

Constraints and Opportunities for Expressive Information Design

Matthew Brehmer · Microsoft Research · [@mattbrehmer](https://twitter.com/mattbrehmer)

Outline

- What is **expressive information design**?
- My **background**, **methods**, and **values**
- **Focus** section 1: *Considerations and tools for expressive information design*
- **Focus** section 2: *Expressive information design for mobile devices*
- **Ongoing** and **future** research
- Why **SIAT**?

Coverage of Topics & Publications

↳ Considerations and tools for expressive information design:

- *Timeline Storyteller* ^{c7}, *DataToon* ^{c8}, *Charticulator* ^{j7}, *ChartAccent* ^{c5}, *Timelines Revisited* ^{j6}, *TimeLineCurator* ^{j4}

▣ Visualization task analysis:

- *A Typology of Abstract Visualization Tasks* ^{j1}, *Visualizing Dimensionally-Reduced Data* ^{w3}

❑ Evaluating _____ :

- *Data-Driven Stories* ^{bc1}, *Visualization Authoring Systems* ^{w5}, *Variants of Multi-Series Bar Charts* ^{c6},
- *Overview: A Document Mining Tool for Journalists* ^{j2}

■ Visualization for mobile devices:

- *Ranges Over Time* ^{j8}, *Animation vs. Small Multiples* ^{wp*}

↳ Visualization for resource conservation:

- *Workflows for Energy Portfolio Analysis* ^{j5}

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What is Expressive Information Design?

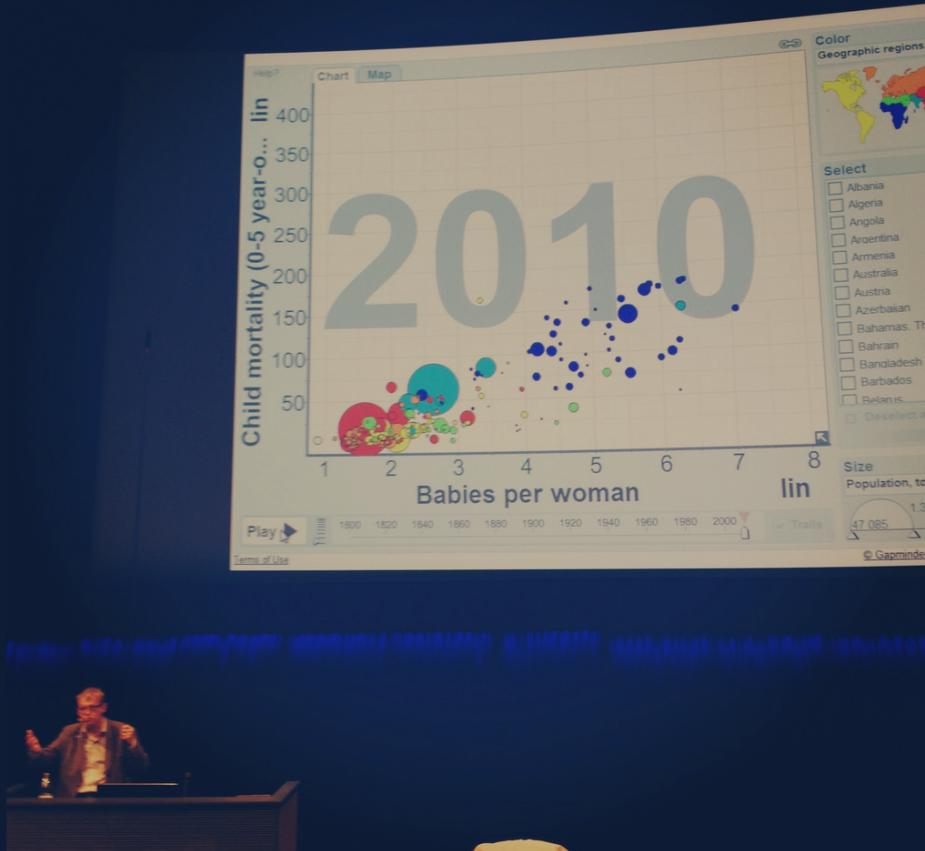
From the perspective of an **information visualization** researcher.

What is Expressive Information Design?

- Combining **visualization**, **annotation**, and **explanation** to **present** information to an audience.
- Thinking systematically about **tasks**, **design choices**, and **constraints**.
- Identifying ways to **assess** alternative design choices.

Presenting Information to the Public

e.g., Hans Rosling's TED presentations about global economic and public health indicators.



Presenting Information to the Individual

Information that is **personally-relevant** and **appropriate** for the **context**.

e.g., Mobile news; apps for tracking personal activity, health, finance, ...

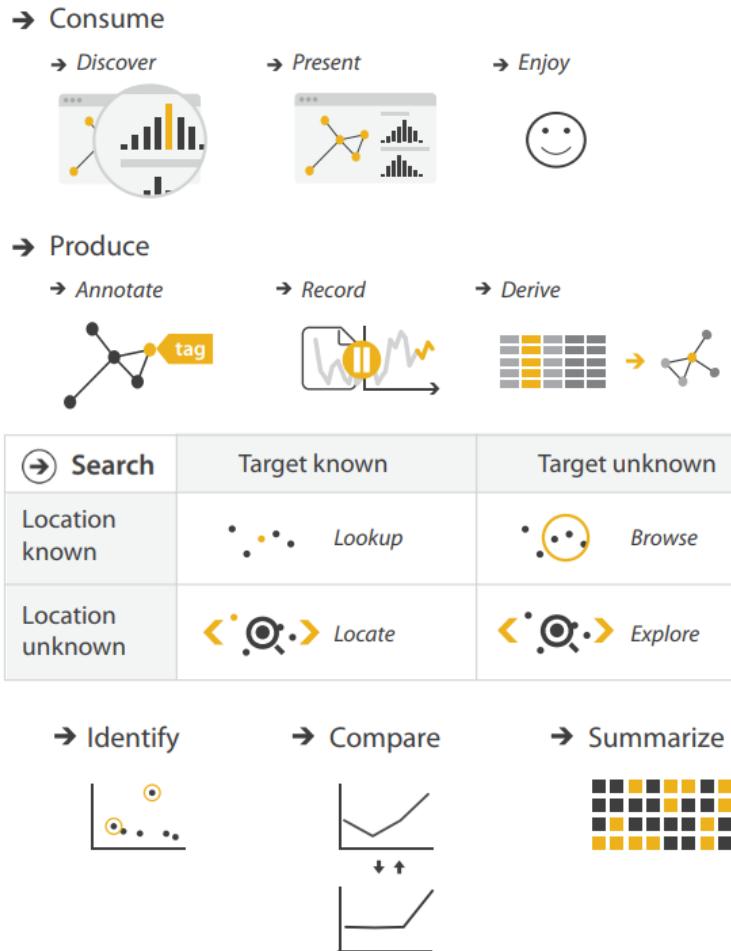


Aspects of Expressive Information Design

Thinking systematically about **tasks**, **design choices**, and **constraints**.

Thinking Systematically about Tasks

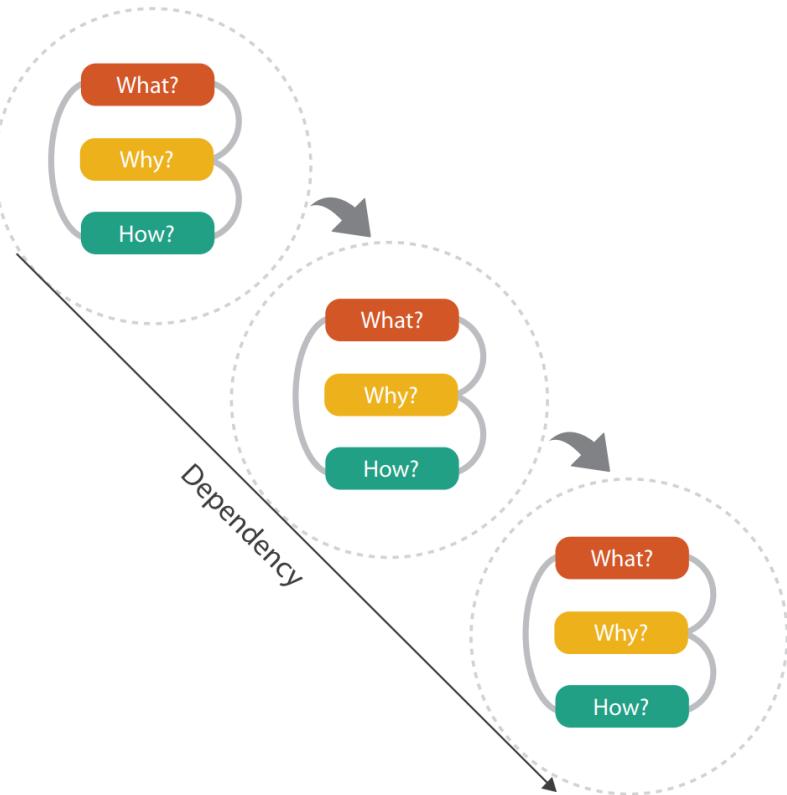
❑ **A Multi-Level Typology of Abstract Visualization Tasks.** Brehmer and Munzner.
In *IEEE Transactions on Visualization and Computer Graphics* (VIS 2013, InfoVis Track).



Thinking Systematically about Tasks

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The **most cited IEEE InfoVis paper since 2013**, with more than 280 citations*.



Thinking Systematically about Design Choices

Identifying the dimensions of **design spaces** that characterize...

- ... ways to **visually represent** data,
- ... ways to **interact** with these representations,
- ... ways to **highlight** and **annotate** them, and
- ... ways to **combine visual** content with **textual** explanation.

In an expressive information design tool, how do you present these choices?

e.g., Low-level visual encoding choices (shape, color, ...) or chart templates (bar, line, ...)

Constraints on Expressivity

Constraints imposed by **authors**, and those imposed by the **context** or the **audience**.

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Constraints on Expressivity

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Resources. e.g., enabling expressive information design for those on a deadline.

Context. e.g., anticipating the visual and data literacy of the audience,

Or anticipating the device that the audience will use.

My Background, Methods, & Values

My Background

2011 - 2016: PhD **Computer Science** specializing in **Information Visualization**

2009 - 2011: MSc **Computer Science** specializing in **Human-Computer Interaction**

2004 - 2009: Bachelor of **Computing** specializing in **Cognitive Science**

Design & Research Methods

Design & Implementation:

- User interface design | Visualization design & development | Toolkit development

Qualitative:

- Visualization design studies* | Requirements analysis | Chart reproduction studies
- Chauffeured demos | Content analysis | Post-deployment usage analysis

Quantitative:

- Laboratory experiments | Crowdsourced experiments | Statistical analysis

The Value of Democratizing Information Design

How can I enable under-served groups of people to...

Expressively **visualize** their data?

Present compelling data-driven stories?

Make personal **decisions** grounded in data?

The Value of Democratizing Information Design

Situating my research within the academic visualization community.

Considering applications of visualization **beyond** those in **professional data analysis**.

e.g., Why are **journalists** and **educators** presenting information using **business intelligence** tools?

e.g., What are the **best practices** for the visual display of **personal-relevant** information on a **phone**?

The Value of Connecting Research & Practice

Disseminating visualization **research** into **practice**, and **vice versa**.

Promoting and studying the **adoption** of deployed information design tools and research prototypes.

Collecting examples of information design **produced by practitioners**.

Fostering a **dialogue** between **researchers** and **practitioners** (e.g., OpenVisConf, VisInPractice)*.

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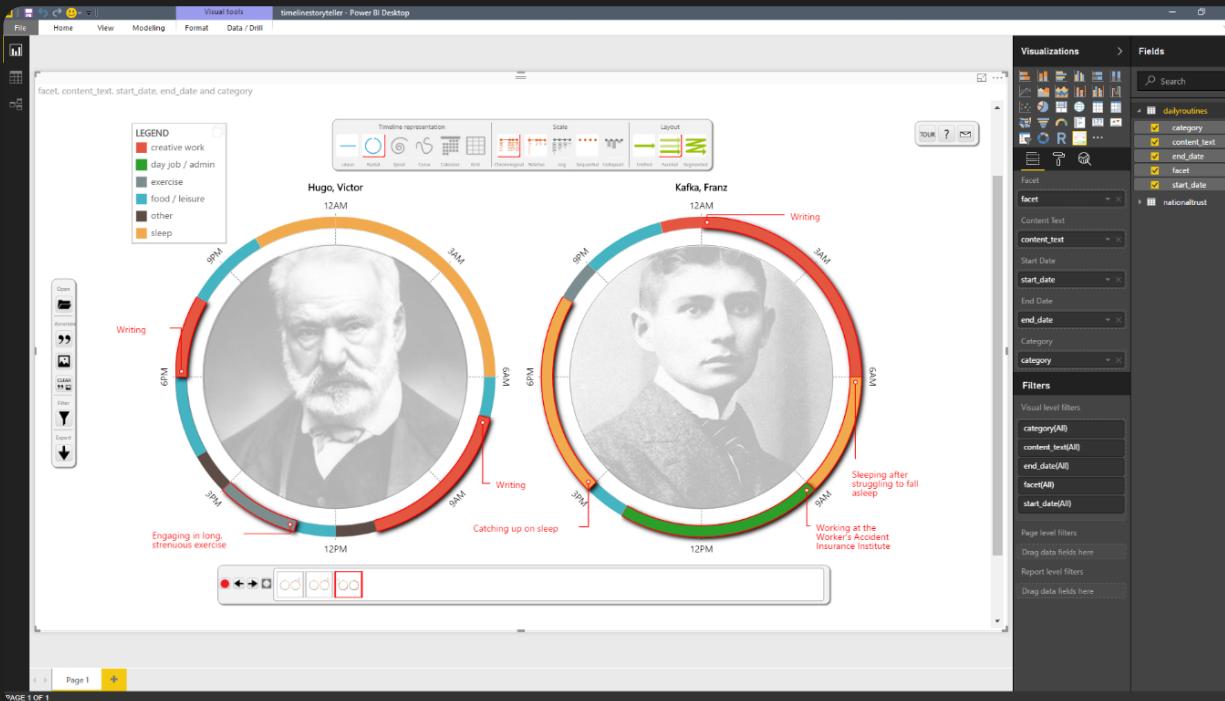
The Daily Routines of Famous Creative People



Expressive Information Design with Timelines

□ *Timeline Storyteller: The Design & Deployment of an Interactive Authoring Tool for Expressive Timeline Narratives.*

Brehmer, Lee, Riche, Tittsworth, Lytvynets, Edge, and White. In Proc. *Computation + Journalism 2019*.



