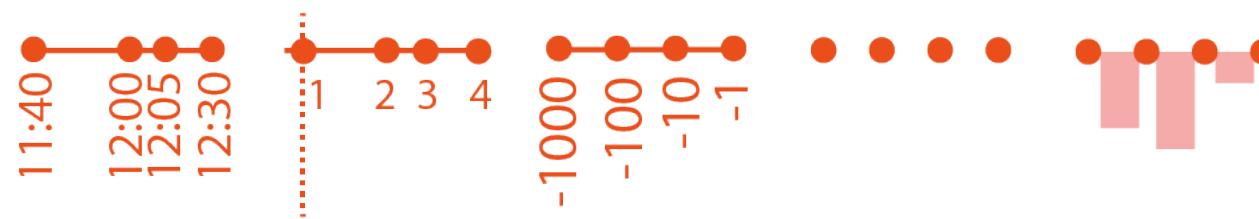


A Timeline Design Space

REPRESENTATION:



SCALE:



LAYOUT:



Research Process

1. I collected and categorized **145** timelines and timeline tools to establish the dimensions.
2. I validated the dimensions of the design space with **118** additional timelines (**263** total).
3. I implemented points in the design space with **28** representative datasets.

1. *Cartographies of Time* (Rosenberg & Grafton),
Visualization of Time-Oriented Data (Aigner *et al.*), *Making Timelines* (Groeger), ...

2. visual.ly, the [Kantar IIB Showcase](#), massvis.mit.edu, ...

3. Survey data and dataset index can be found at timelinesrevisited.github.io.

Purposeful, interpretable, & generalizable timeline designs at timelinesrevisited.github.io

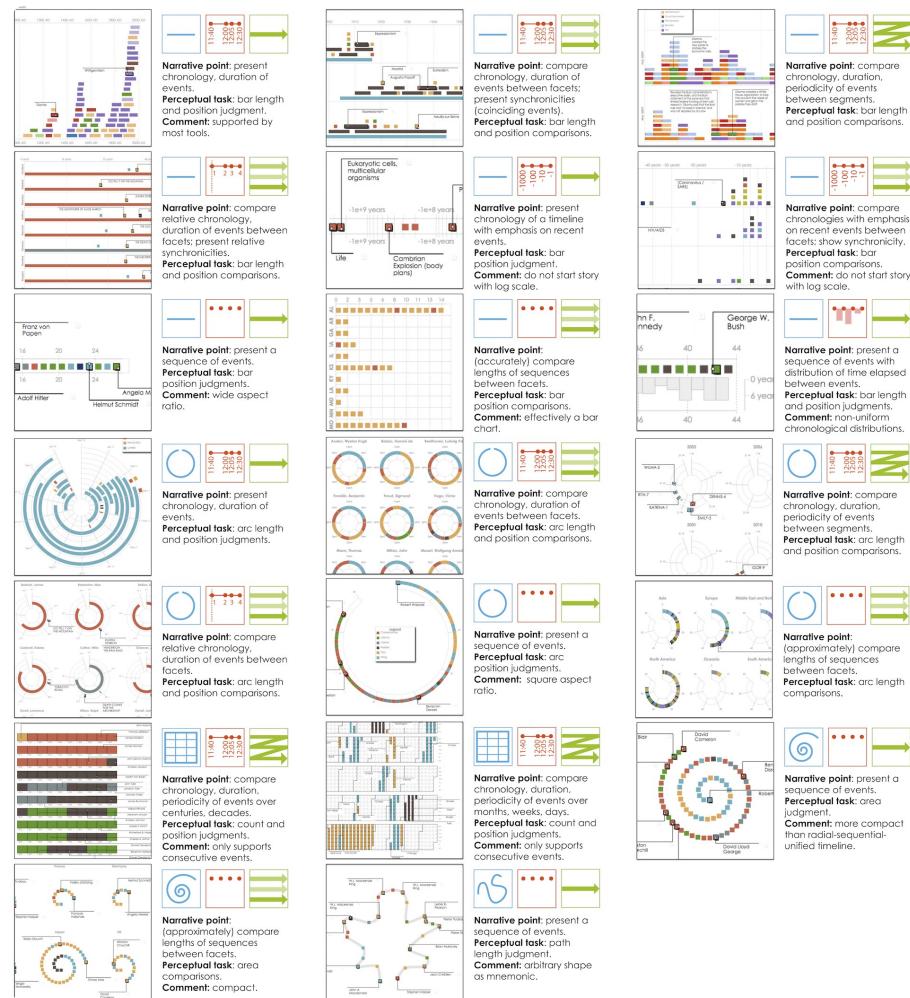
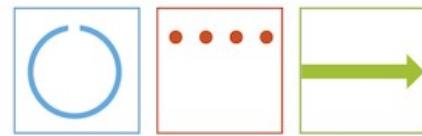
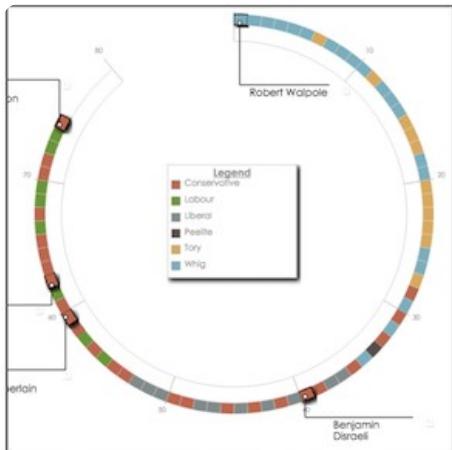


Image: a visual index of points in the timeline design space.

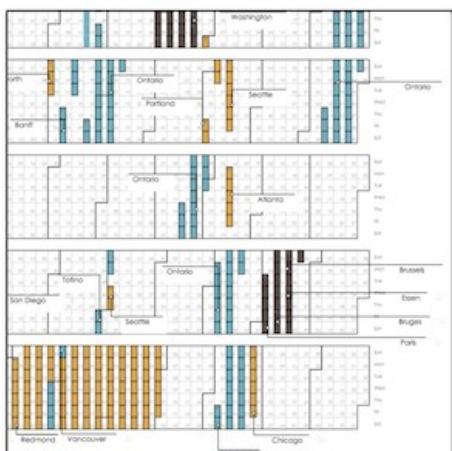
Purposeful, interpretable, & generalizable
timeline designs at timelinesrevisited.github.io



Narrative point: present a sequence of events.

Perceptual task: arc position judgments.

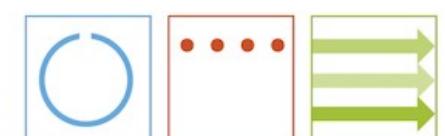
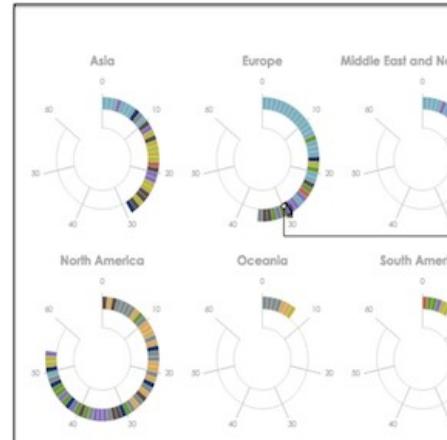
Comment: square aspect ratio.



Narrative point: compare chronology, duration, periodicity of events over months, weeks, days.

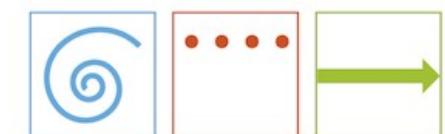
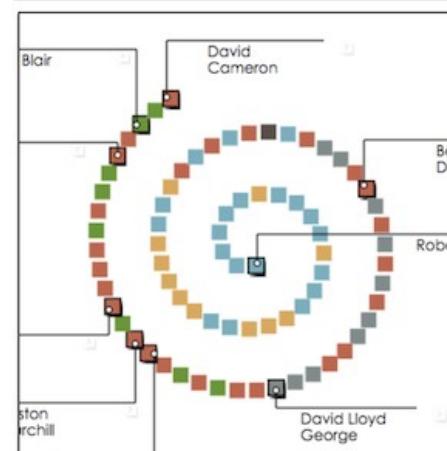
Perceptual task: count and position judgments.

Comment: only supports consecutive events.



Narrative point: (approximately) compare lengths of sequences between facets.

Perceptual task: arc length comparisons.



Narrative point: present a sequence of events.

Perceptual task: area judgment.

Comment: more compact than radial-sequential-unified timeline.

