University of Bremen

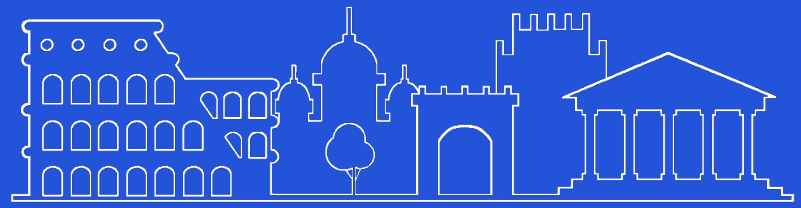
Global Dynamics of Social Policy CRC 1342

EUROVIS 2022

Mobile and Multimodal? A Comparative Evaluation of Interactive Workplaces for Visual Data Exploration

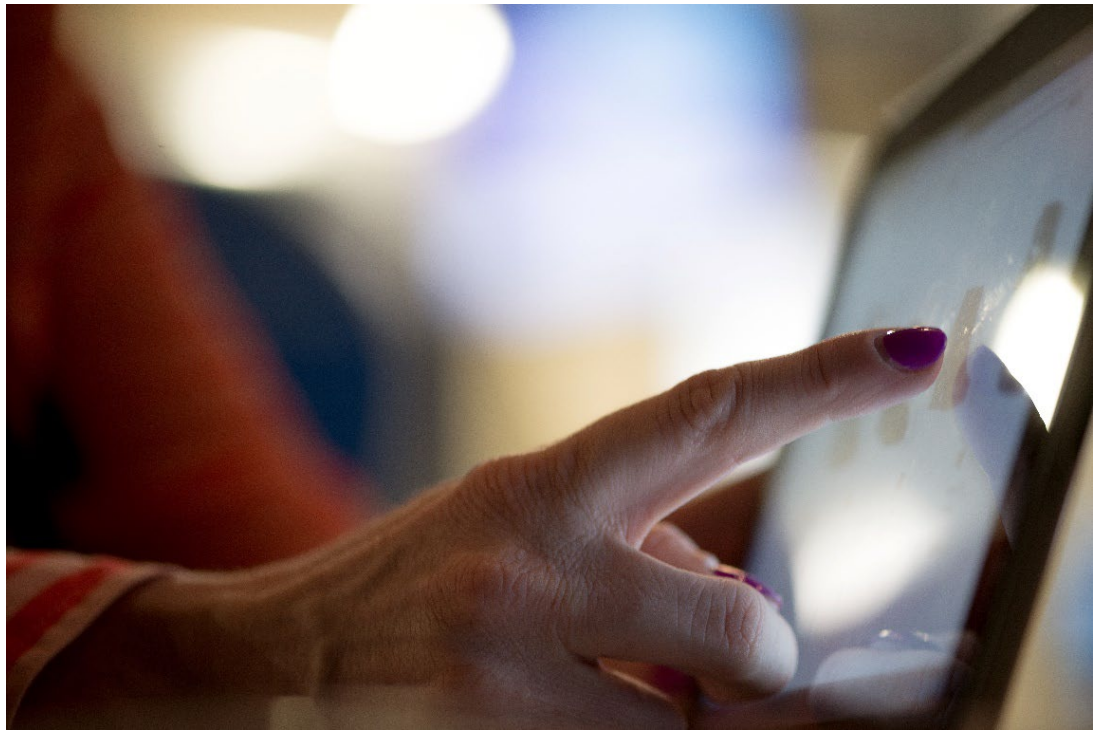
Gabriela Molina León*, Michael Lischka, Wei Luo, Andreas Breiter



• 24th EG Conference on Visualization • Rome • 13-17 June 2022 •

How do we interact with data?



How do we interact with data?