↗ timelinestoryteller.com | ↗ github.com/Microsoft/timelinestoryteller

Timelines Revisited

- *Timelines Revisited: A Design Space and Considerations for Expressive Storytelling.*
Brehmer, Lee, Bach, Riche, and Munzner. In *IEEE TVCG* (presented at VIS 2017).

Timelines are visual representations of categorical event sequences.

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

How have **practitioners** used them for storytelling?

How have people drawn timelines over the course of history?

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 or repeat?

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

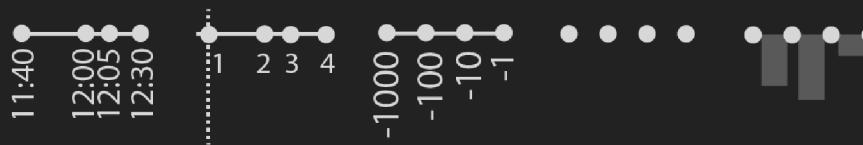
A Timeline Design Space

□ *Timelines Revisited: A Design Space and Considerations for Expressive Storytelling.*
Brehmer, Lee, Bach, Riche, and Munzner. In *IEEE TVCG* (presented at VIS 2017).

Representation



Scale



Layout



Timelines Revisited: The Research Process

1. Collecting and categorizing **145** timelines and timeline tools to establish the dimensions.

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

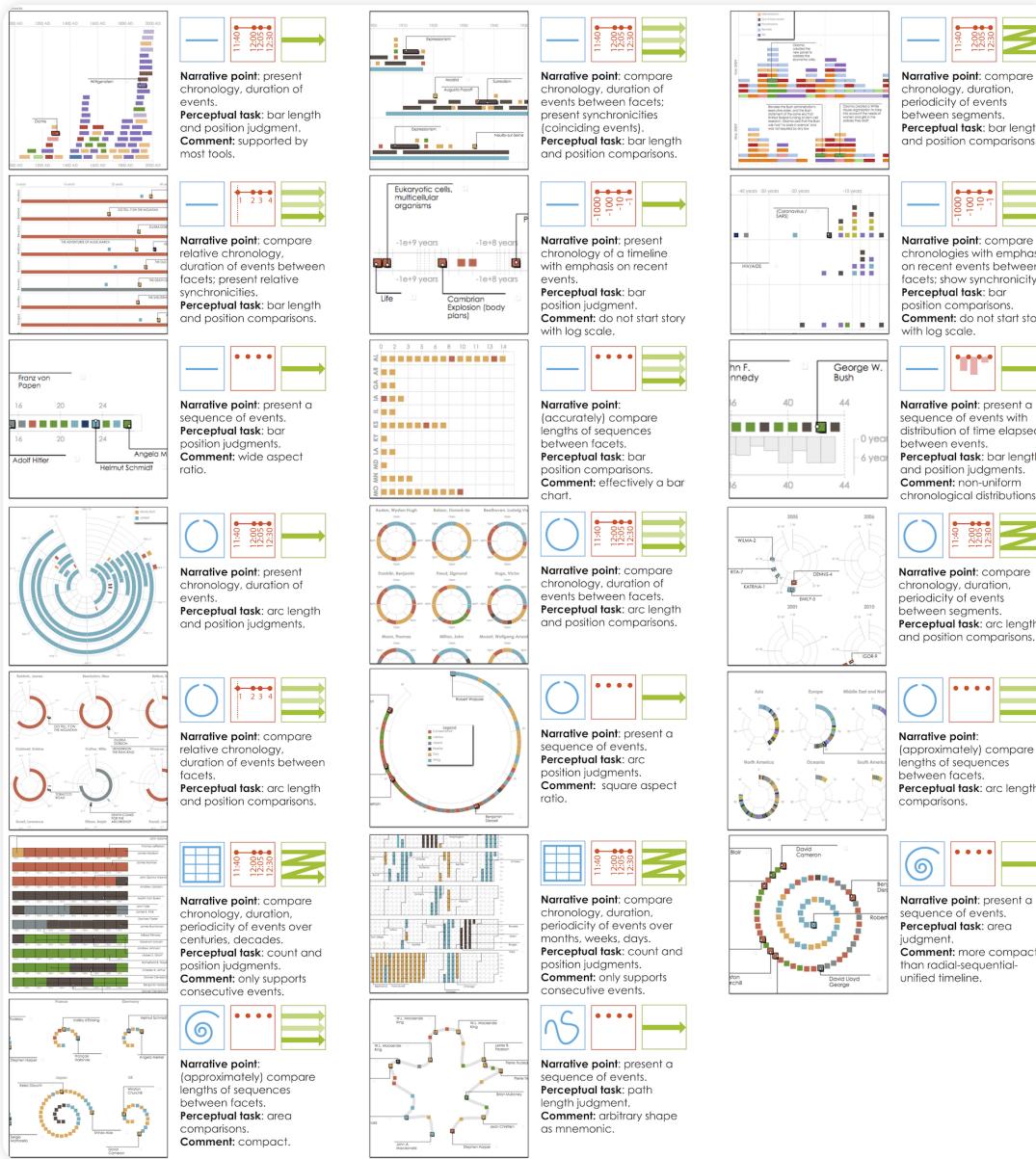
2. Validating the dimensions of the design space with **118** additional timelines (**263** total).

• Sources included: [visual.ly](#), the Kantar Information is Beautiful Showcase, [massvis.mit.edu](#), ...

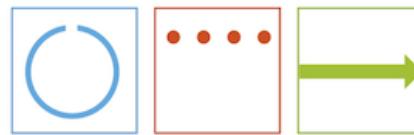
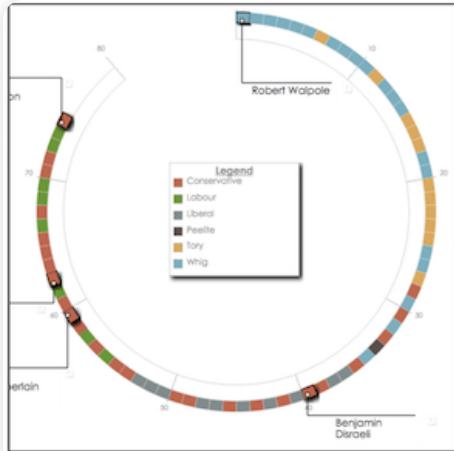
3. Implementing points in the design space with **28** representative datasets.

• e.g., Conflicts, epidemics, lifespans, head of state tenures, news stories, natural disasters, publication records, geological history, ...

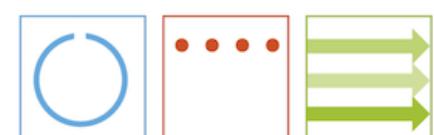
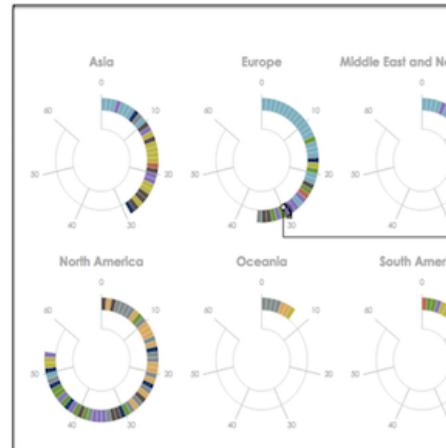
A set of purposeful, interpretable, & generalizable timeline designs at timelinesrevisited.github.io 



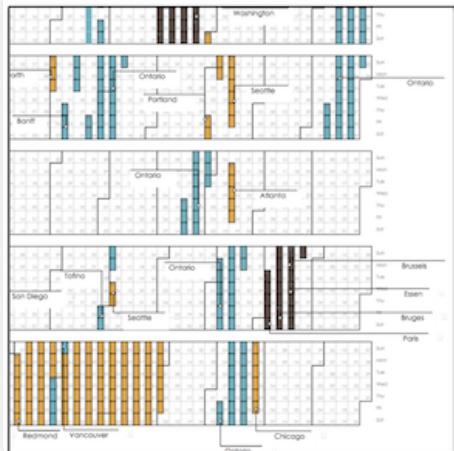
Thinking Systematically About Tasks & Design Choices



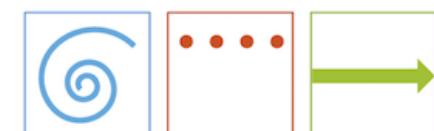
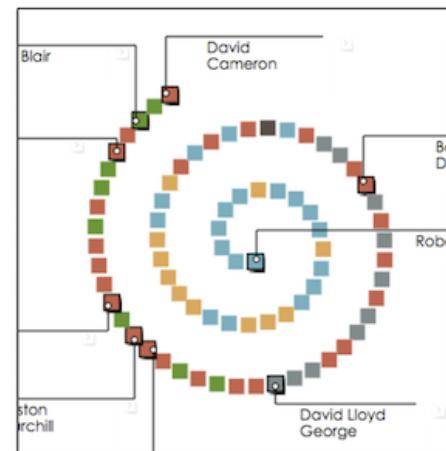
Narrative point: present a sequence of events.
Perceptual task: arc position judgments.
Comment: square aspect ratio.



Narrative point: (approximately) compare lengths of sequences between facets.
Perceptual task: arc length comparisons.

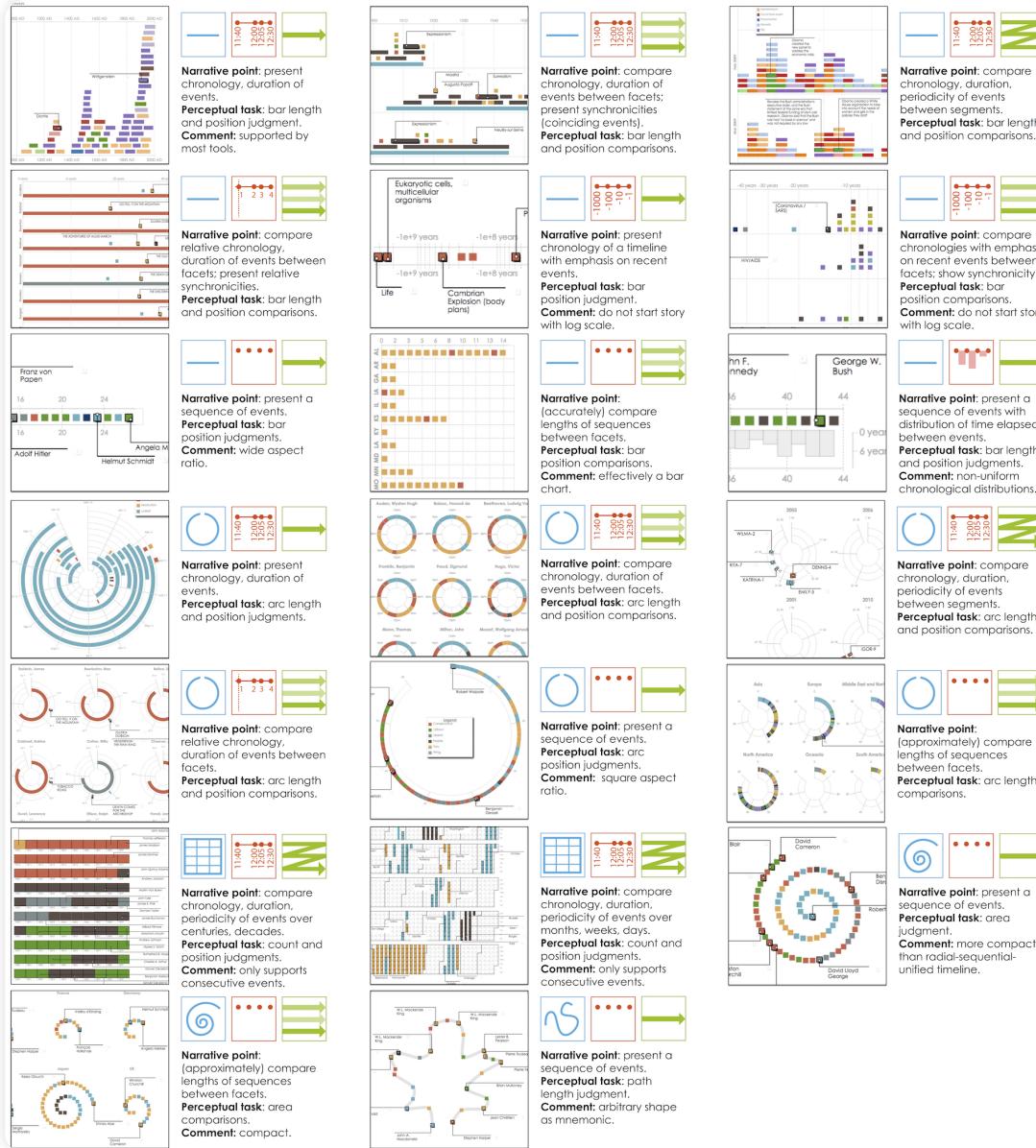


Narrative point: compare chronology, duration, periodicity of events over months, weeks, days.
Perceptual task: count and position judgments.
Comment: only supports consecutive events.



Narrative point: present a sequence of events.
Perceptual task: area judgment.
Comment: more compact than radial-sequential-unified timeline.