Using our Timeline Design Space

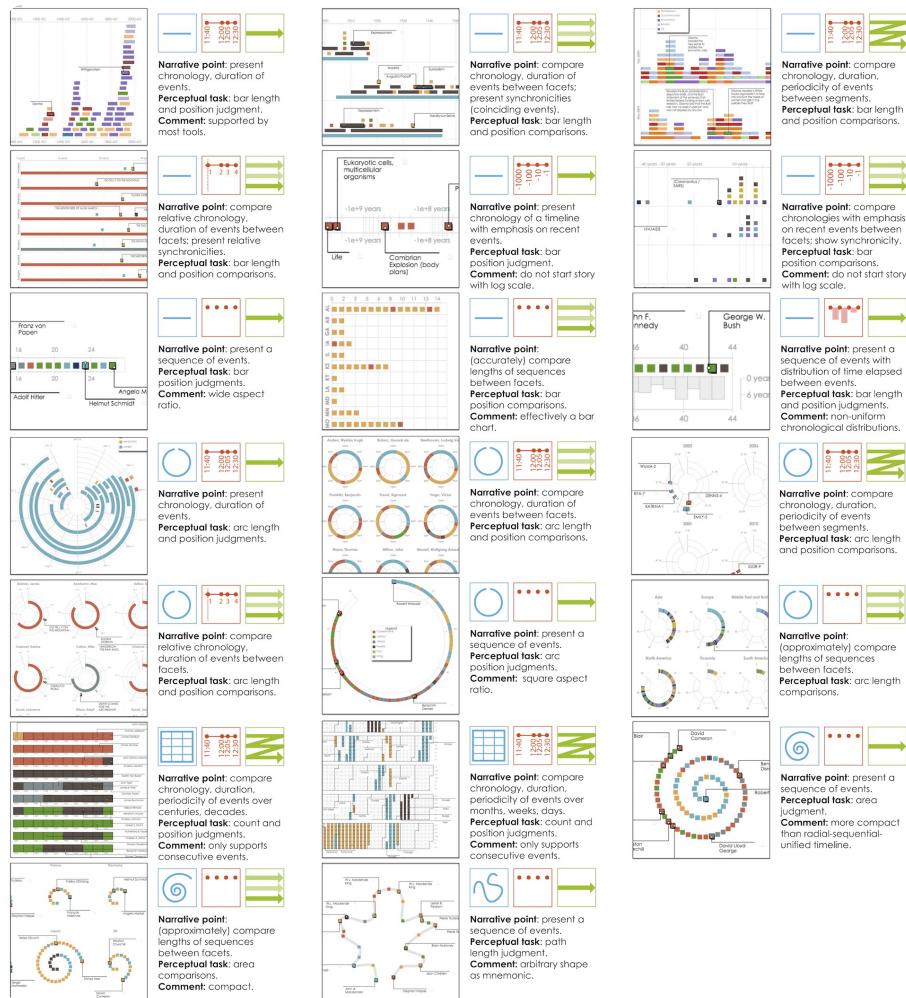


Image: a visual index of points in our timeline design space.

Expressive Storytelling with Timelines

Provide alternative representations for time, and

Provide alternative time scales.

Anticipate chronological or non-chronological narratives.

Incrementally reveal visual elements, selectively highlighting and annotating to direct attention.

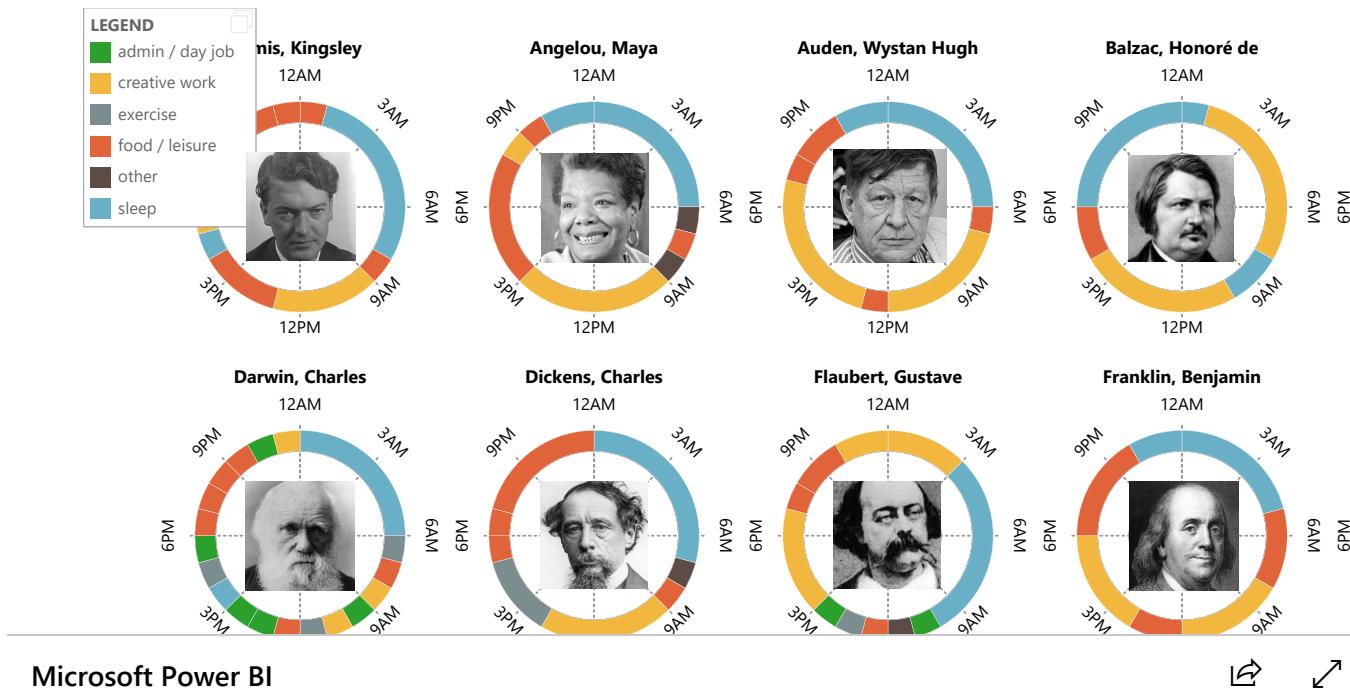
Timeline Storyteller

Produce visually expressive timeline narratives in the browser or in [Microsoft Power BI](#).



timelinestoryteller.com

The Daily Routines of Famous Creative People



Evaluating Timeline Storyteller

A laboratory study to assess expressivity seemed to be inappropriate.

Can I better understand how people use it with their own data?

How does the content they produce reflect my timeline design space?

Promoting Timeline Storyteller

I demonstrated it at the 2017 [Tapestry Conference](#) and at [OpenVisConf](#) 2017.

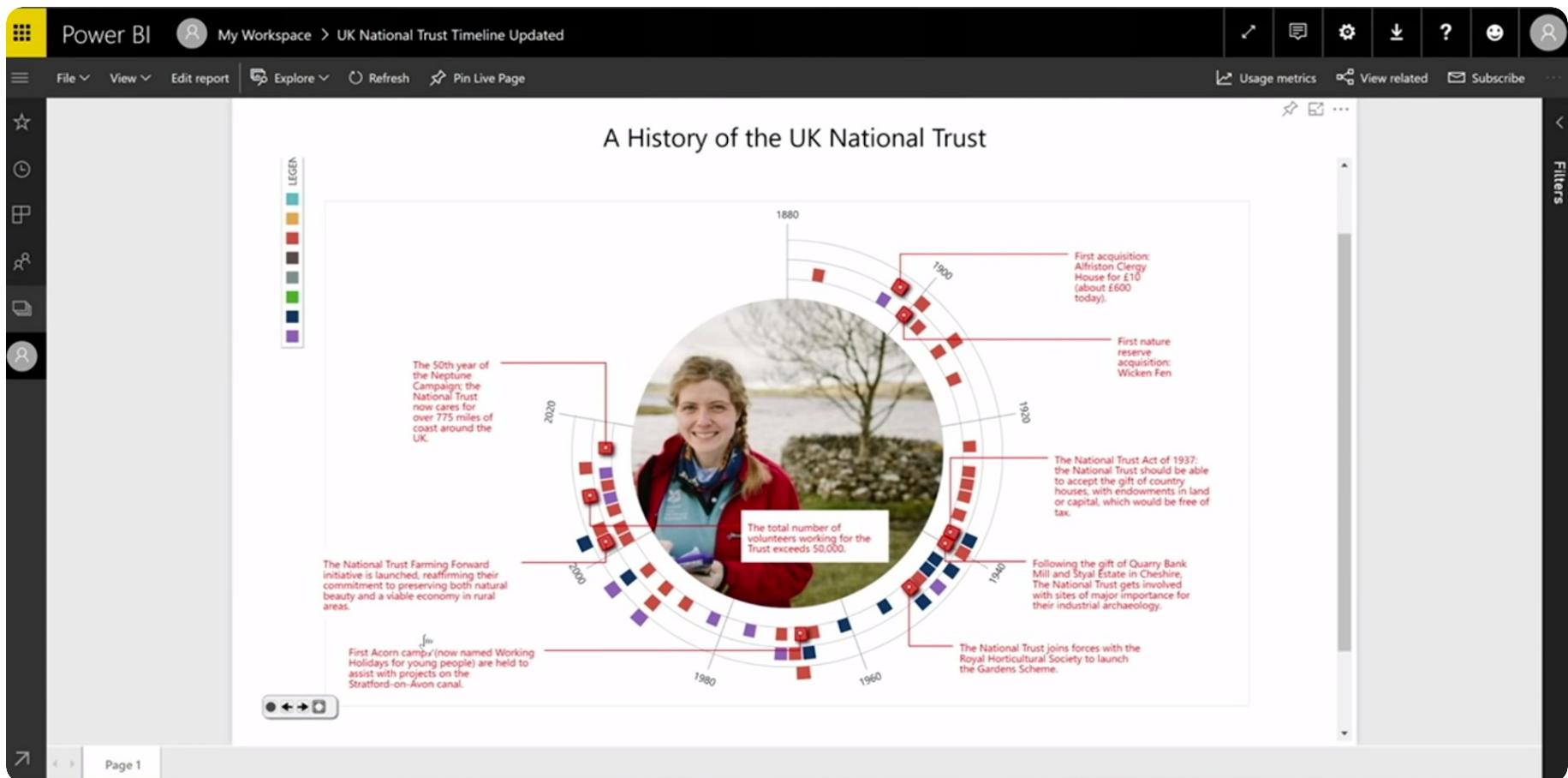
Meanwhile, my collaborator (Chris White) used it in his keynote at the 2017 [Dublin Data Summit](#),

And Microsoft's Data Journalism Team demonstrated it at the 2017 [Future of Storytelling Summit](#).