- On desktop PCs and laptops, we mostly use the mouse and keyboard (WIMP interfaces)
- However, we use mobile devices more often to browse the web[1]:
  - Smartphones
  - Tablets
  - Smartwatches
- They support other interaction modalities, such as:
  - Touch
  - Pen
  - Speech

[1] BroadbandSearch.net (2022). *Mobile Vs. Desktop Internet Usage*.

What we know so far

- Drucker et al. (2013) compared a gesture-based interface with a WIMP interface on tablets
  - Participants were significantly faster with the gestured-based interface
  - They preferred it over the WIMP interface

- Combining pen and touch is both powerful and perceived as more natural (Hinckley et al., 2010)
- People prefer multimodal over unimodal interaction (Saktheeswaran et al., 2020)

How could tablet-based multimodal visualizations be used in a **work setting**?

How could tablet-based multimodal visualizations be used in a **work setting**?

How do they **differ** from their desktop WIMP counterparts?

… in terms of performance

… in terms of user experience

… in terms of interaction strategies

Case study: Social science research

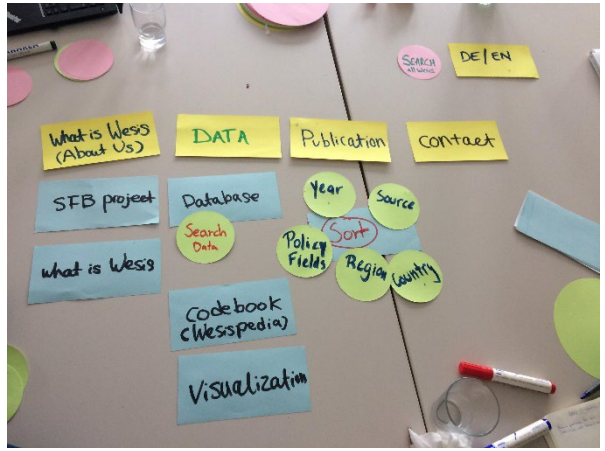
- We collaborated with social science researchers
- They collect spatio-temporal data, often relative

  (Colombia, 2001, 94.23%)

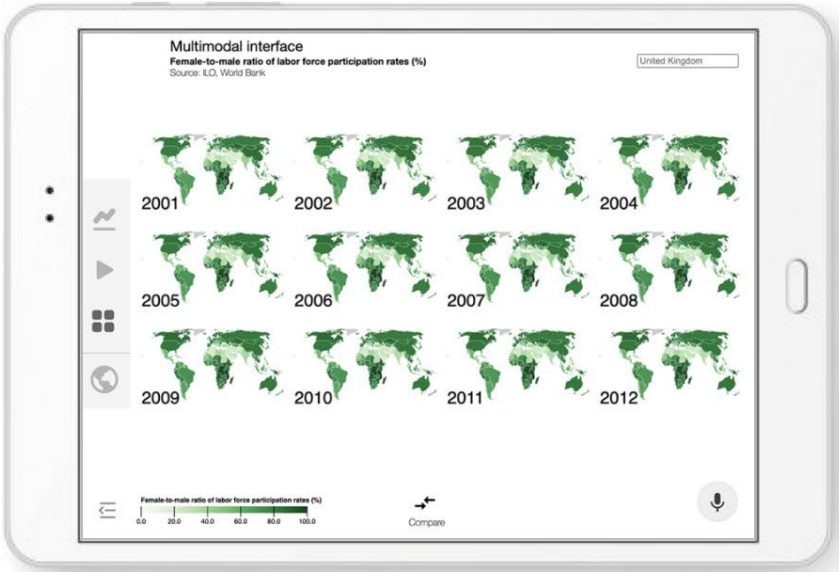
- They wished to explore development indicators
- Our goal was to support their data exploration through a web-based visual system
- We abstracted their tasks according to the task typology of Andrienko & Andrienko (2006)

Access to electricity (% of population)