Using our Timeline Design Space



Expressive Storytelling with Timelines

❑ *Timelines Revisited: A Design Space and Considerations for Expressive Storytelling.*
Brehmer, Lee, Bach, Riche, and Munzner. In *IEEE TVCG* (presented at VIS 2017).

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.

↗ timelinesrevisited.github.io | project website.

Timeline Storyteller

❑ *Timeline Storyteller: The Design & Deployment of an Interactive Authoring Tool for Expressive Timeline Narratives.*

Brehmer, Lee, Riche, Tittsworth, Lytvynets, Edge, and White. In Proc. *Computation + Journalism* 2019.



Evaluating Timeline Storyteller

A controlled **laboratory study** to assess expressivity seemed to be **inappropriate**.

How do people use it **with their own data**?

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

Promoting Timeline Storyteller to Practitioners

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

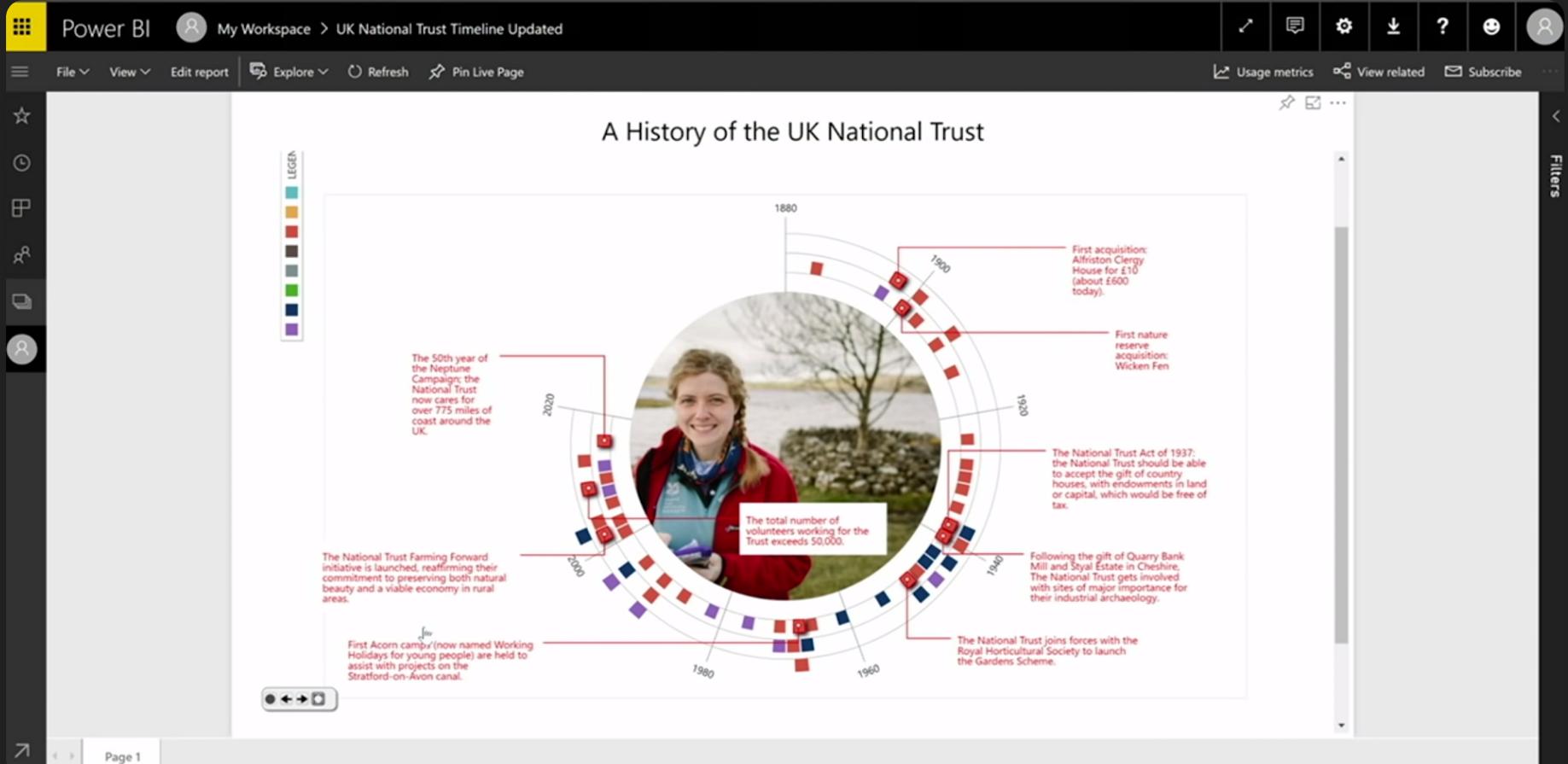
My co-author (White) used it in his 2017 [Dublin Data Summit](#) keynote,

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

I wrote about it on the official [Power BI Blog](#),

I co-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 **exported content** from the web version, and

I tracked **download metrics** of the Power BI desktop version.

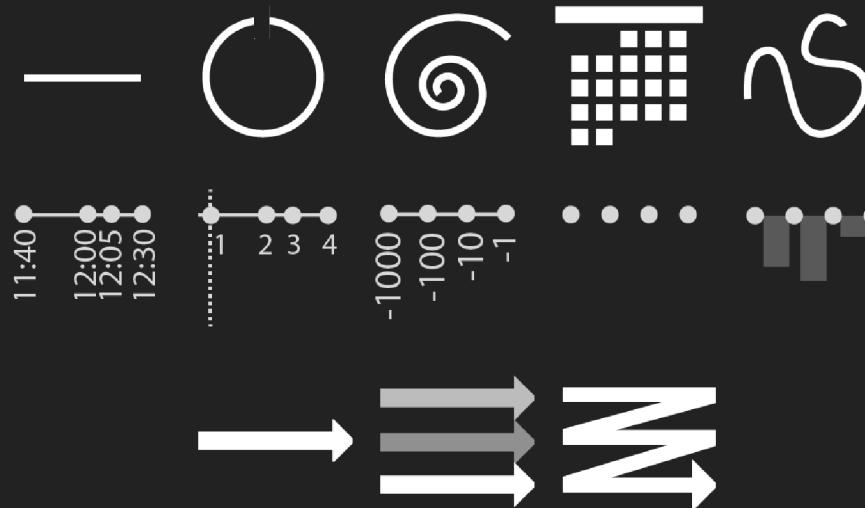
I collected entries from a **data storytelling contest** with the Power BI user community.

Timeline Storyteller: Content Analysis

223 unique items of exported content from the web version (subject to author consent).

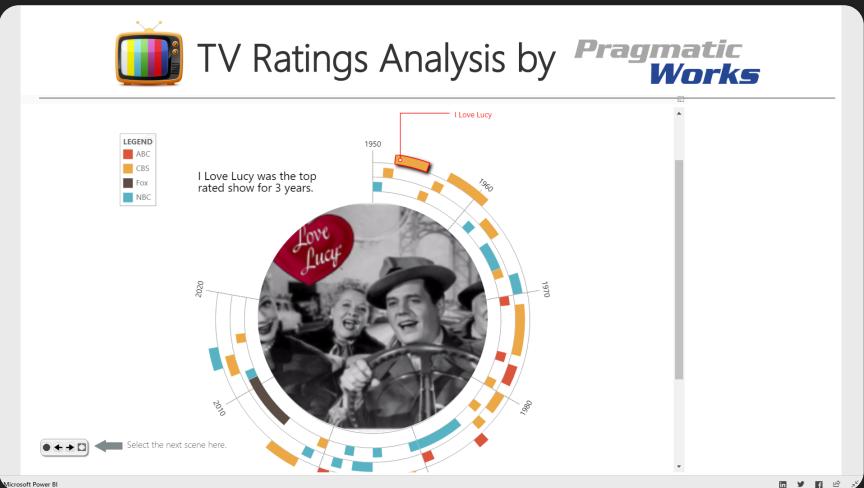
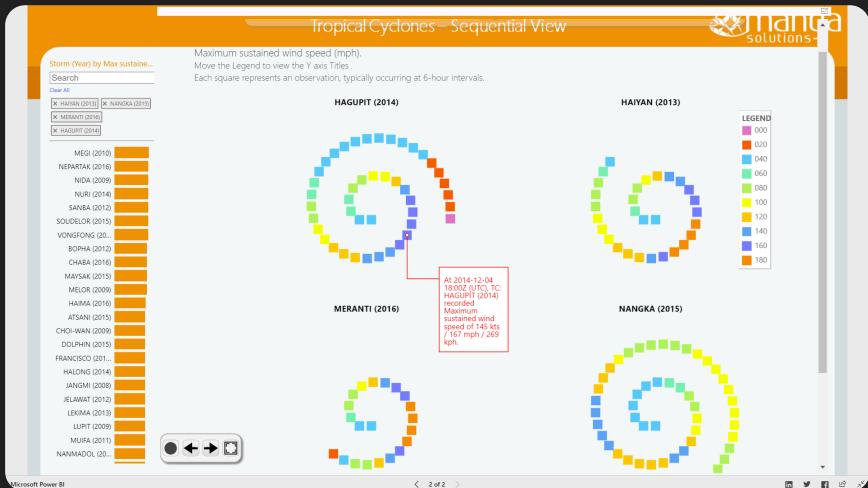
The corpus spanned my timeline design space - with a couple of exceptions.

The **Linear** representation and **Chronological** time scale were most common.



Timeline Storyteller: Content Analysis (cont.)

Example entries from the Power BI user community **data storytelling contest**:



Tropical Cyclones by Manga Solutions. | *TV Network Ratings* by Pragmatic Works.

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.

* As of January 2019

Timeline Storyteller: Conclusions & Opportunities

No prior **interactive tools** for presenting **expressive timeline narratives**.

The first to incorporate multi-scene stories with **unconventional visual representations**.

Incremental **reveal** + **transform**; selective **highlight** + **annotate** can be applied to other data types.

Recommend design choices and **annotations** based on properties of the dataset.

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

Other Expressive Information Design Tools (1 of 3)

ChartAccent: Annotation for Data-Driven Storytelling.

Ren, Brehmer, Lee, Höllerer, and Choe. In Proc. 2017 IEEE PacificVis Symp.



chartaccent.github.io

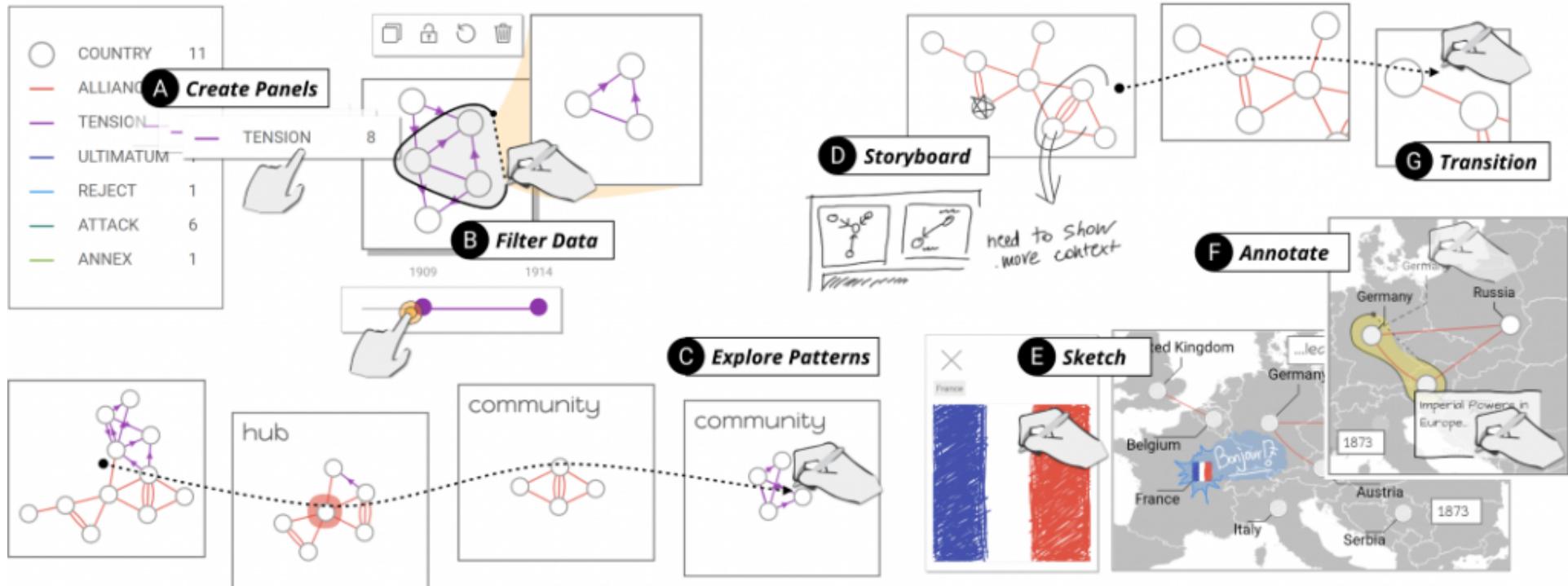


github.com/chartaccent

Other Expressive Information Design Tools (2 of 3)

□ DataToon: Drawing Dynamic Network Comics With Pen + Touch Interaction.

Kim, Riche, Bach, Xu, **Brehmer**, Hinckley, Pahud, Xia, McGuffin, and Pfister. In Proc. ACM CHI 2019.