I wrote about it on the official [Power BI Blog](#), and along with the Data Journalism Team

I produced a tutorial and interview for the [Power BI YouTube channel](#).

Promoting Timeline Storyteller (cont.)



A customer demonstrated it in the opening keynote of the 2017 Data Insights Summit.

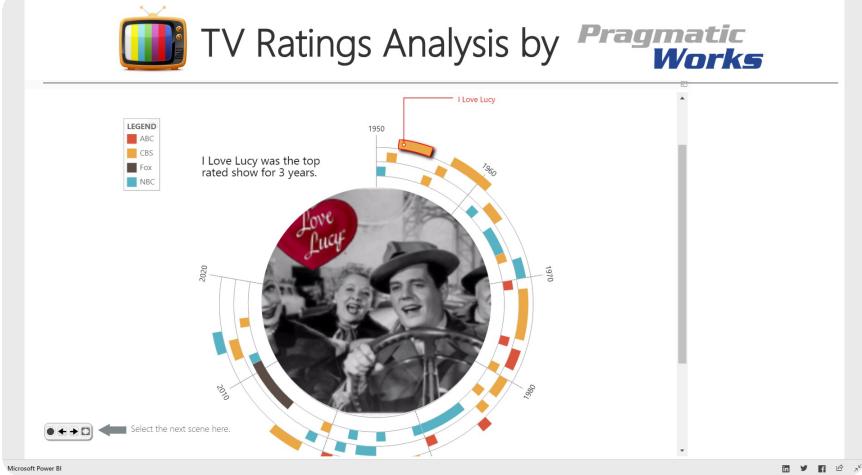
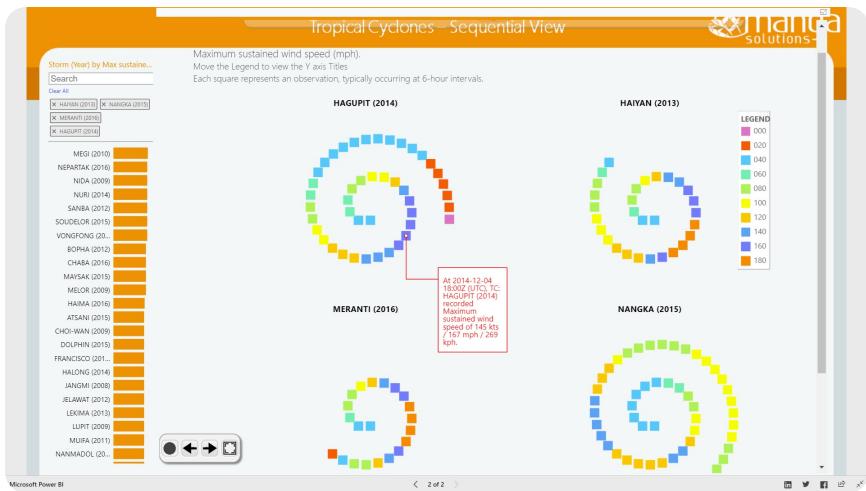
Timeline Storyteller: Collecting Usage Data

I collected entries from a data storytelling contest held with the Power BI user community.

I collected exported content from the web version, and

I tracked download metrics of the Power BI desktop version.

Timeline Storyteller: Contest Winners



[L] *Tropical Cyclones* by Manga Solutions (2017).

[R] *TV Network Ratings* by Pragmatic Works (2017).

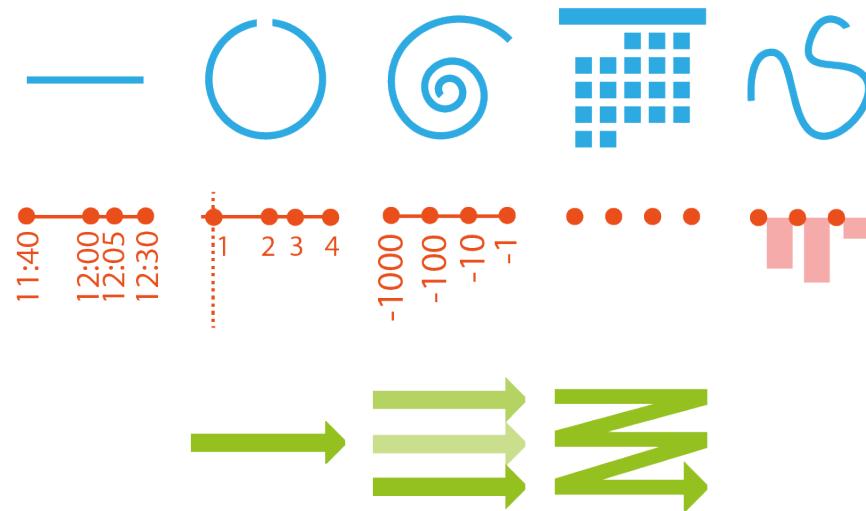
Timeline Storyteller: Content Analysis

I examined exported content from the web version (subject to author consent).

This resulted in a corpus of 223 unique artifacts,

Which spanned my timeline design space (with a couple of exceptions),

Though the Linear representation and Chronological scale were most common.



Timeline Storyteller: Usage Metrics*

Over 36,000 downloads of the Power BI version.

Over 51,000 views of our YouTube tutorial.

Over 150 stars of Github repository.

Timeline Storyteller: Lessons Learned

You can never have enough **tutorial content** and **design inspiration**.

I could recommend **design choices** and **annotations**.

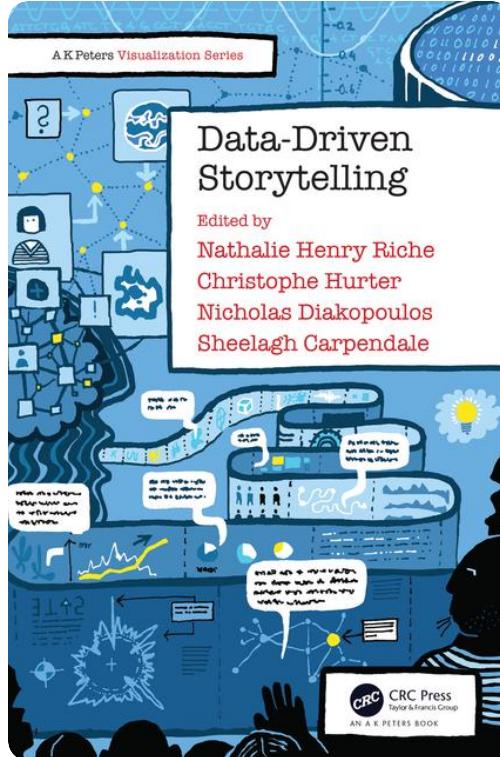
The viewing experience ought to be **more responsive**.

Other Expressive Information Design Tools



I also contributed to the [ChartAccent](#), [DataToon](#), & [Charticulator](#) projects.

Evaluating Data-Driven Stories



We catalog relevant perspectives, criteria, methods, and metrics for evaluating data-driven stories.

Outline

Why Visualization?

Why Expressivity? What are the Constraints?

Why Me?

Focus Section 1: Supporting Expressive Information Design

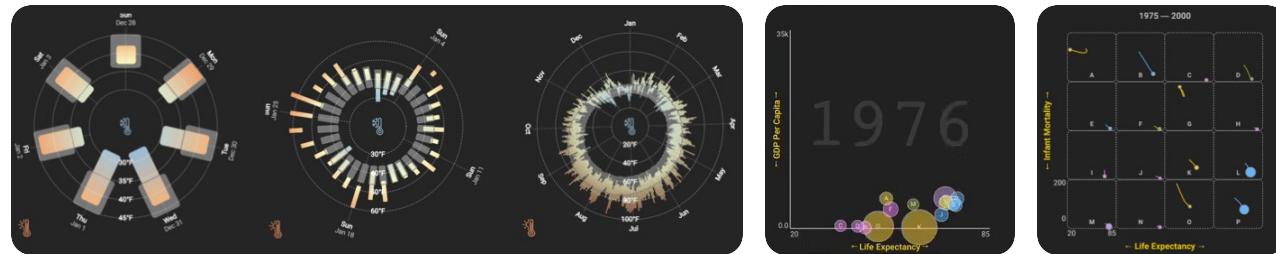
Focus Section 2: Expressive Information Design for Mobile Devices

Ongoing Work and Future Research Program

Why SIAT?