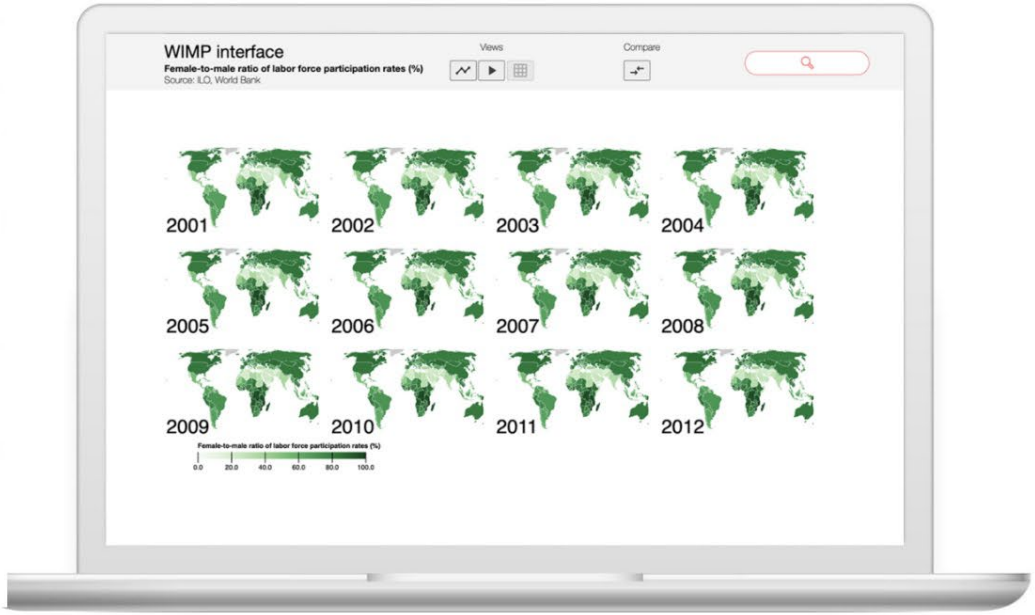
Country	2000	2001	2002
Austria	100	100	100
Azerbaijan	98.91	98.64	100
Bahamas	100	100	100
Brazil	94.41	96.02	96.65
Cambodia	16.60	15.51	18.81



We compare 2 interactive workplaces



Multimodal interface



WIMP interface

Touch Pen Speech

Mouse Keyboard

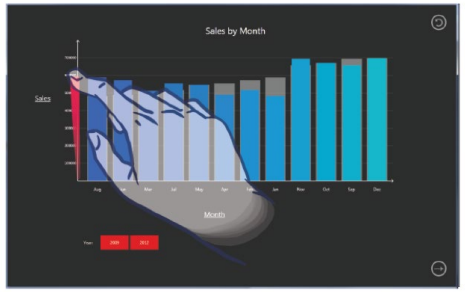
Design principles

Design principles

DP1 Leverage standard interaction techniques of multimodal systems.

DP2 Leverage standard interaction techniques of WIMP interfaces.

InChorus (Srinivasan et al., 2020)



TouchViz (Drucker et al., 2013)

Orko (Srinivasan and Stasko, 2018)

Design principles

DP3 Use standard touch gestures. 

- Tap, double tap, drag, swipe, and pinch.

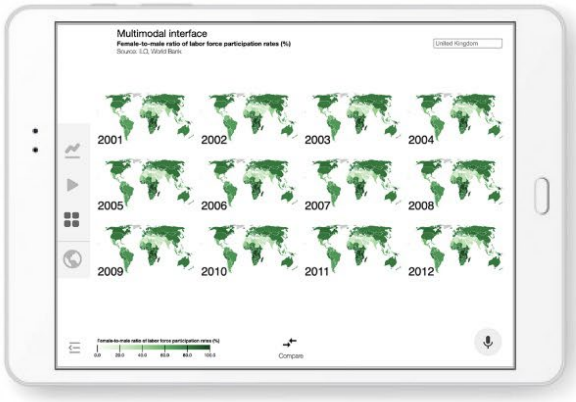
DP4 Achieve interaction consistency.