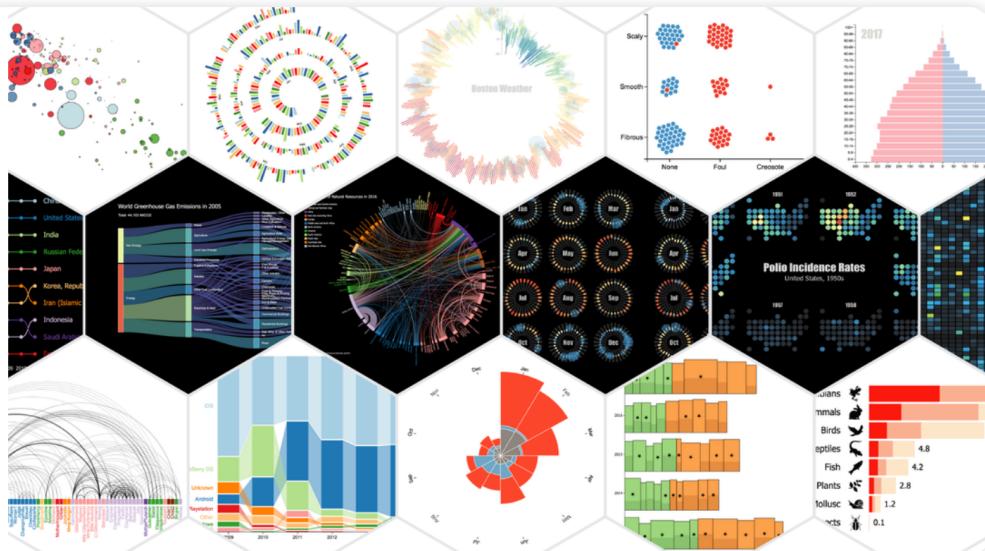
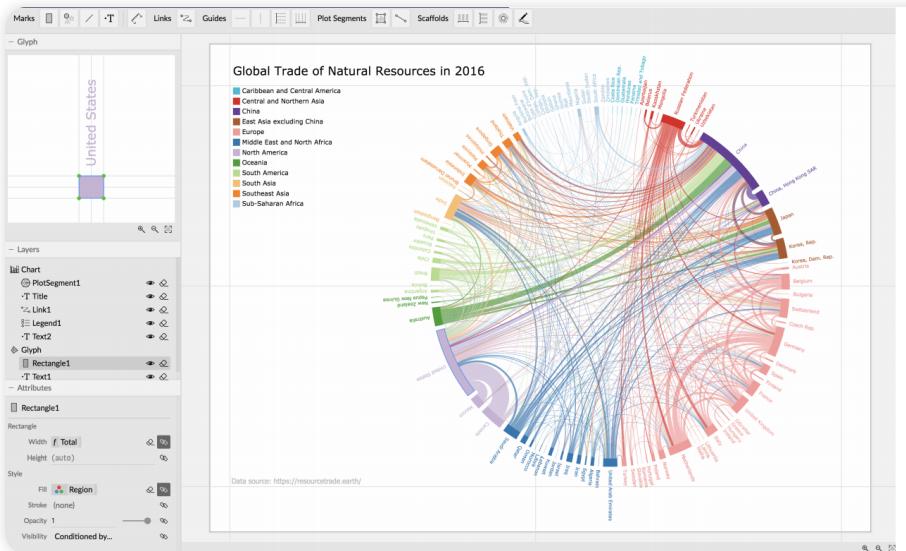


↗ aka.ms/DataToon

Other Expressive Information Design Tools (3 of 3)

Charticulator: Interactive Construction of Bespoke Chart Layouts.

Ren, Lee, and Brehmer. In *IEEE TVCG* (VIS 2018, InfoVis Track).



🏆 Honorable Mention for Best Paper at IEEE InfoVis 2018.

🏅 Shortlisted for the 2018 Kantar Information is Beautiful Awards.

↗ charticulator.com | ↗ github.com/Microsoft/Charticulator

Evaluating Expressive Information Design Tools

❑ Reflecting on the Evaluation of Visualization Authoring Systems.

Ren, Lee, **Brehmer**, and Riche.

In Proc. BELIV 2018 (*Evaluation and Beyond - Methodological Approaches for Visualization*).



Lessons from evaluating tools incl. **Timeline Storyteller**, **ChartAccent**, & **Charticulator**.

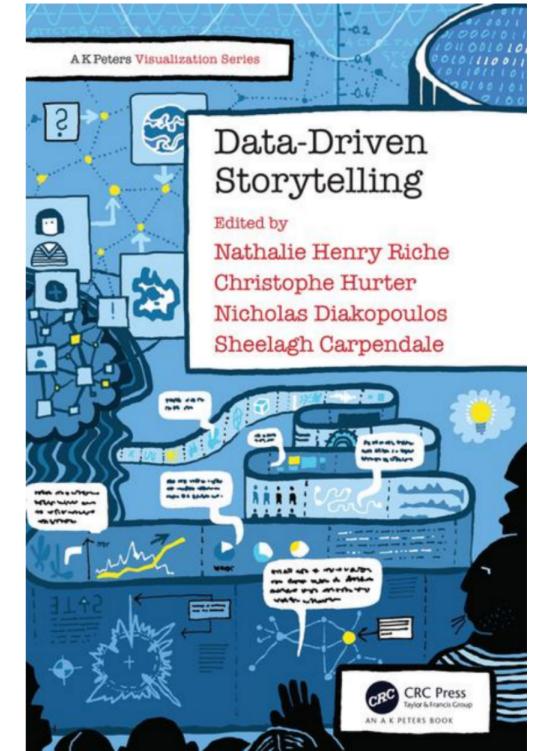
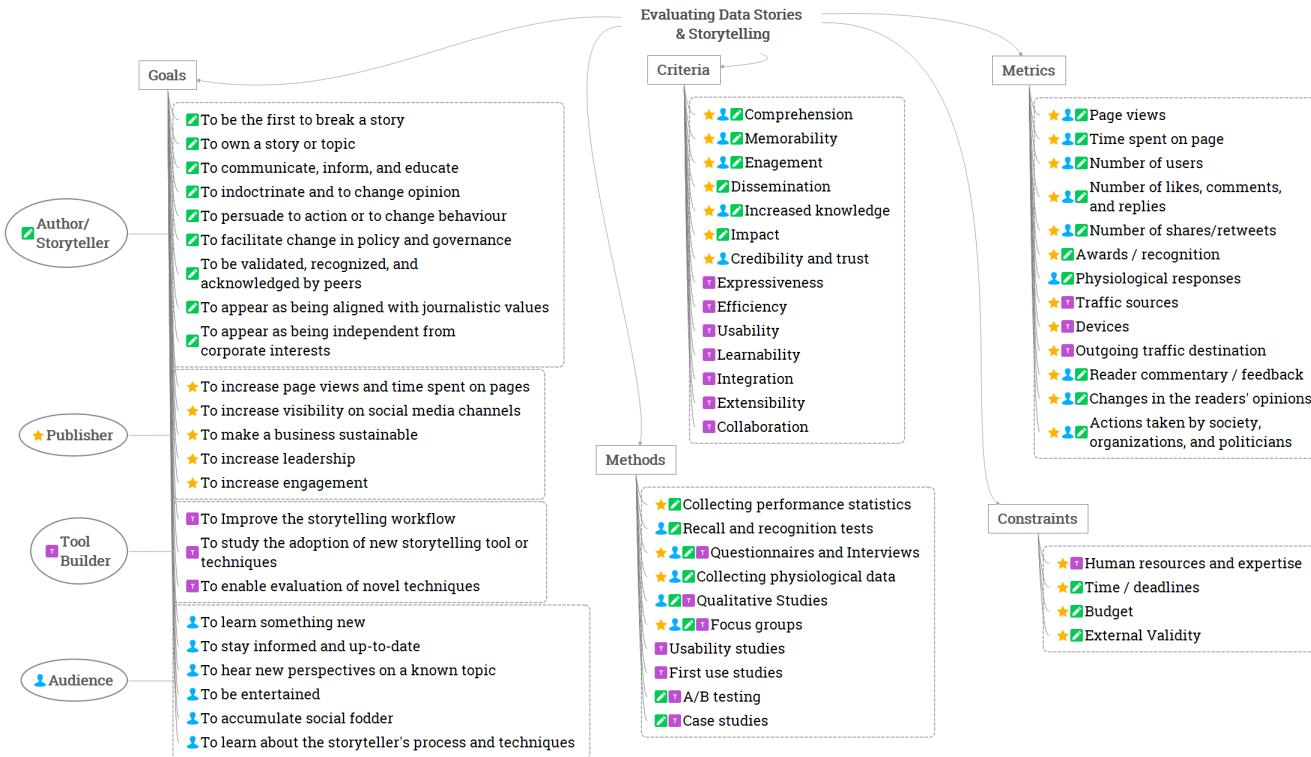
Emphasis on **post-deployment content analysis** and **reproduction studies**.

❑ aka.ms/renbeliv18

Beyond Tools: Evaluating Data-Driven Stories

☐ Evaluating Data-Driven Stories & Storytelling Tools.

Amini*, Brehmer* (equal contribution), Bolduan, Elmer, and Wiederkehr.
In *Data-Driven Storytelling* (CRC Press 2018).



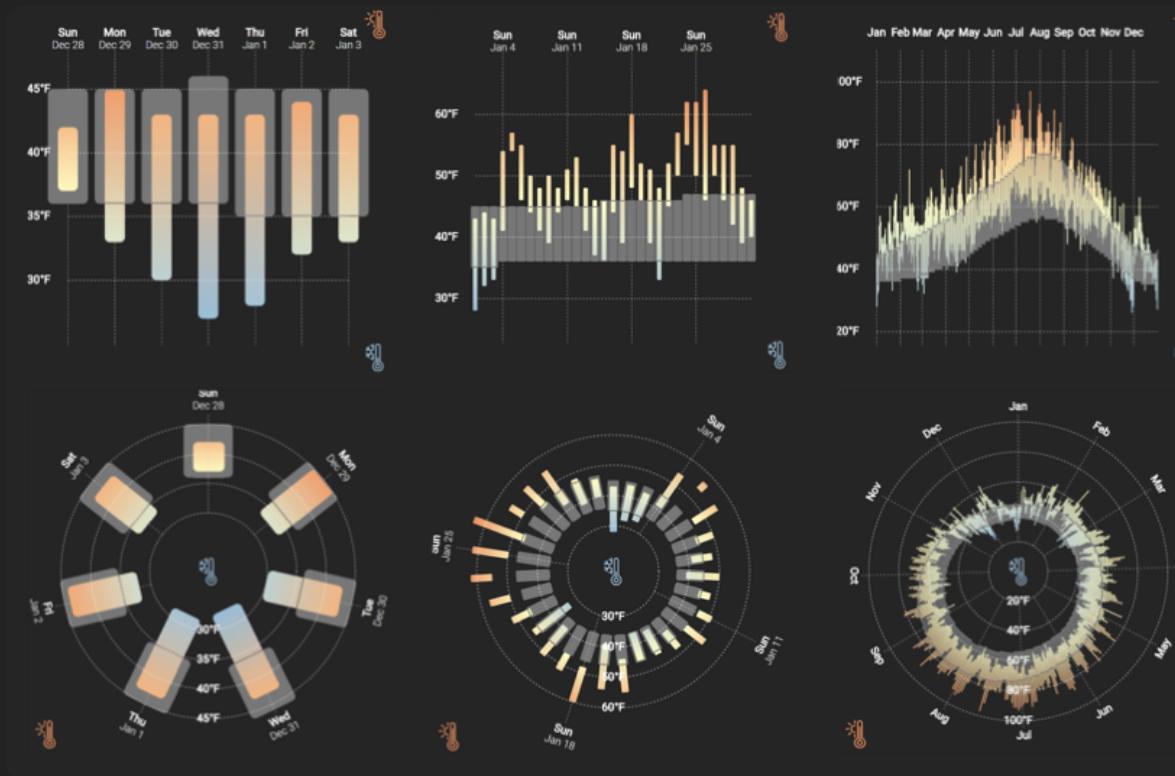
A summary of **perspectives**, **criteria**, **methods**, **metrics**, and **constraints** w.r.t. **evaluation**.

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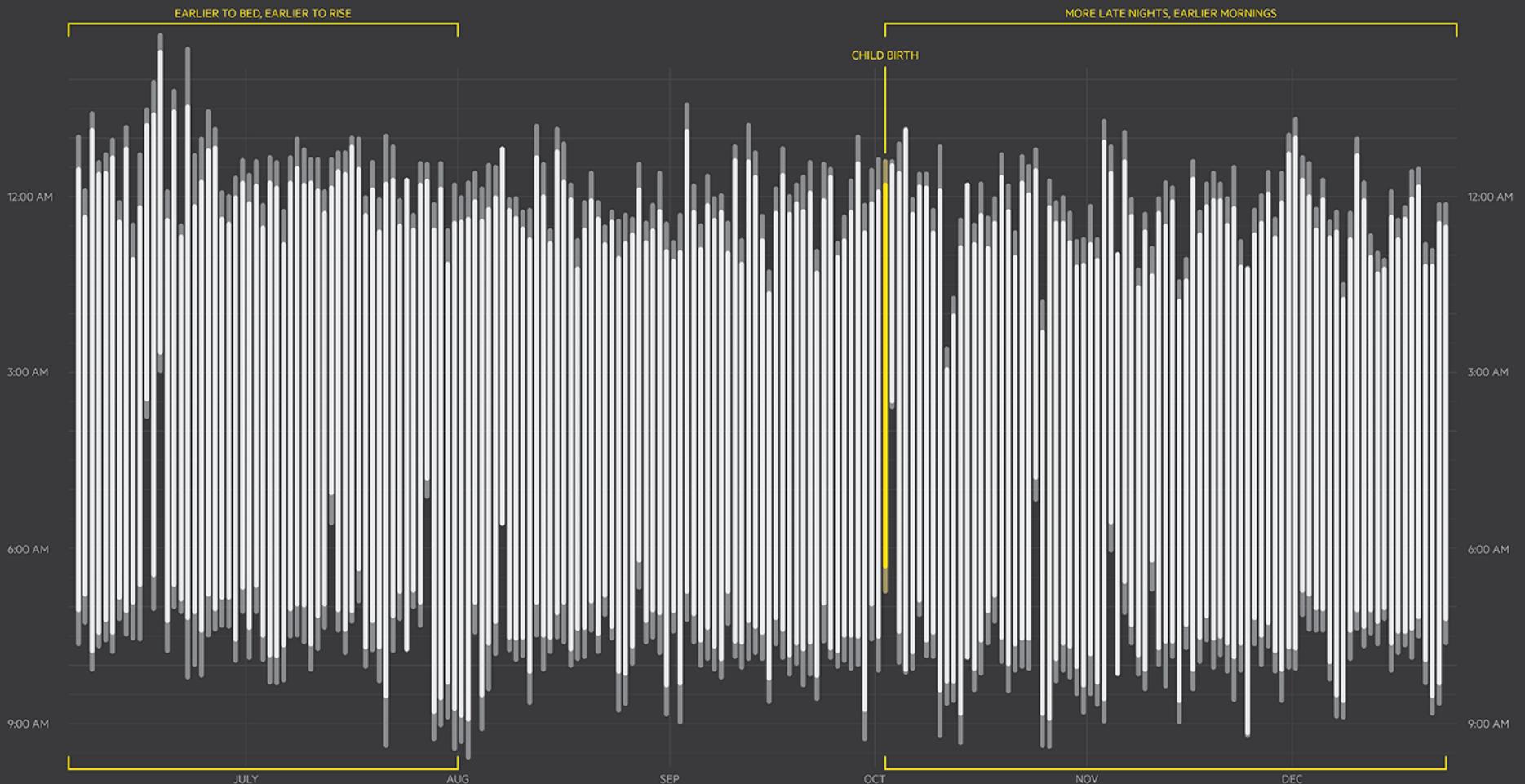
Information Design Choices on Mobile Phones