Focus Section 2

Expressive Information Design for Mobile Devices

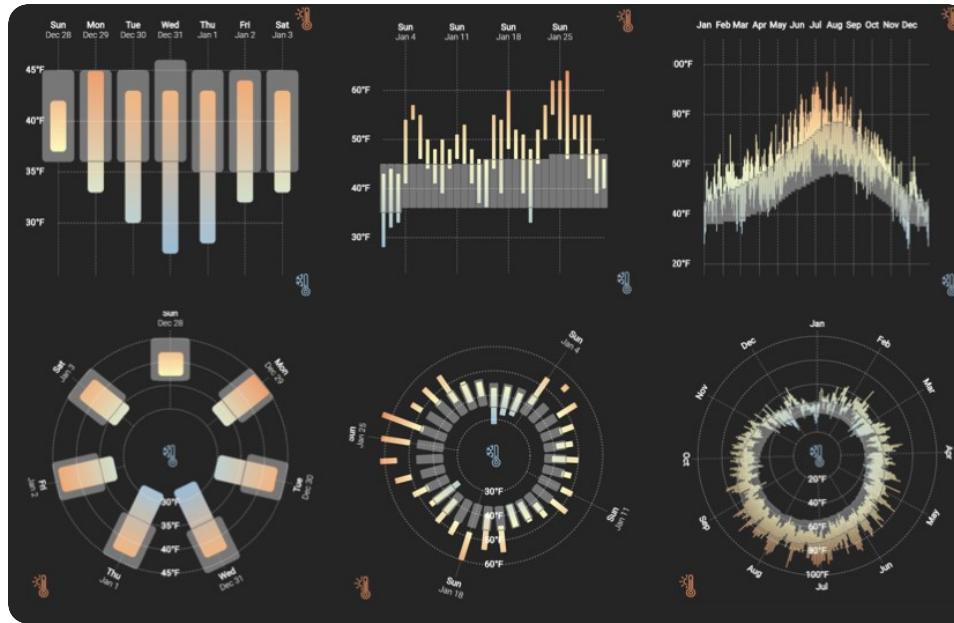


■ *Data Visualization on Mobile Devices*.
Lee, Brehmer, Isenberg, Choe, Langer, and Dachselt.
In Extended Abstract Proc. 2019 ACM CHI Conf.

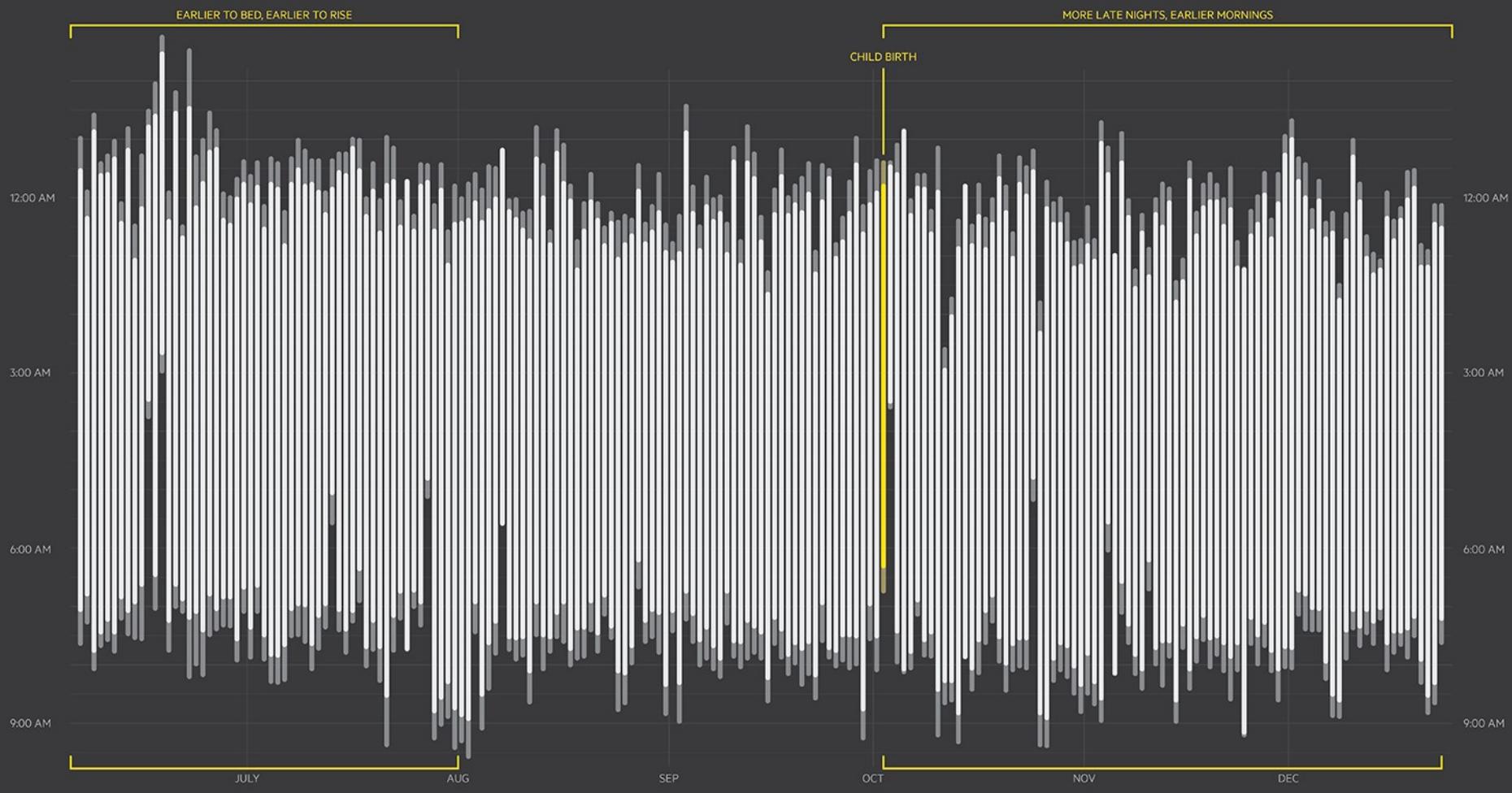
■ *Visualizing Ranges over Time on Mobile Phones: A Task-Based Crowdsourced Evaluation*.
Brehmer, Lee, Isenberg, and Choe. In IEEE TVCG (VIS 2018, InfoVis Track).

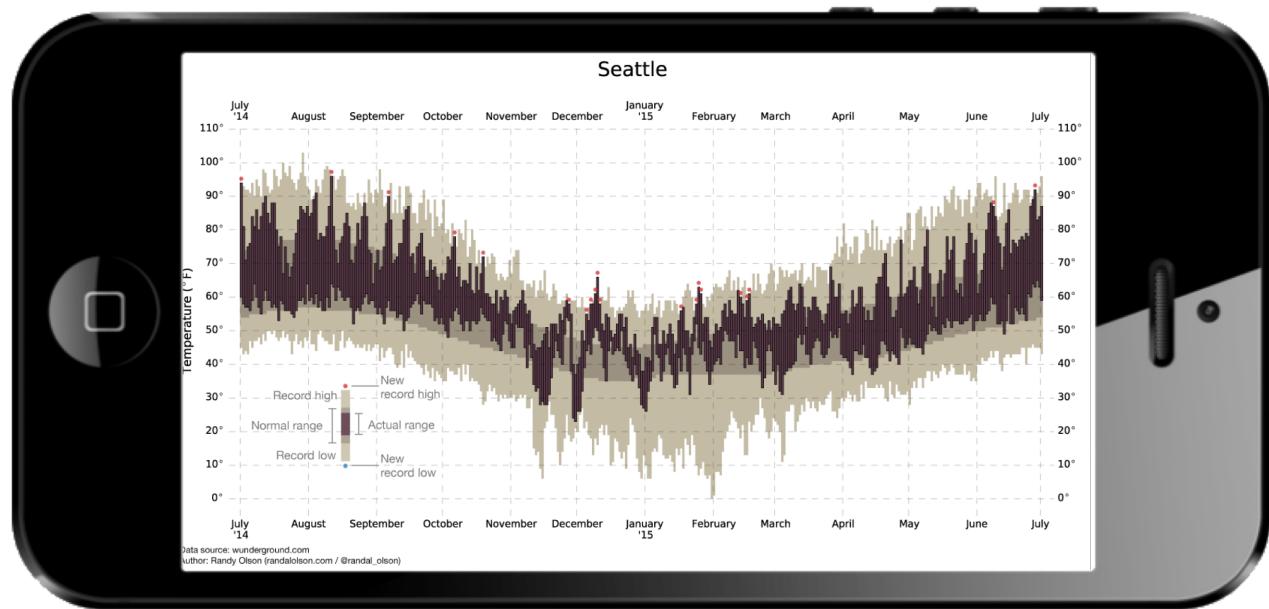
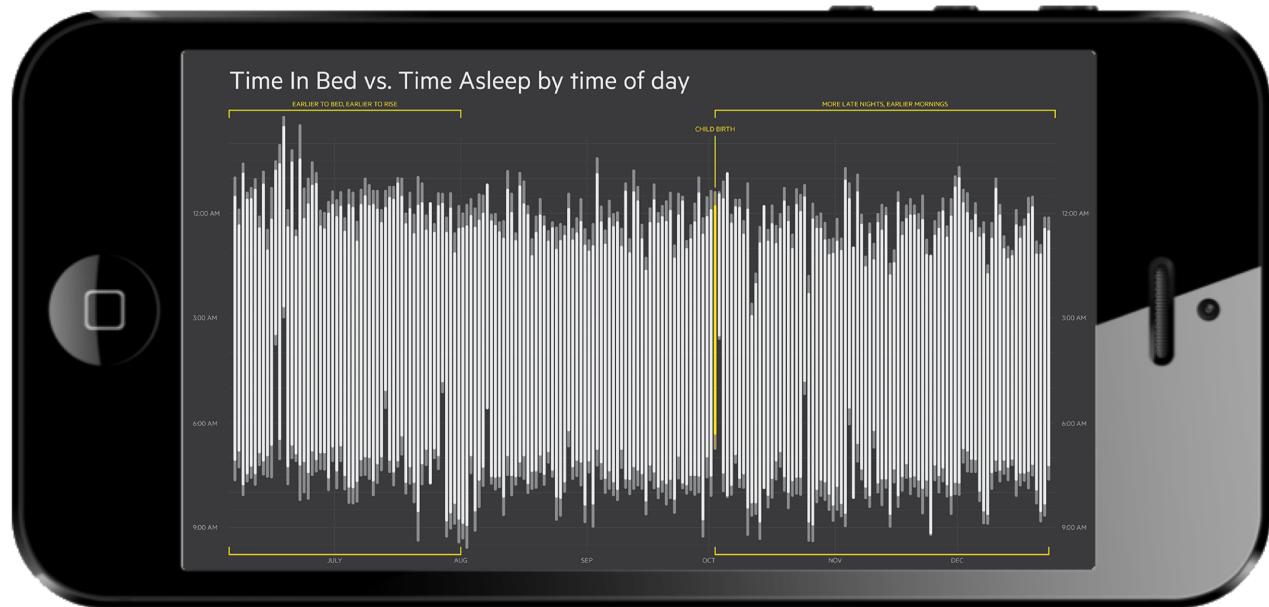
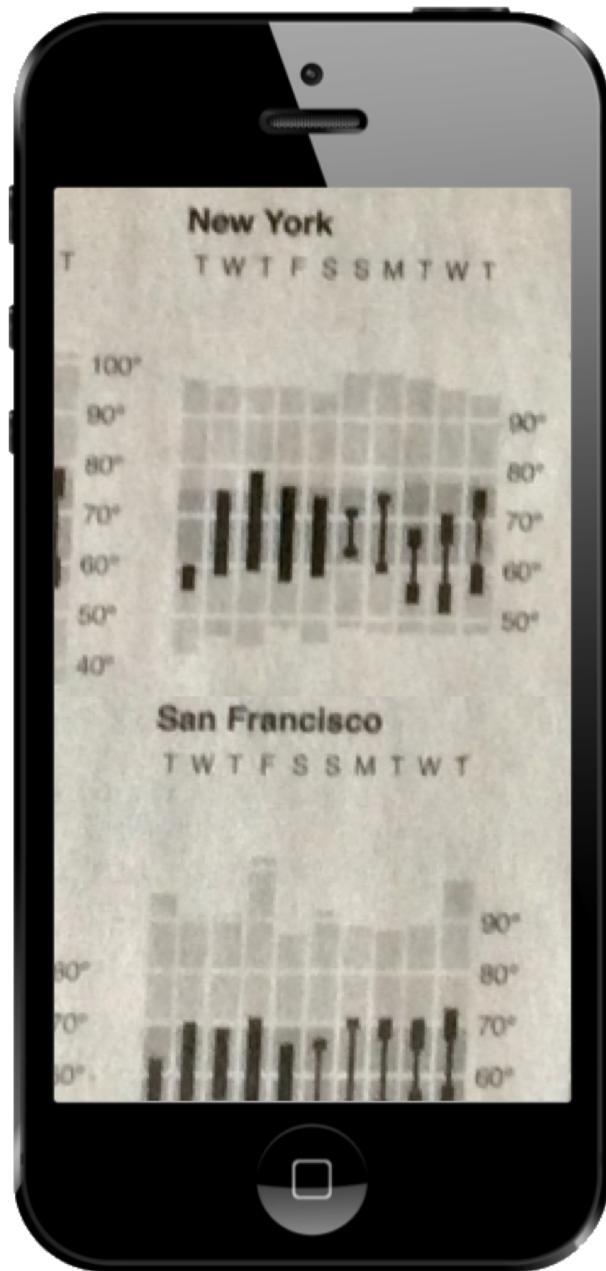
■ *Too Small for Multiples? Animated vs. Faceted Trend Visualization on Mobile Phones*.
Brehmer, Lee, Isenberg, and Choe. arXiv (cs.HC) preprint, Jan. 2019.