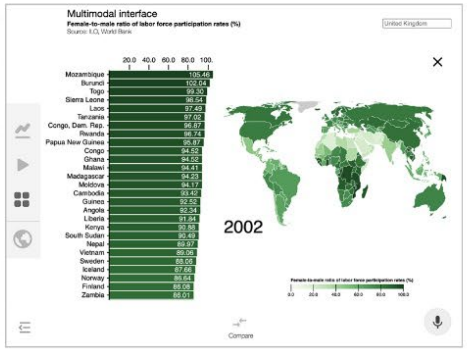
- Multiple coordinated views should include consistent interactions across views (Sadana and Stasko, 2016)

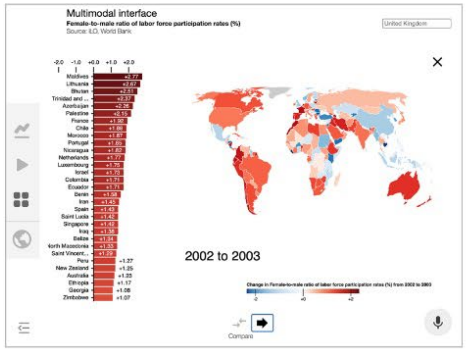
DP5 Introduce WIMP elements when necessary.

- We added redundant WIMP elements in specific cases to ensure a good experience (Drucker et al., 2013)