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



↗ aka.ms/ranges-tvcg

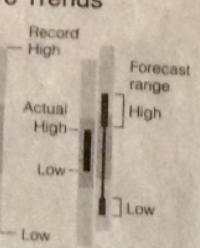
Time In Bed vs. Time Asleep by time of day



0-Day Temperature Trends

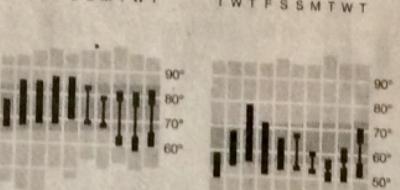
High and low temperatures for the past few days and forecasts for next five. Yesterday's highs and lows are based on preliminary data.

as
T F S S M T W T



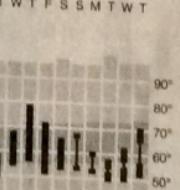
Atlanta

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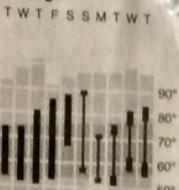
Boston

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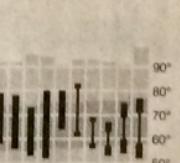
Chicago

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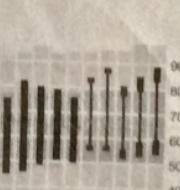
Cleveland

T W T F S S M T W T



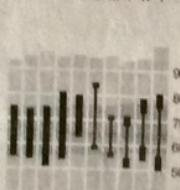
Denver

T W T F S S M T W T



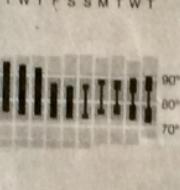
Detroit

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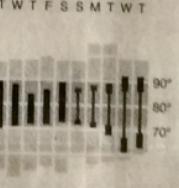
Ft. Myers

T W T F S S M T W T



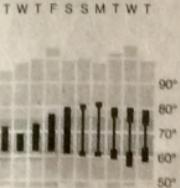
Houston

T W T F S S M T W T



Los Angeles

T W T F S S M T W T



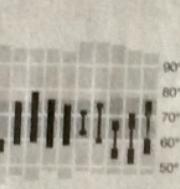
Minneapolis

T W T F S S M T W T



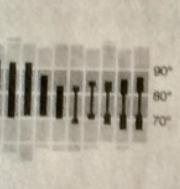
New York

T W T F S S M T W T



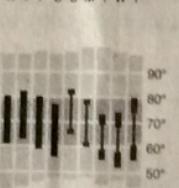
Orlando

T W T F S S M T W T



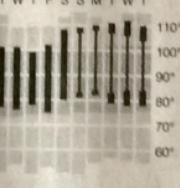
Philadelphia

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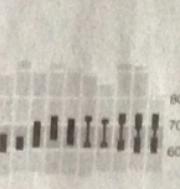
Phoenix

T W T F S S M T W T



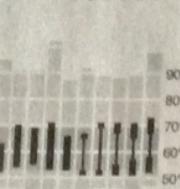
San Diego

T W T F S S M T W T



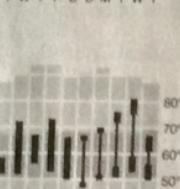
San Francisco

T W T F S S M T W T



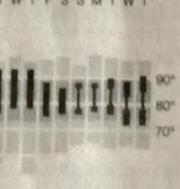
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T W T F S S M T W T



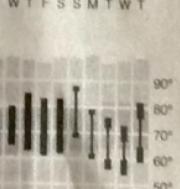
Tampa

T W T F S S M T W T



Washington

T W T F S S M T W T



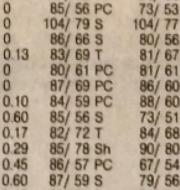
Key West

T W T F S S M T W T



London

T W T F S S M T W T



Madrid

T W T F S S M T W T



Moscow

T W T F S S M T W T



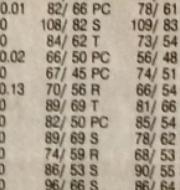
Lansing

T W T F S S M T W T



Nice

T W T F S S M T W T



Ole

T W T F S S M T W T



Paris

T W T F S S M T W T



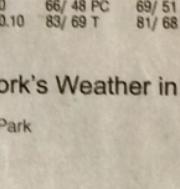
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T W T F S S M T W T



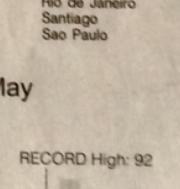
Lubbock

T W T F S S M T W T



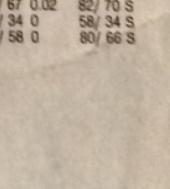
Madison

T W T F S S M T W T



Memphis

T W T F S S M T W T



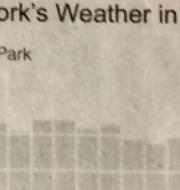
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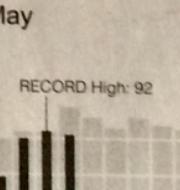
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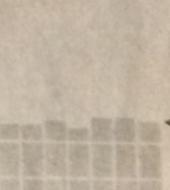
Mpls.-St. Paul

T W T F S S M T W T



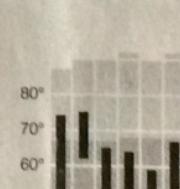
Mobile

T W T F S S M T W T



Monterey, Calif.

T W T F S S M T W T



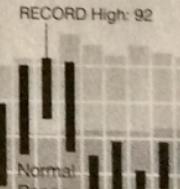
Nashville

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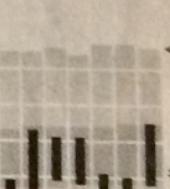
New Orleans

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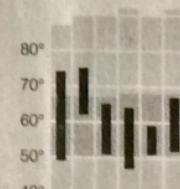
Norfolk

T W T F S S M T W T



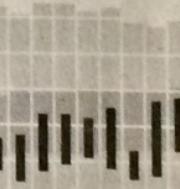
Oklahoma City

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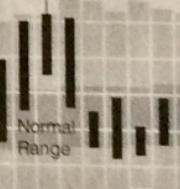
Omaha

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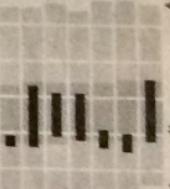
Orlando

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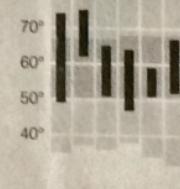
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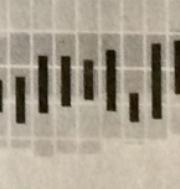
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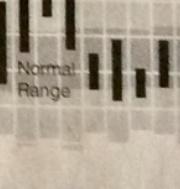
Pittsburgh

T W T F S S M T W T



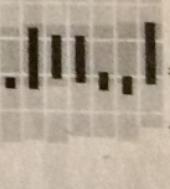
Portland, Me.

T W T F S S M T W T



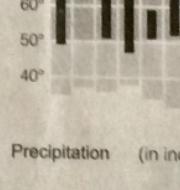
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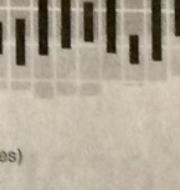
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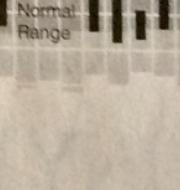
Raleigh

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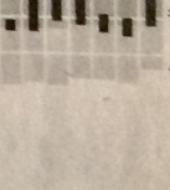
Reno

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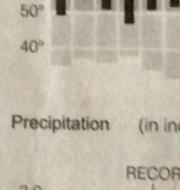
Richmond

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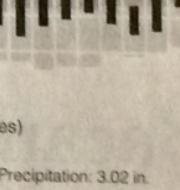
Sacramento

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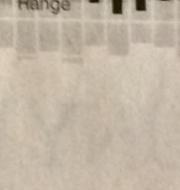
Salt Lake City

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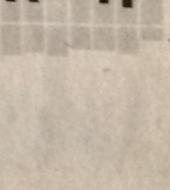
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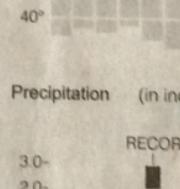
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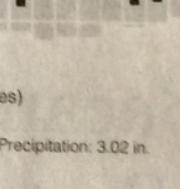
San Francisco

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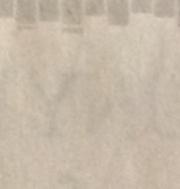
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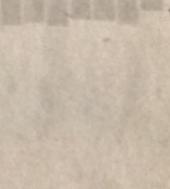
San Juan

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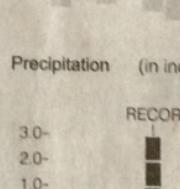
Savannah

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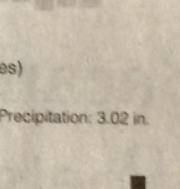
Seattle

T W T F S S M T W T



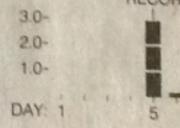
Shreveport

T W T F S S M T W T



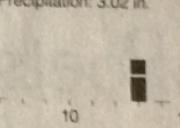
Temperature

Central Park



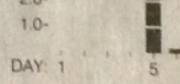
Precipitation

(in inches)

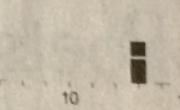


RECORD High: 92°

Normal Range



RECORD Precipitation: 3.02 in.