Visualizing Ranges Over Time on Mobile Phones



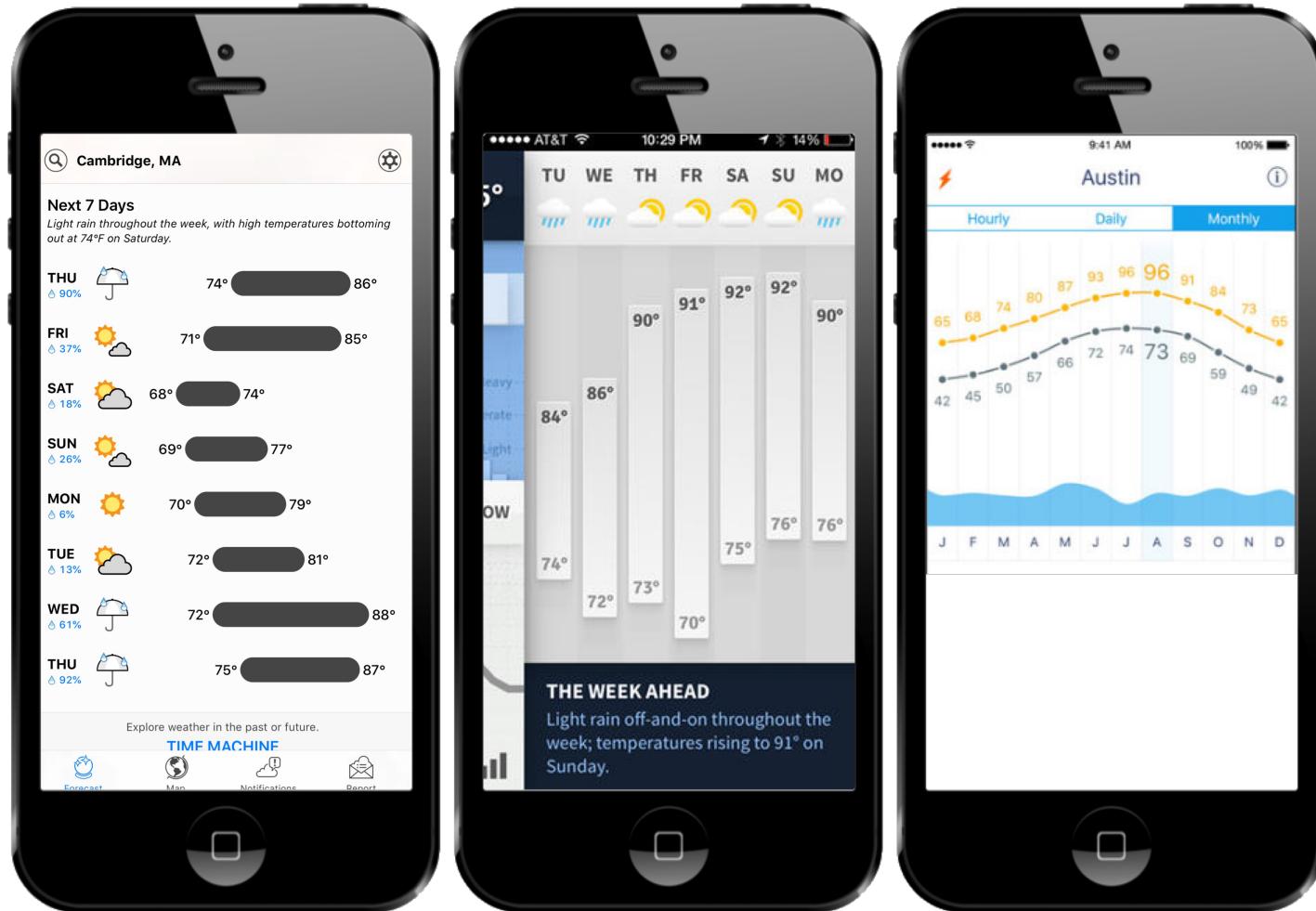
Time In Bed vs. Time Asleep by time of day





Images (clockwise from left): *The New York Times* · Eric Boam · Randy Olson.