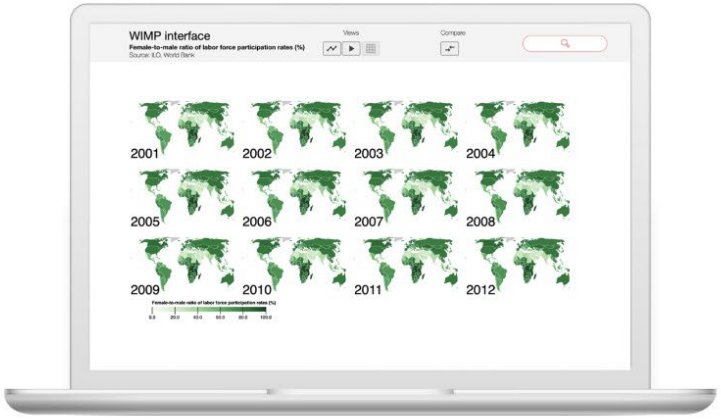
Visualization system

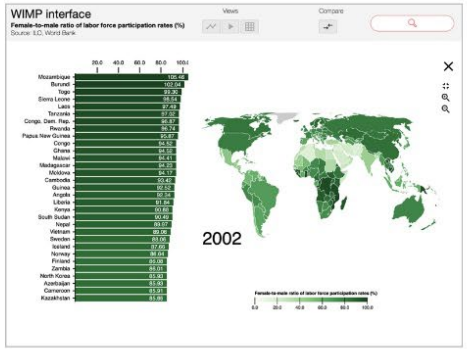


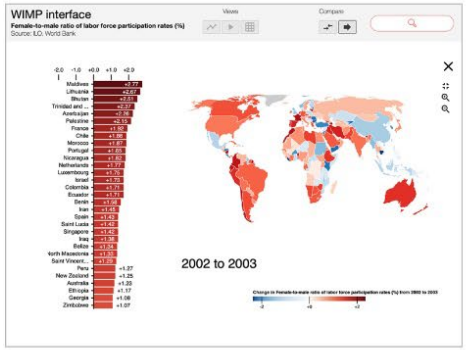




Multimodal interface







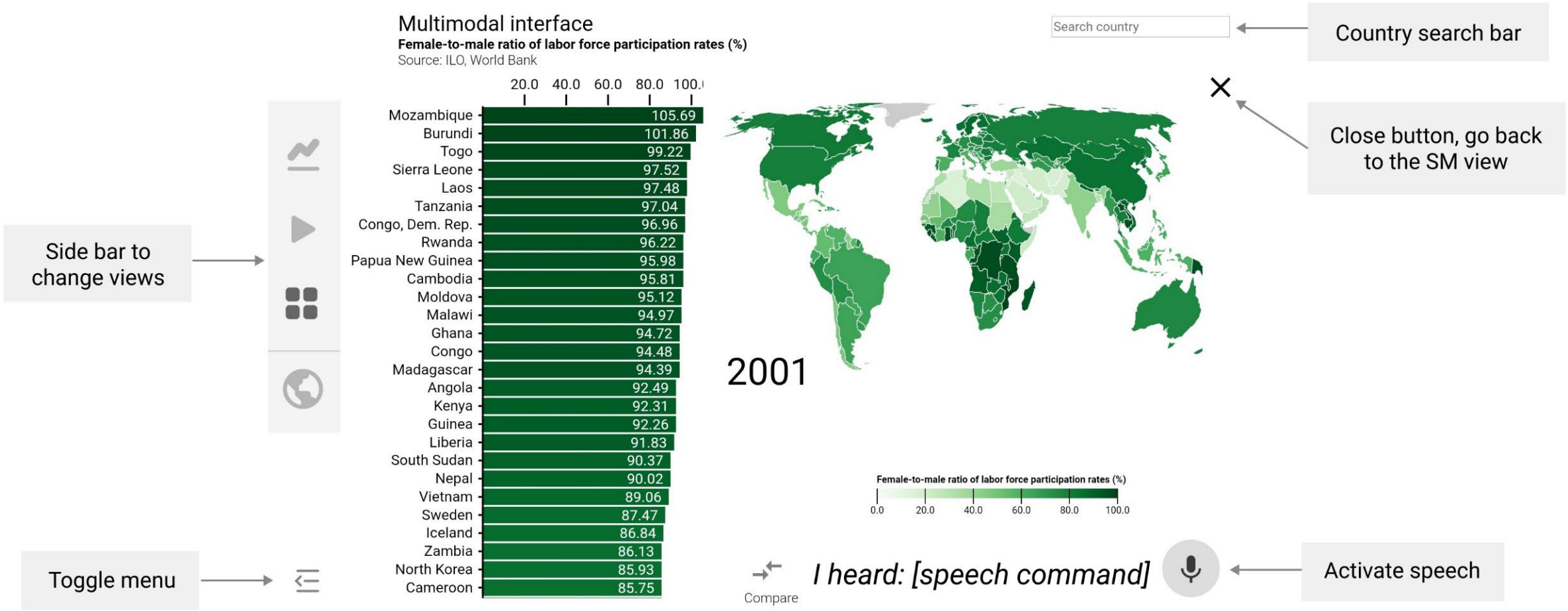
Small Multiples view

Detail view

Comparison view

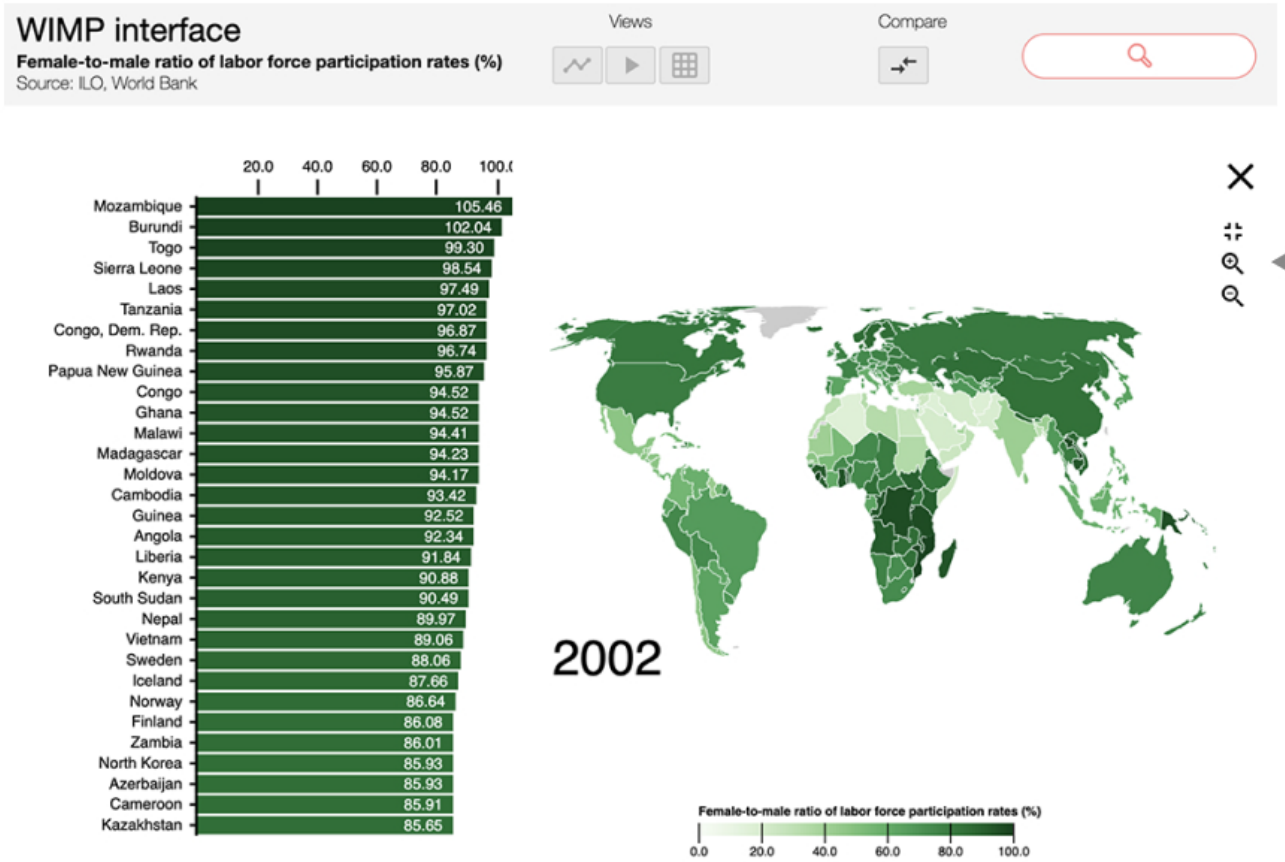
WIMP interface

Visualization system
Multimodal interface



Visualization system
WIMP interface

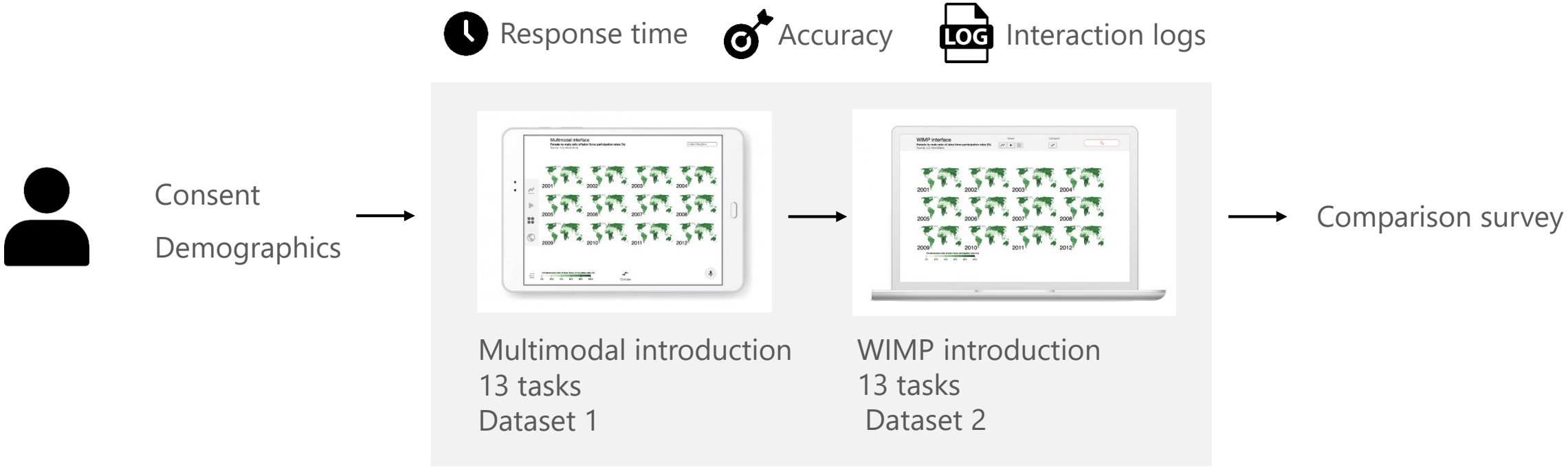
Fixed menu
for WIMP elements



More buttons

Comparative evaluation

- Within-subjects, semi-remotely.
- We measured performance and user experience.
- We logged their interactions based on screen and interaction recordings.