DAY: 1

5

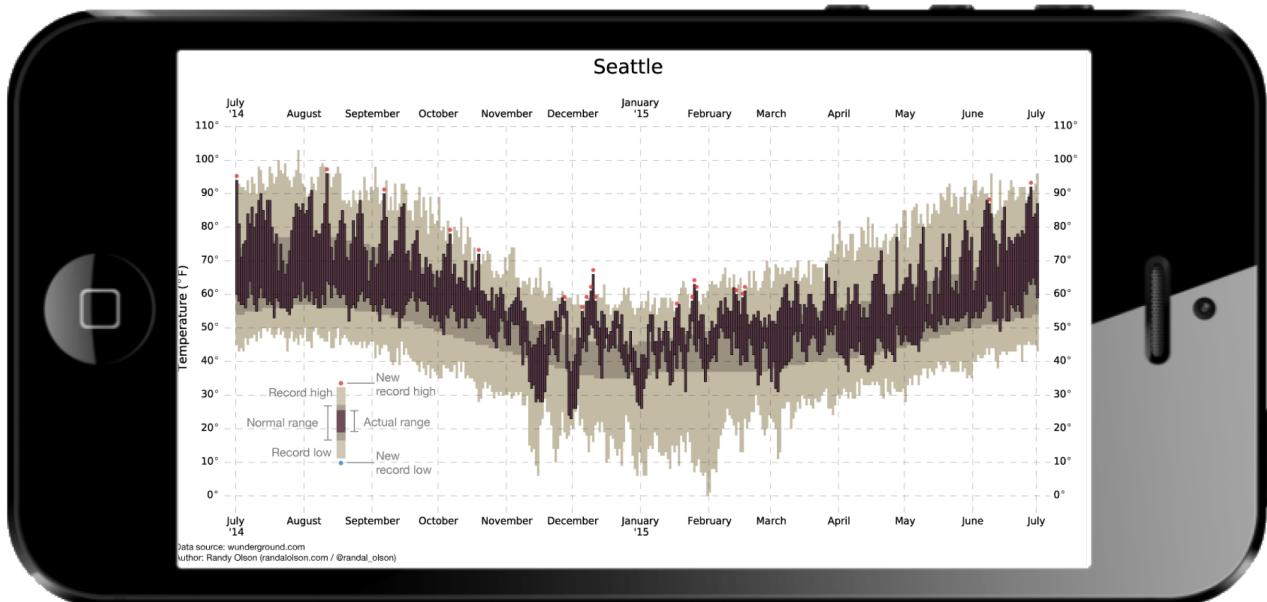
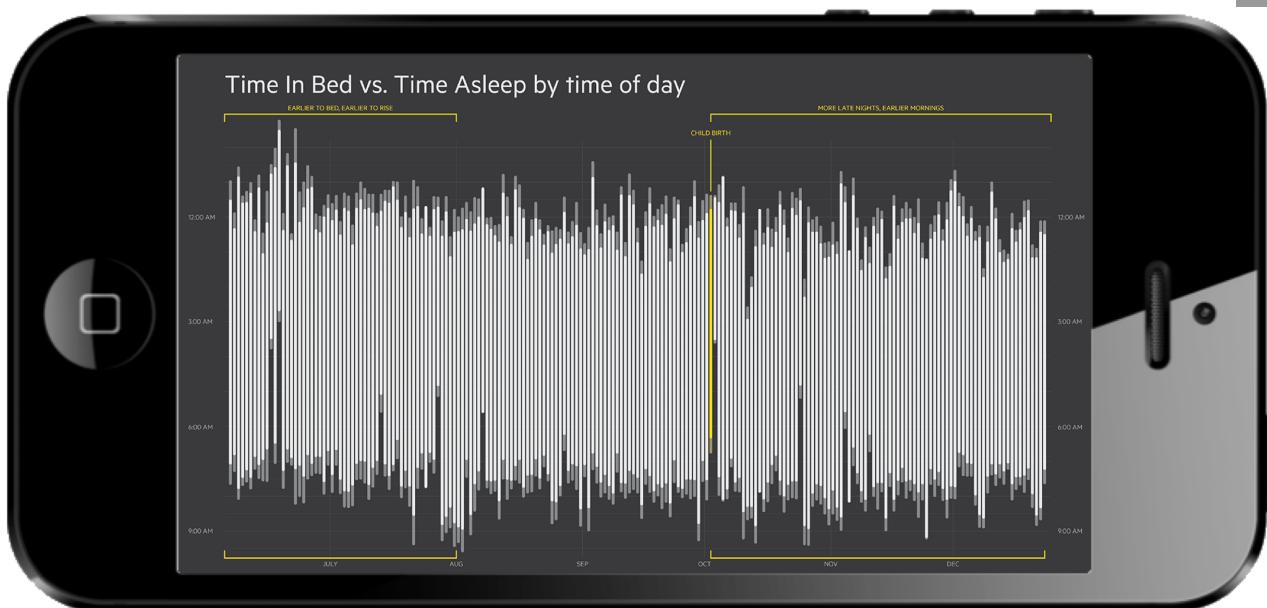
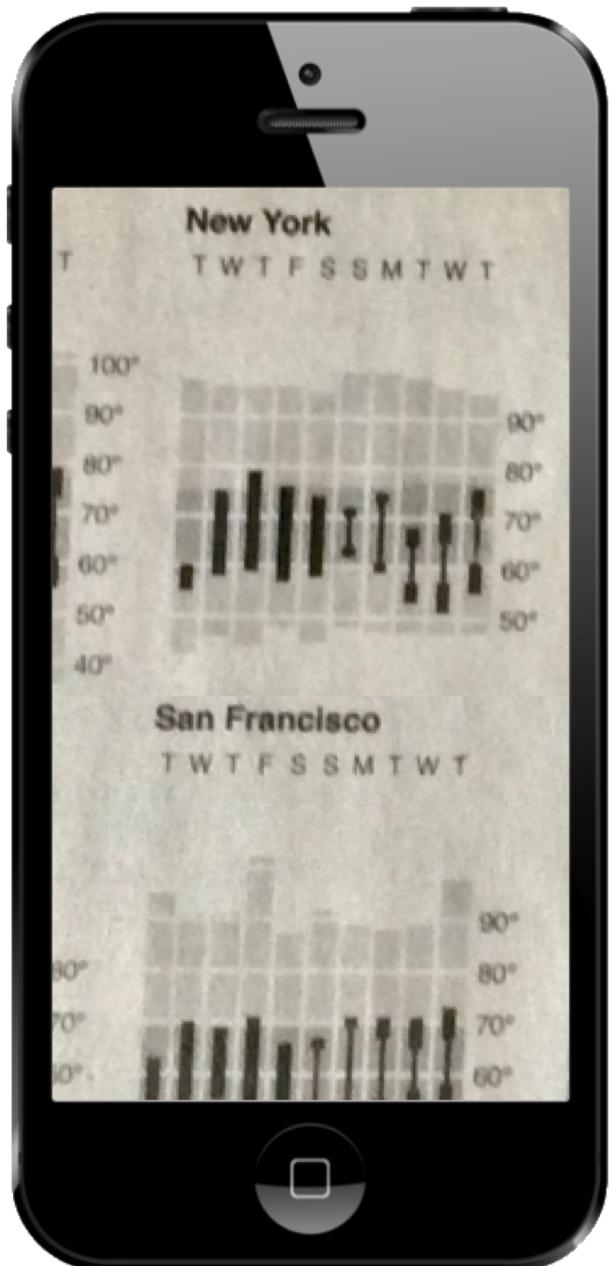
10

15

20

25

30



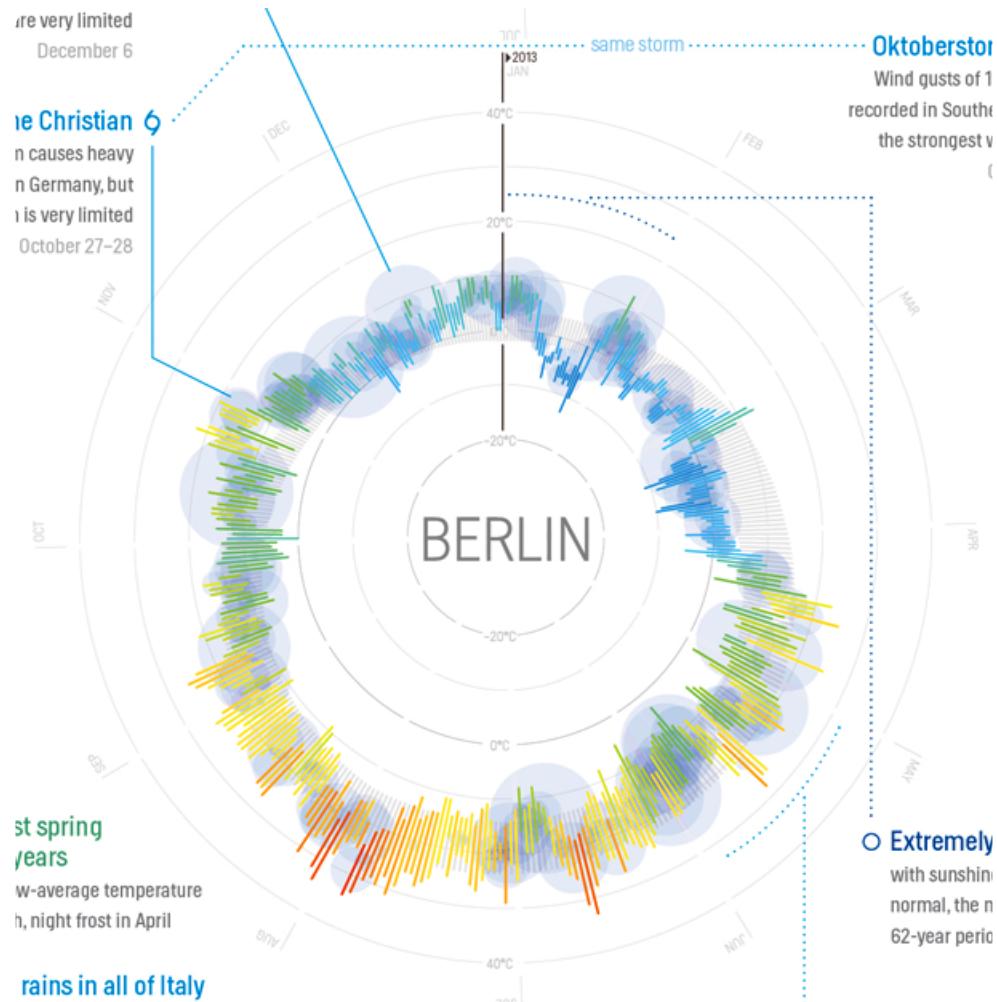
Ranges in Weather Apps



Ranges in Sleep Tracking Apps



Ranges and Radial Representations



SMARTPHONE

TABLET

ALL

CIRCLE 28

BAR 20

LINE 14

MAP 11

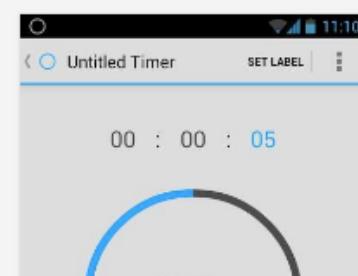
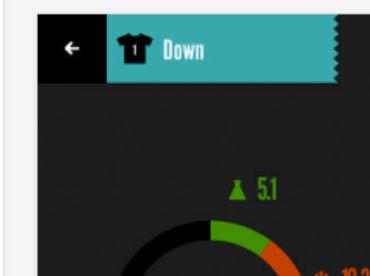
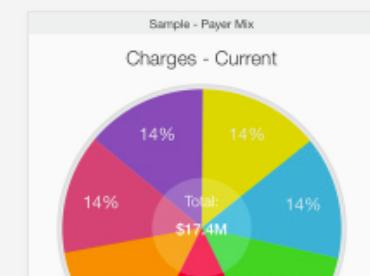
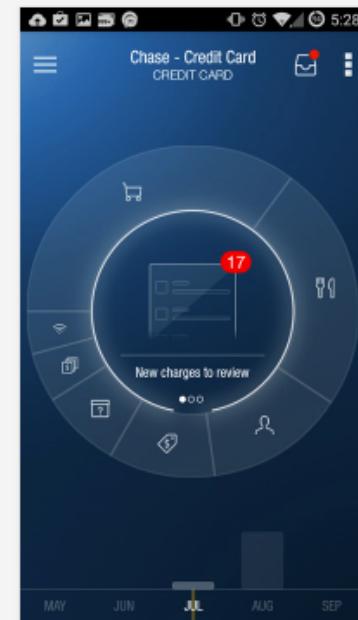
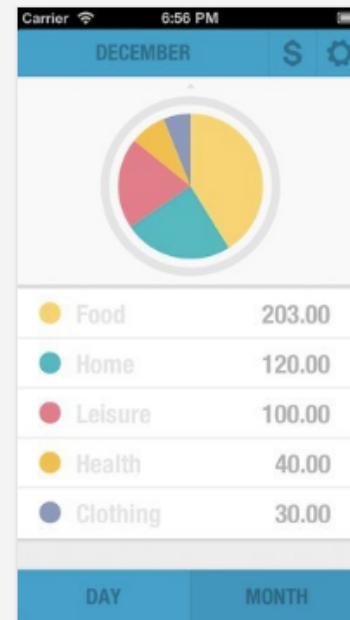
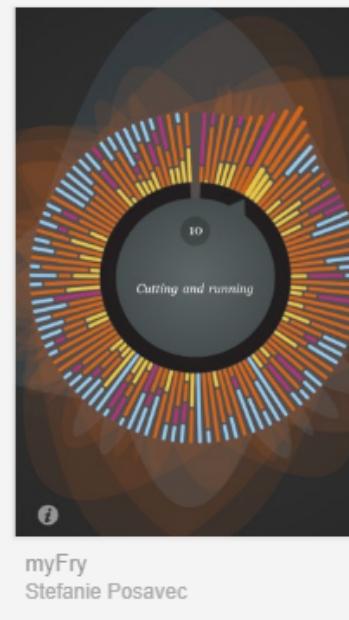
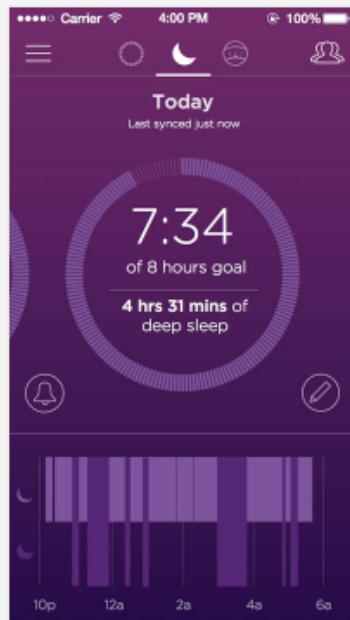
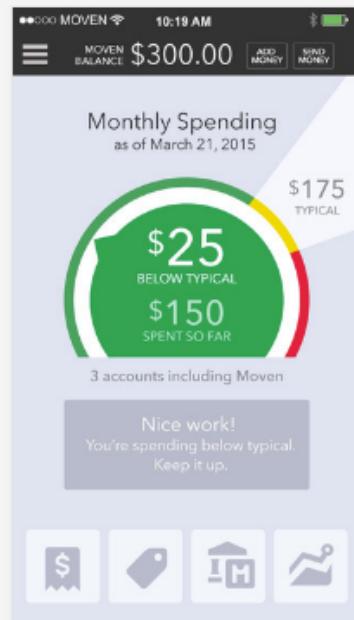
AREA 9