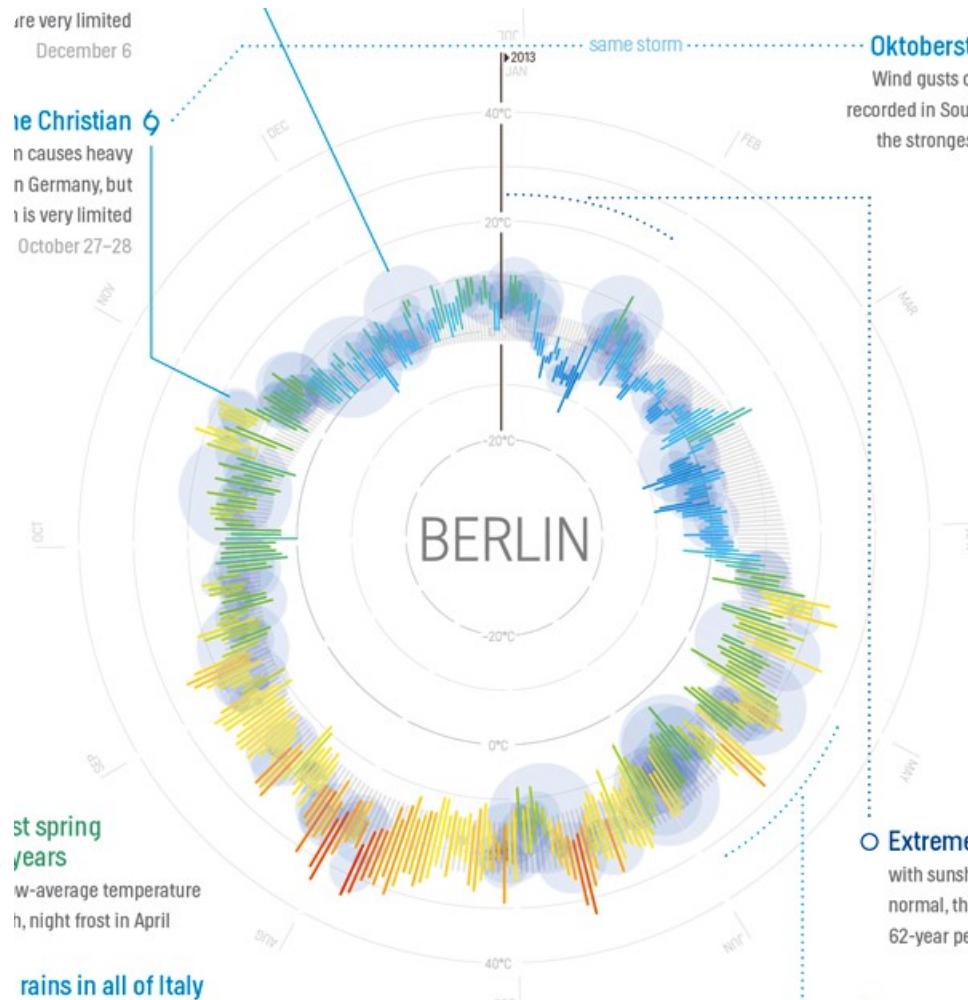
Ranges in Weather Apps



Ranges in Sleep Tracking Apps

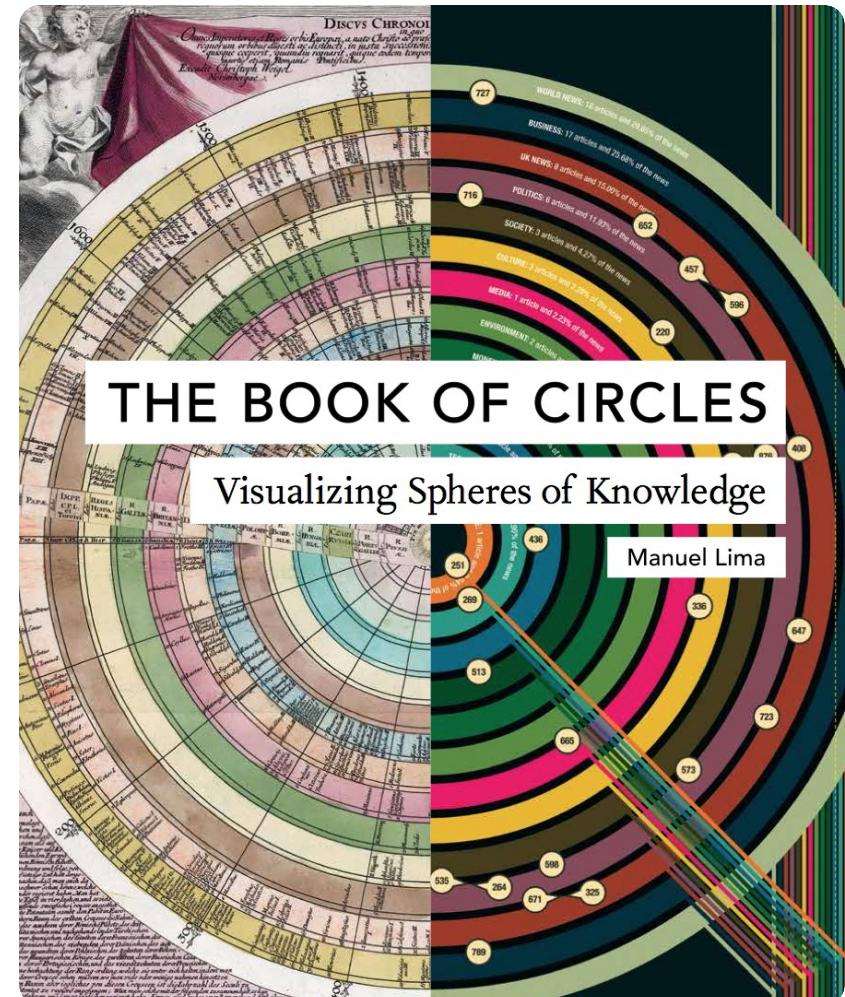


Ranges and Radial Representations



Oktobersturm

Wind gusts of 1 recorded in South
the strongest v





SMARTPHONE

TABLET

ALL

CIRCLE 28

BAR 20

LINE 14

MAP 11

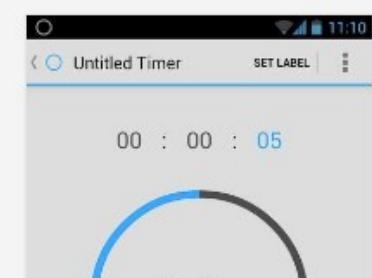
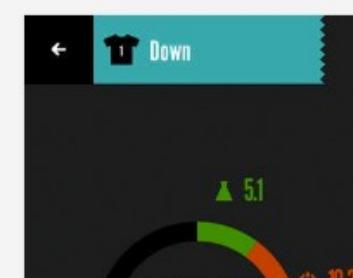
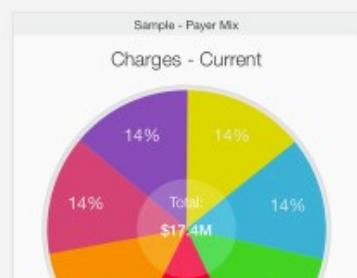
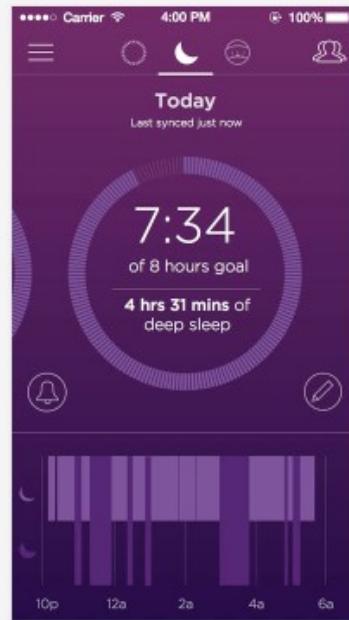
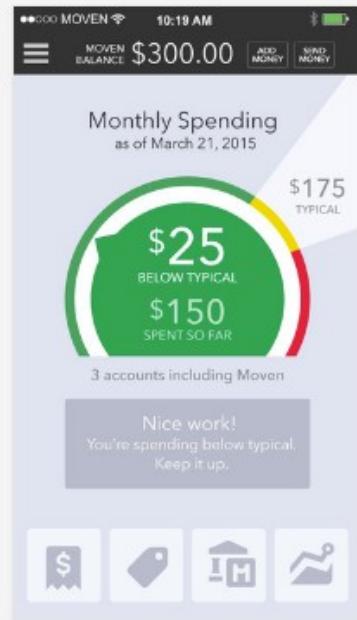
AREA 9

POINT 6

TEXT 4

TABLE 1

NETWORK 1



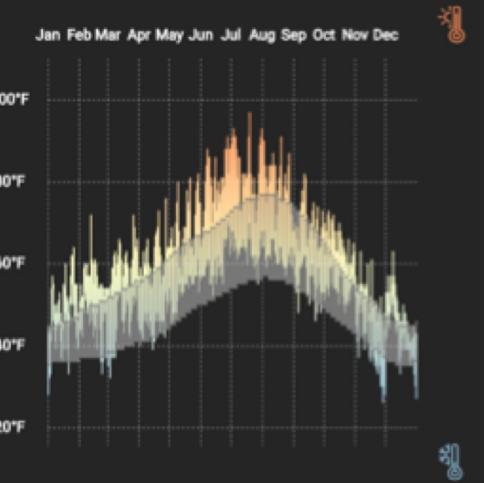
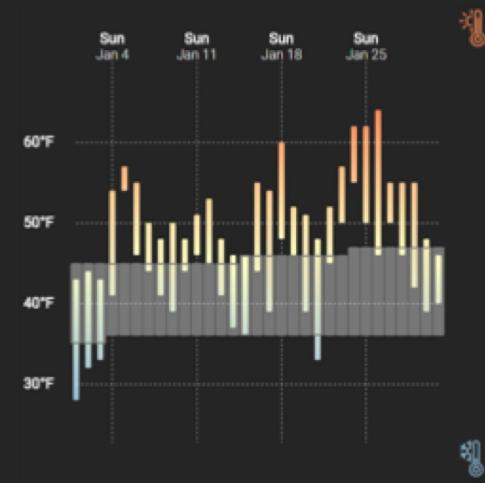
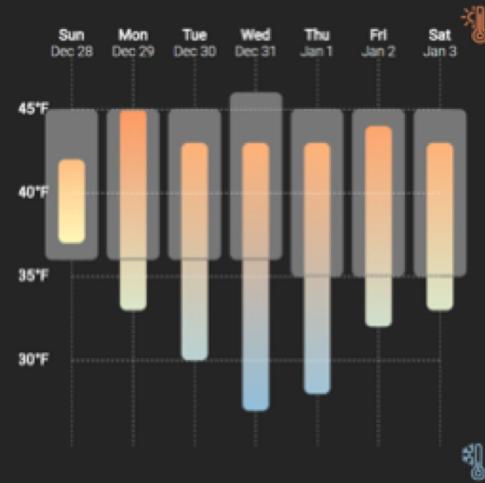
A Crowdsourced Experiment on Mobile Phones