Comparative evaluation

- Real-world datasets from the World Bank (2001 – 2012)
  - Child mortality rate per 1000 live births
  - Female-to-male ratio of labor force participation rates

- Exploratory tasks (Andrienko & Andrienko, 2006)
  - 5 elementary tasks, e.g. direct lookup.
  - 8 synoptic tasks, e.g. pattern search.

- Hypotheses

  H1 The experts will need more time on the multimodal interface.

  H2 The experts will make fewer errors on the WIMP interface.

  H3 Participants will prefer the multimodal interface.

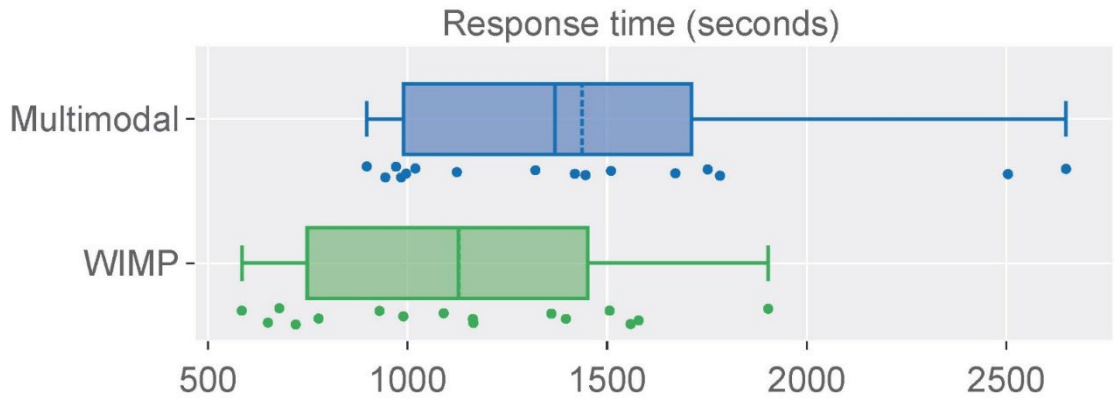
Results
Participants

- We recruited 16 social scientists
  - Diverse disciplines, mainly political science and sociology
- They spoke English fluently but were no native speakers
- Interaction experience
  - For five participants, this was the first time using a pen
  - For seven, it was the first time using speech input
- Nine owned a tablet

Results
Response time

H1 The experts will need more time on the multimodal interface.

Interface	Response time (sec)
WIMP	86.80
Multimodal	110.54



Participants were **significantly faster** on the WIMP interface with a medium-to-large effect.

$t(15) = 1.83$; $p = 0.043$; $r = 0.43$

Results
Accuracy

H2 The experts will make fewer errors on the WIMP interface.