POINT 6

TEXT 4

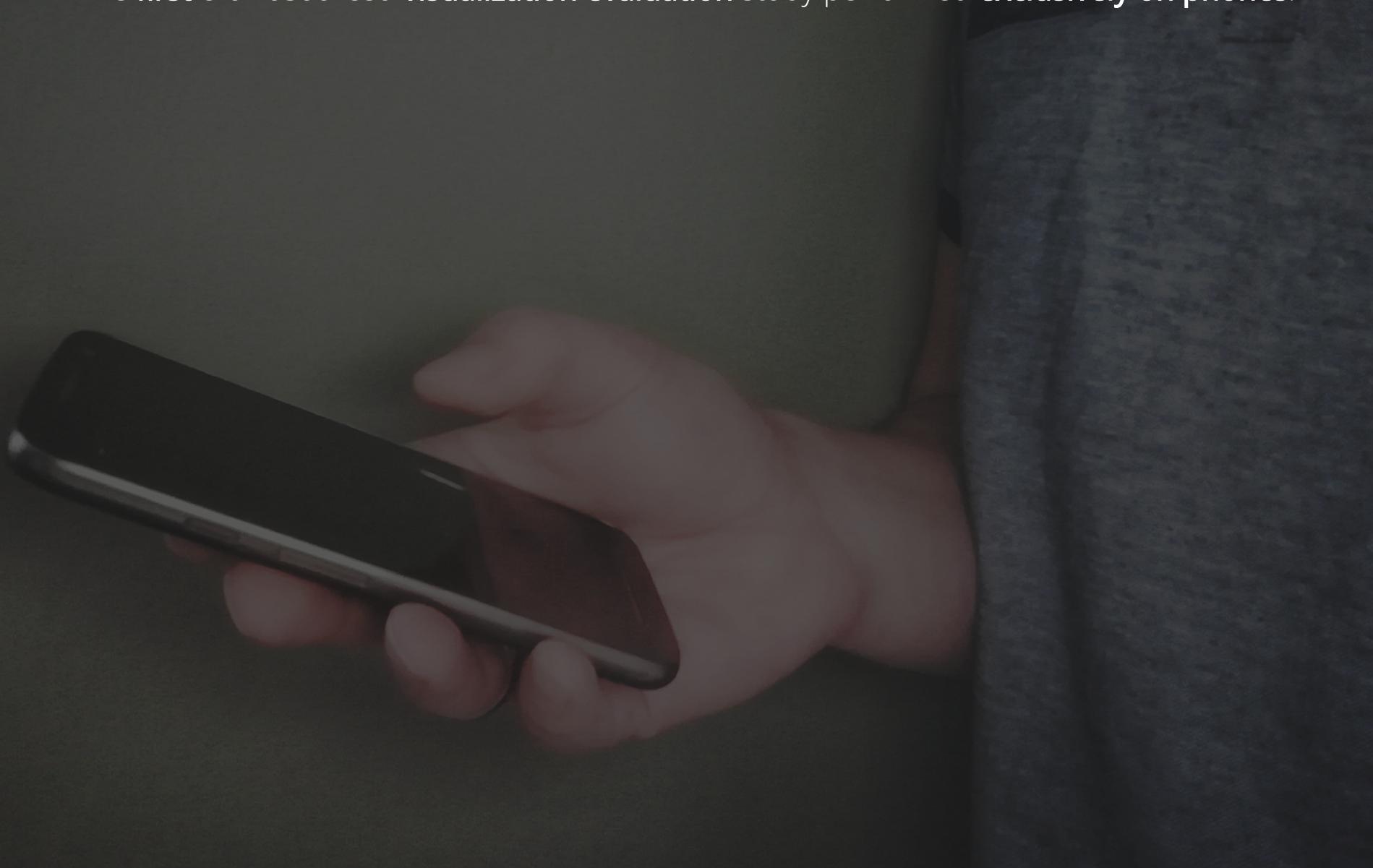
TABLE 1

NETWORK 1



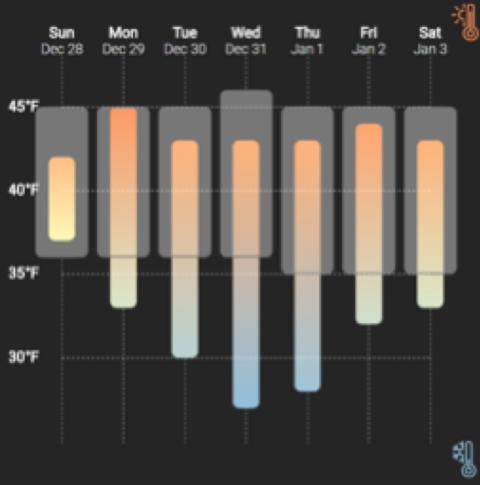
A Crowdsourced Experiment on Mobile Phones

The **first** crowdsourced **visualization evaluation** study performed **exclusively on phones**.

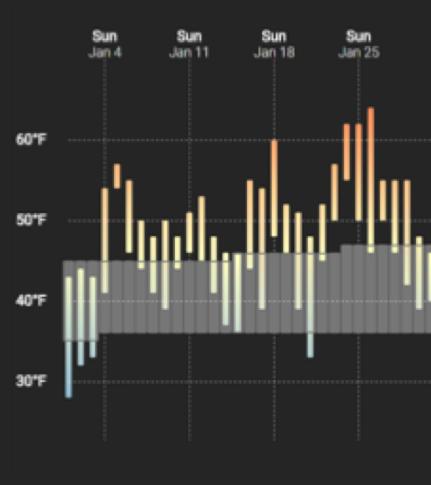


Linear

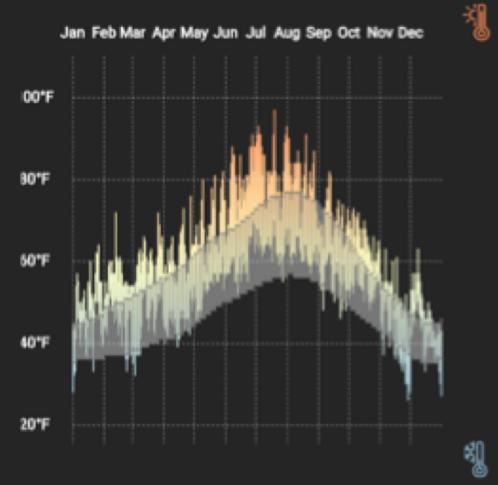
Week



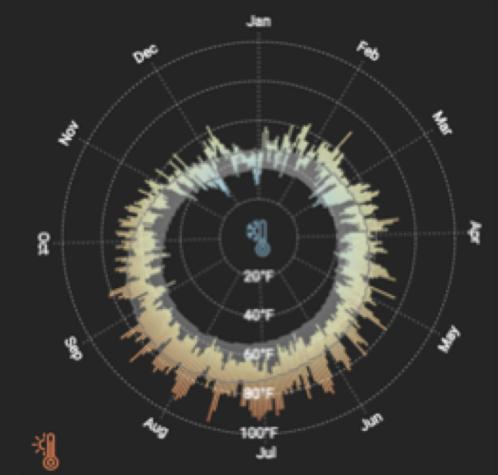
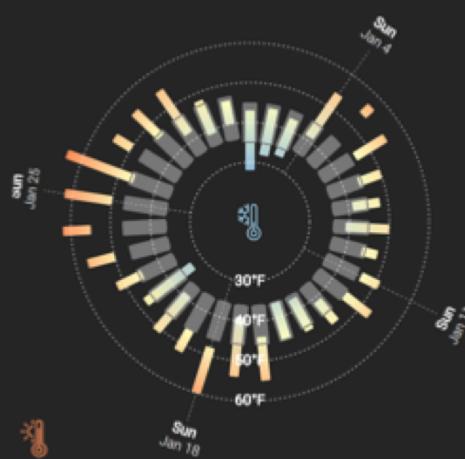
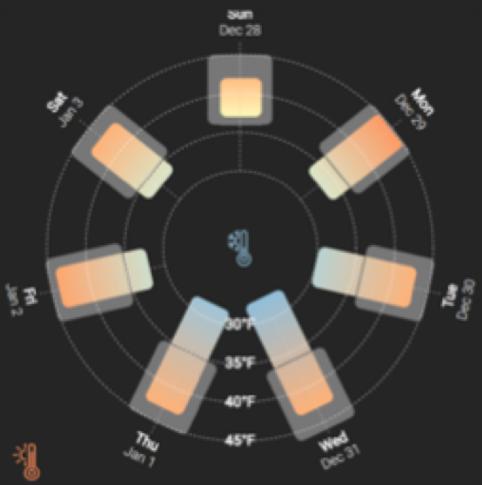
Month



Year



Radial



Thinking Systematically About Tasks

Tasks derived from *A Multi-Level Typology of Abstract Visualization Tasks*.
Brehmer and Munzner. In *IEEE TVCG* (VIS 2013, InfoVis Track):

- **Locate** Dates
- **Identify** Values
- **Locate** Extreme Values
- **Compare** Values
- **Compare** Ranges

Dependent Measures

For each trial:

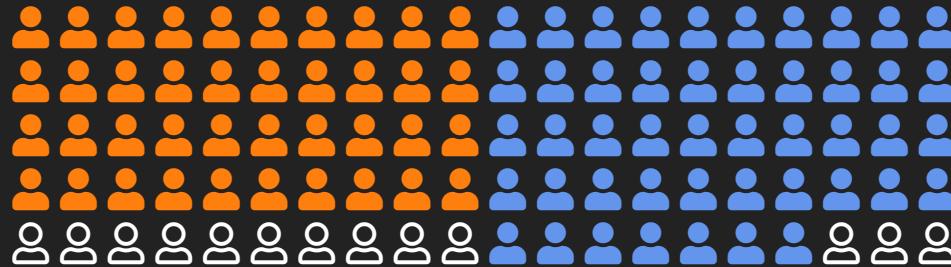
- ⌚ Trial completion time
- ✓ Response accuracy

At each level of granularity:

- 👍 Preference: Linear or Radial
- ☰ Confidence: Low to High

Participants

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



84 trials per participant, using their own phone.

Radial or Linear?

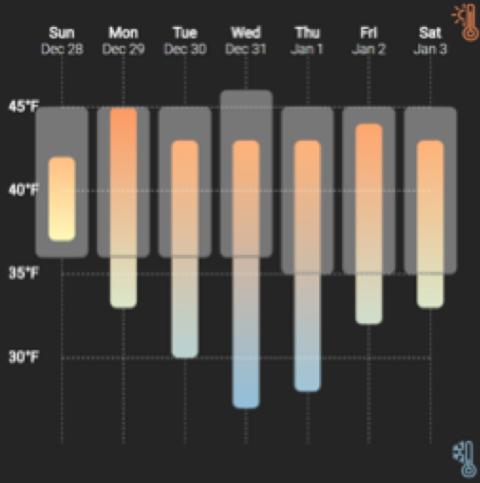
Detailed statistics are provided in:

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

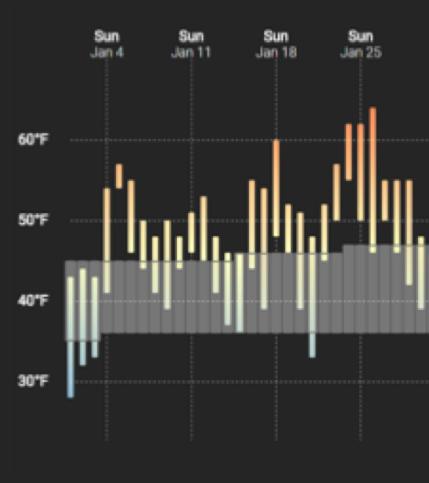
- 💡 People are, in general, **slower with radial** representations.
- ✓ Accuracy appears to be **data- and task-dependent**:
e.g., **less accurate with radial** when **identifying** and **locating** values in absence of seasonal variation.
- 👍 People **prefer** (and are **more confident** with) **linear** representations.

Linear

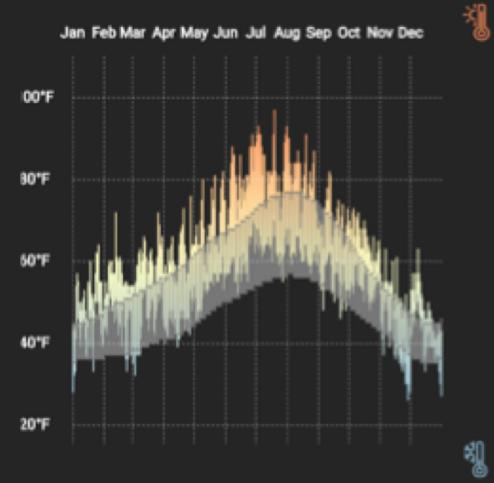
Week



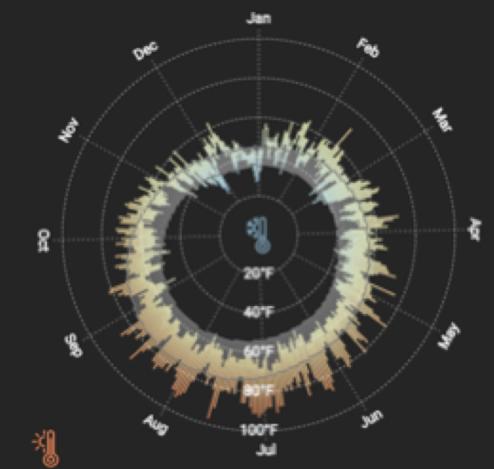
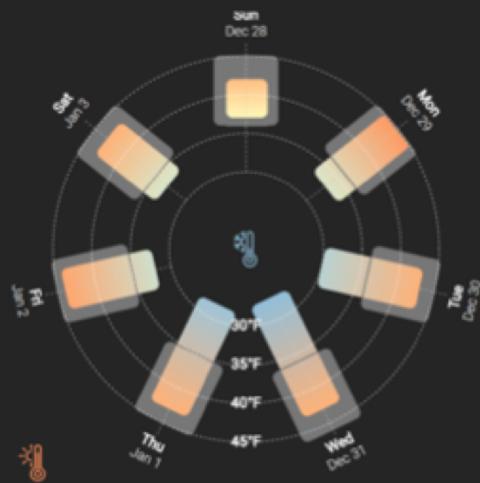
Month