Week

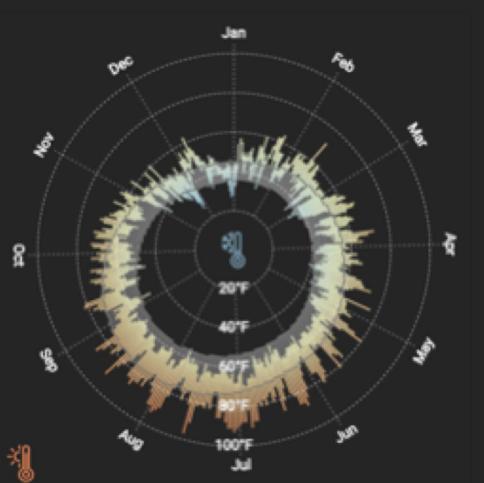
Month

Year

Linear



Radial



Experimental Tasks

Locate Dates

Read Values

Locate Extreme Values

Compare Values

Compare Ranges

Dependent Measures

For each trial:

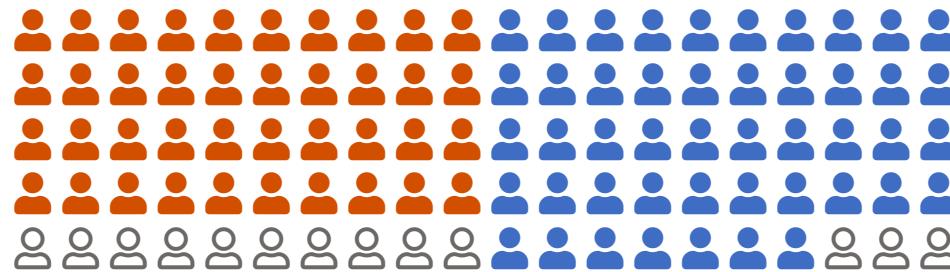
-  Trial completion time
-  Response accuracy

At each level of granularity:

-  Preference: Linear or Radial
-  Confidence: Low (1) to High (5)

Participants

Temperature (N = 40), Sleep (N = 47)



84 trials per participant, 20 - 25 minutes to complete full experiment

Radial or Linear?

People are, in general, slower with radial representations.

Only in some data + task contexts are people less accurate with a radial representation
(i.e., reading and locating values in the absence of seasonal variation).

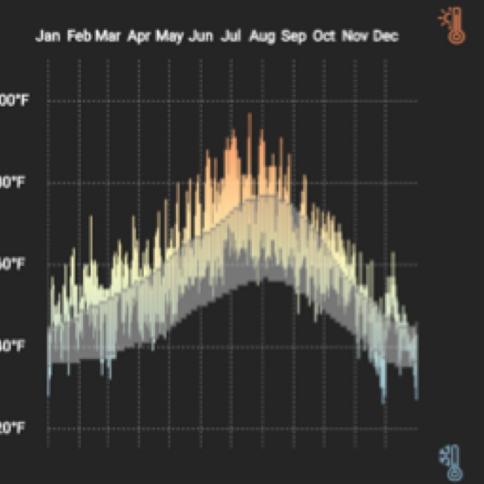
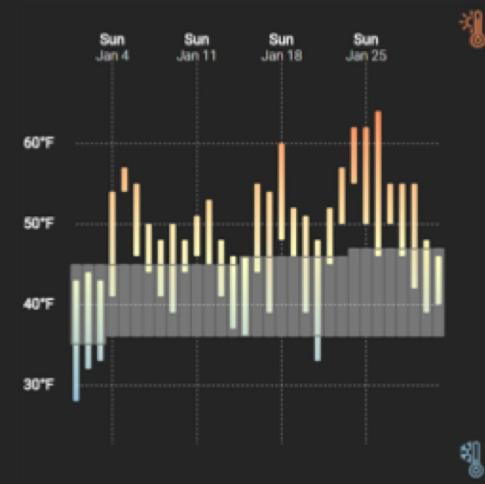
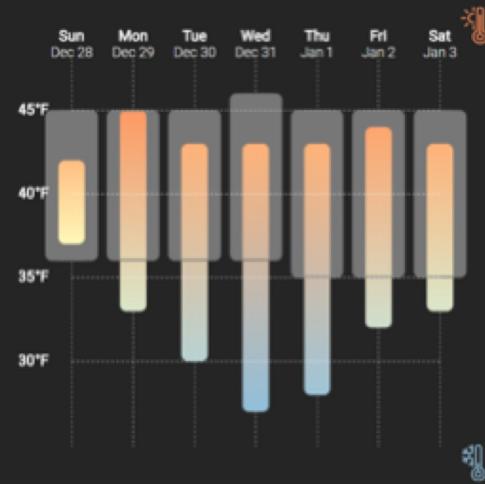
People prefer (and are more confident with) linear representations

Week

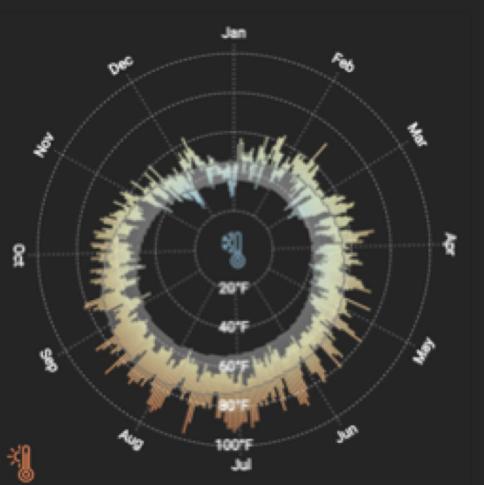
Month

Year

Linear



Radial



Week vs. Month vs. Year

People are typically slower with a month than with a week of ranges.