Year



Radial



Week vs. Month vs. Year

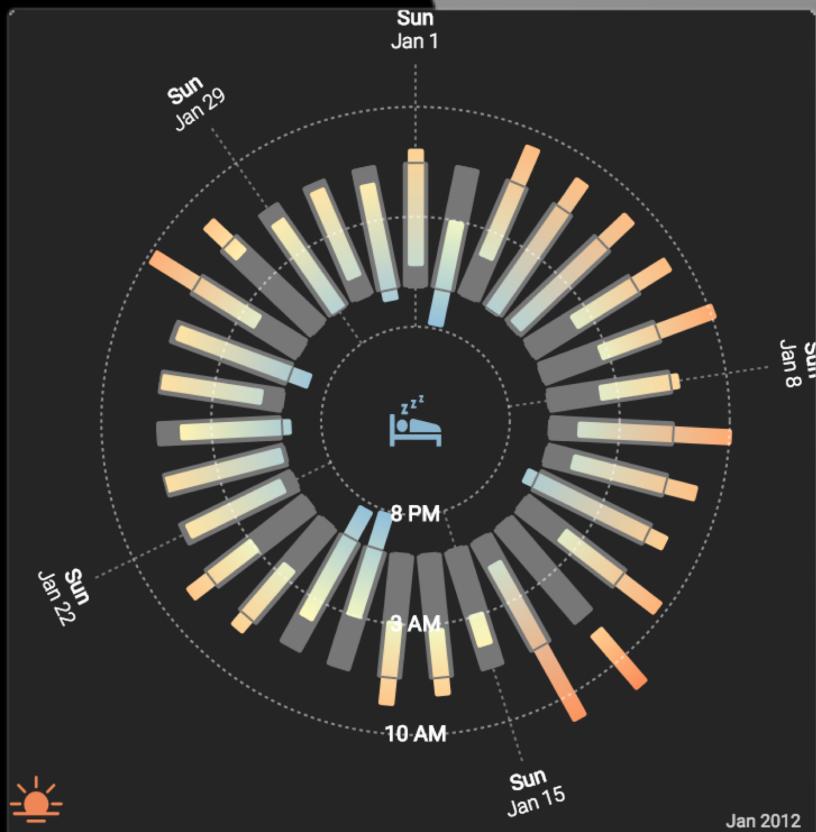
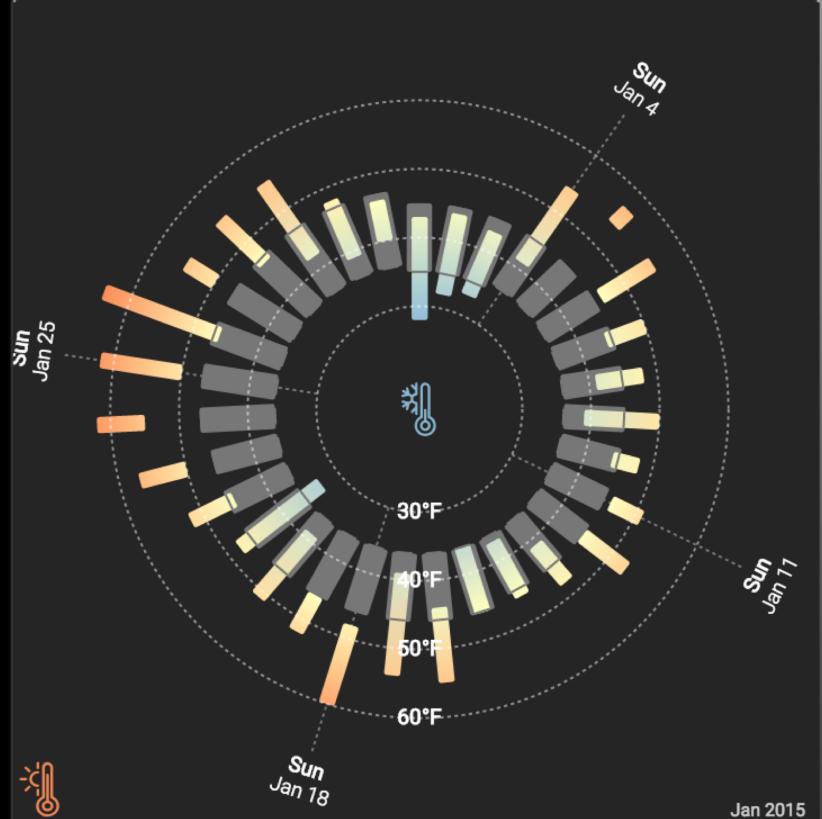
Detailed statistics are provided in:

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

- ⌚ 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**.

e.g., **seasonal variation** in annual temperature appears to be **beneficial** for locating extreme values.

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



Ranges Over Time on Mobile Phones: Conclusions

Is a **cycle** **meaningful** in the context of the data?

Does the task involve **locating** values? Or **comparing** them?

Is **efficiency** important?

Locating values quickly? → Choose **Linear**.

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

Ranges Over Time on Mobile Phones: Opportunities

More research is needed to **assess visualization design choices** on mobile phones.

↗ aka.ms/ranges | (mobile only) experimental app.

↗ github.com/Microsoft/RangesOnMobile | open source app and analysis.

↗ medium.com/multiple-views-visualization-research-explained | blog post for practitioners.

Outline

- What is **expressive information design**?
- My **background**, **methods**, and **values**
- **Focus** section 1: *Considerations and tools for expressive information design*
- **Focus** section 2: *Expressive information design for mobile devices*
- **Ongoing** and **future** research
- Why **SIAT**?

Expressive Info. Design for Mobile Devices, Continued^{9.2}

□ *A Comparative Evaluation of Animation and Small Multiples For Trend Visualization on Mobile Phones.*
Brehmer, Lee, Isenberg, and Choe. Working paper, Jan. 2019.



↗ aka.ms/multiples | (mobile only) experimental app.

Expressive Info. Design for Mobile Devices, Continued

9.3

Discoverable Interactions for Navigating & Selecting Time-Varying Data on Mobile Phones.

Brehmer, Lee, Collins, and Hinckley. Ongoing work.

Motivation: few people interact with interactive news graphics beyond scrolling.

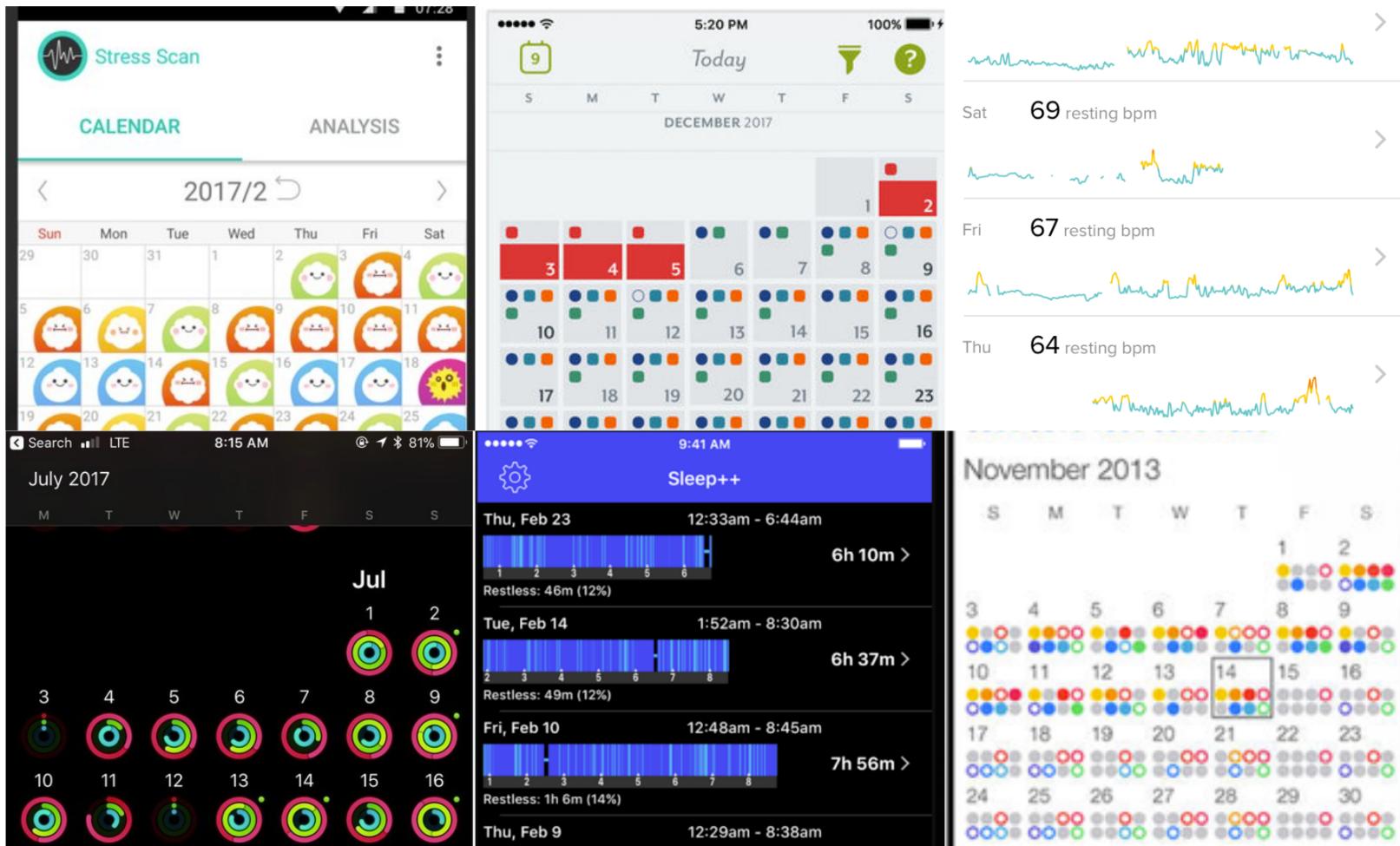
Many interactions anticipate a desktop context, but most of the audience is **using a mobile device**.

UI elements for navigating multidimensional time-varying data occupy **too much screen real estate**.

Expressive Info. Design for Mobile Devices, Continued

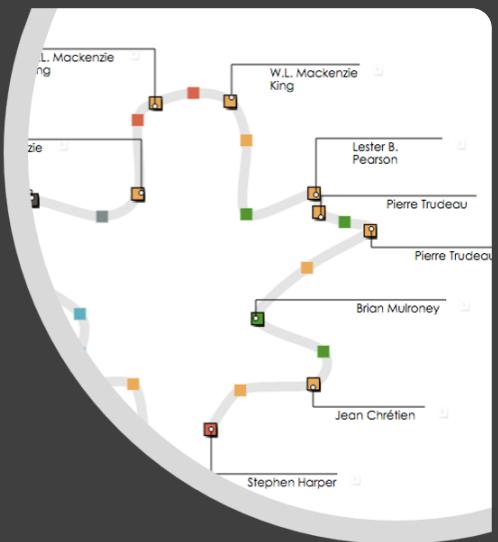
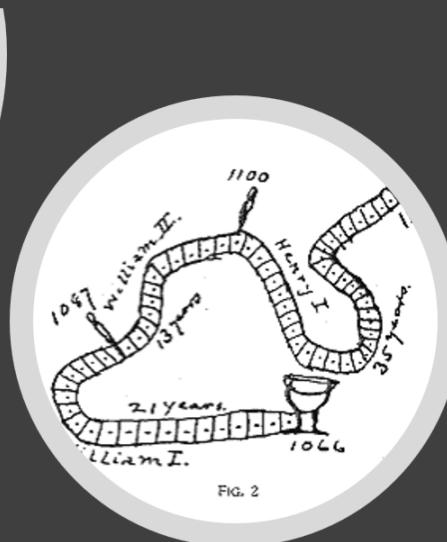
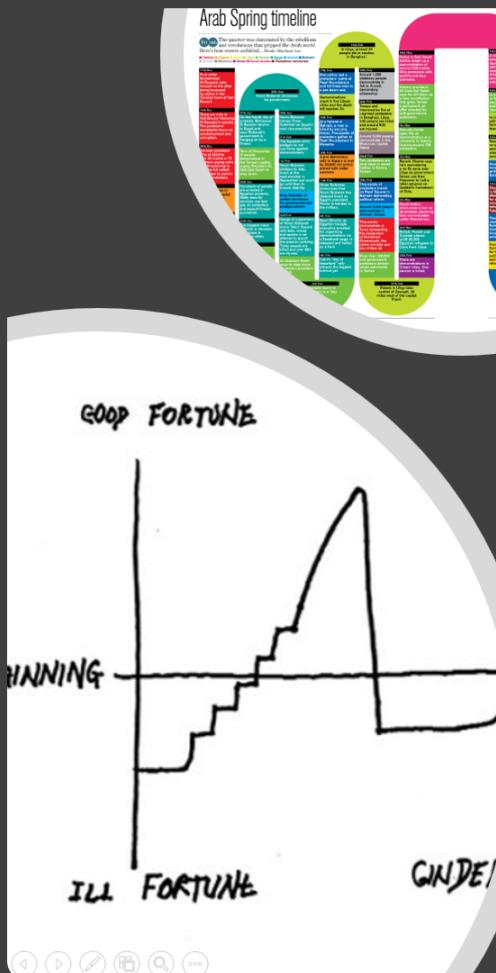
Smaller Multiples: Assessing Multidimensional Glyph Design on Mobile Phones.

Brehmer, Lee, Isenberg, and Choe. Planned work.



Considerations for Expressive Info. Design, Continued

The Performative and Whimsical Drawing of Timelines with Pen + Touch Interaction.
Planned work.



Opportunities for Expressive Information Design

A Research Program

Opportunities for Expressive Information Design

Designing and evaluating **inviting** and **memorable** techniques for **presenting information**.

Widening the scope of data types: e.g., **spatiotemporal** data, **dynamic networks**, ...

Collecting and **assessing** design choices from the **research** and **practice** communities.

Constraints on Expressive Information Design

Measuring audience **graphicacy*** (visual / data / statistical literacy) and identifying ways to **boost** it.

Information design for an audience with a **limited attention span**.

Mobile-first and **mobile-only** information design.

More **laboratory-** and **crowd-based experimental** work to assess alternative design choices.

Democratizing Expressive Information Design

Individuals: Visualization of **personally-relevant** information for making decisions in daily life.

Presenters: Interactive design tools for **those without programming expertise** or ample time;

Recommendations and considerations for **those without design expertise**.

e.g., small or local newsrooms, educators, cultural institutions, curators of digital collections, ...

Outline

- What is **expressive information design**?
- My **background**, **methods**, and **values**
- **Focus** section 1: *Considerations and tools for expressive information design*
- **Focus** section 2: *Expressive information design for mobile devices*
- **Ongoing** and **future** research
- Why **SIAT**?

Why SIAT?

- Students trained in **information design**, **visual communication design**, and **interaction design**.
 - Potential to collaborate on projects on **resource conservation**, **health**, and **cultural heritage**.
 - Research spanning **interactive computing**, **design**, **people**, & the **science of interaction**.
 - **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

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