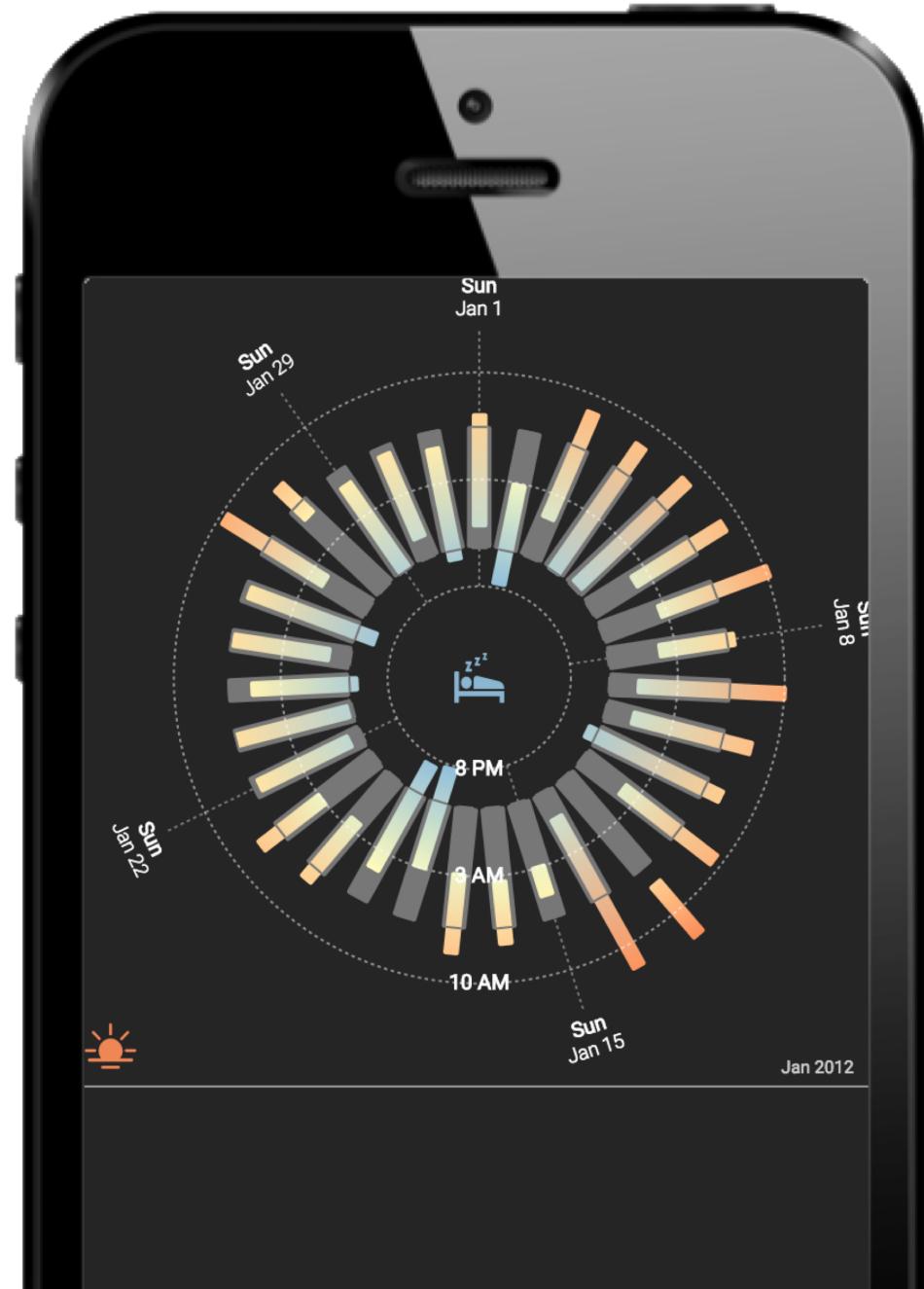
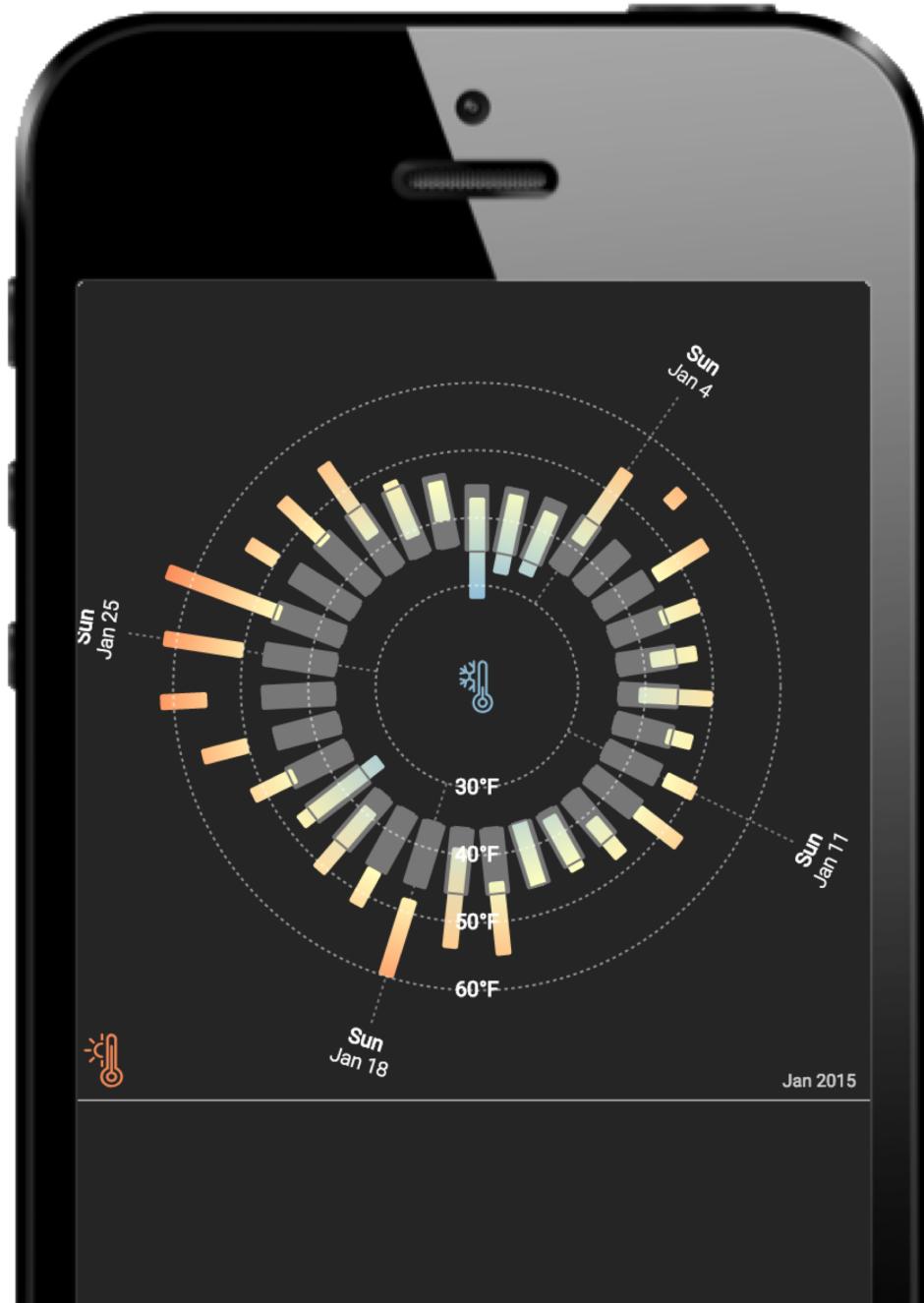
For some tasks, people were less accurate with a month than with a year.

The seasonal variation in annual temperature appears to be beneficial for locating extreme values.

For complete inferential statistics for each task, see the paper:

 *Visualizing Ranges over Time on Mobile Phones: A Task-Based Crowdsourced Evaluation.*
Brehmer, Lee, Isenberg, and Choe. In *IEEE TVCG*(VIS 2018, InfoVis Track).

Temperature (L) and Sleep (R) don't follow monthly cycles.



Selecting an Appropriate Representation and Granularity

Is a cycle meaningful in the context of the data?

Is the task involve locating values? Or comparing them?

Is efficiency the primary consideration?

Locating values quickly? → Choose Linear.

Comparing values (and unconcerned with speed)? → Choose Radial or Linear.

Visualizing Ranges Over Time on Mobile Phones

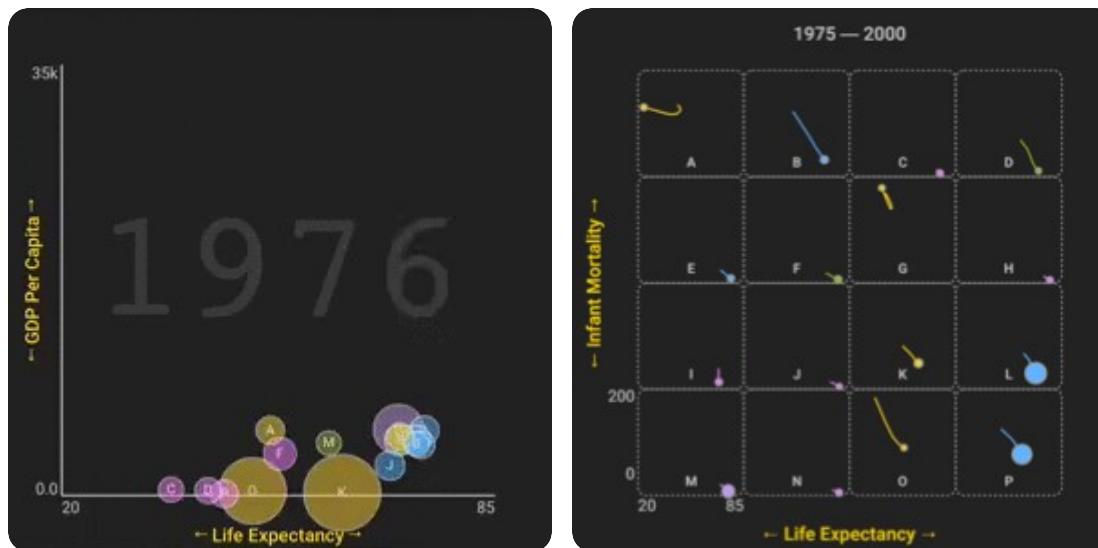
(mobile only) experimental app: aka.ms/ranges

code: github.com/microsoft/RangesOnMobile

blog post: medium.com/multiple-views-visualization-research-explained

Visualization for Mobile Devices, Continued:

Animation vs. Small Multiples for Trend Visualization



Outline

Why Visualization?

Why Expressivity? What are the Constraints?

Why Me?

Focus Section 1: Supporting Expressive Information Design

Focus Section 2: Expressive Information Design for Mobile Devices

Ongoing Work and Future Research Program

Why SIAT?

Expressive Information Design with Pen + Touch Interaction

I envision **performative** and **whimsical** approaches to data-driven storytelling.

Visualization for Mobile Phones

I will test alternative **multidimensional glyph** designs for activity tracking.

Visualization for Mobile Phones

I am designing **discoverable interactions** for navigating time-varying data.

Opportunities for Expressive Information Design

A Research Program

Democratizing Data Visualization

I will strive to support those without programming expertise, design expertise, and other resources, Such as small or local newsrooms, educators, cultural institutions, and curators of digital collections.

Expressive Information Design & Emerging Technology

I will think beyond the mouse and keyboard and consider multimodal human-information interaction, Such as with mobile, pen + touch, wearable, and mixed reality devices, While ensuring that these interactions are discoverable, useful, and enjoyable.

Expressive Information Design and The Attention Economy

I will design **inviting**, **engaging**, and **memorable** techniques for use in data-driven storytelling,

Which can be used to produce stories that are **personally-relevant** to the viewer,

While identifying, testing, and disseminating **expressive information design patterns** along the way.

Expressive Information Design to Boost Graphicacy

I will design and test techniques that aim to improve visual / data / statistical literacy / **graphicacy***,

From annotation and textual explanation to juxtaposing complementary visual representations,

With a particular focus on **communicating uncertainty in data**.

* *Uncertainty, graphicacy, and the power of statistics.*

Alberto Cairo (Oct 18, 2017), thefunctionalart.com.

Expressive Information Design for Decision Support

I will design and test techniques that aim to help people make better decisions grounded in data,
Such as decisions about health, finance, civic engagement, and resource conservation,
While considering the context and device in which this information manifests.

Outline

Why Visualization?

Why Expressivity? What are the Constraints?

Why Me?

Focus Section 1: Supporting Expressive Information Design

Focus Section 2: Expressive Information Design for Mobile Devices

Ongoing Work and Future Research Program

Why SIAT?

Why SIAT?

The students are trained in information design, visual communication design, and interaction design.

There is potential to collaborate on projects on resource conservation, health, and cultural heritage.

Cascadia (Vancouver, Victoria, Seattle) is the world's best place to do visualization research.

It is the ideal place to establish an Expressive Information Design group.

Constraints and Opportunities for Expressive Information Design

Matthew Brehmer · Microsoft Research · [@mattbrehmer](#)

slides: aka.ms/siat1901