Interface	Correct answers (%)
WIMP	86.54
Multimodal	85.10

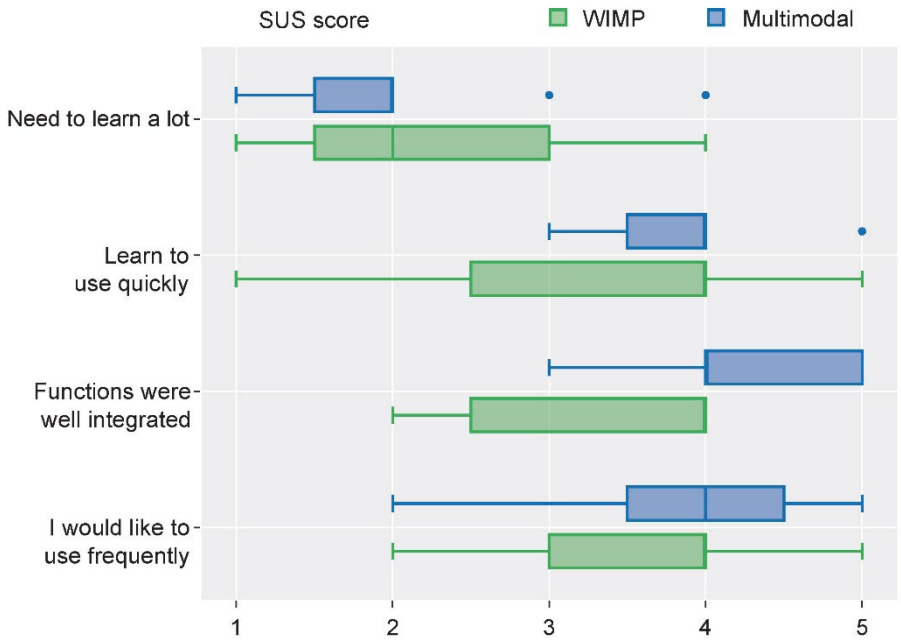
Participants were **not significantly** more **accurate** with the WIMP interface.

$W = 33.5; p = 0.39$

Results
User experience

H3 Participants will prefer the multimodal interface.

Interface	#Participants
WIMP	6
Multimodal	10



- Would they use either version at work?
  - 15 would use the multimodal interface.
  - 14 would use the WIMP interface.

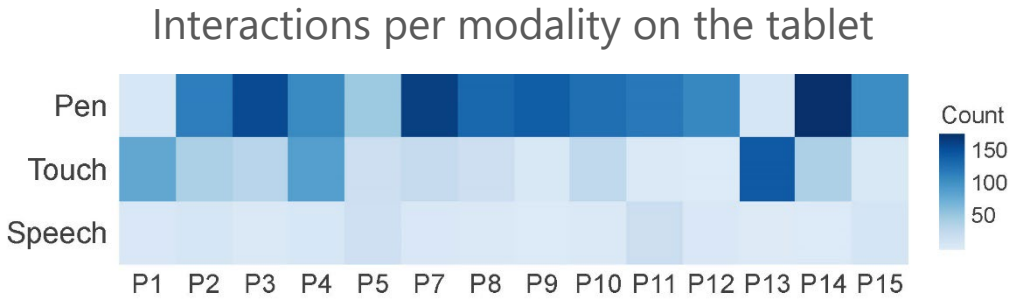
"I'm more used to work with laptops"
- P12

"[The multimodal interface] gives us much more fun than just keyboard and mouse"
- P5

Results
Interactions

- Participants **interacted significantly more** with the multimodal interface.
  (t(13) = 1.85; p = 0.046; r = 0.45)

- Most participants had one dominant modality
  - Everyone used the mouse most on WIMP
  - On the multimodal interface,
    - 11 mostly used the pen
    - 2 mostly touch
    - 1 almost equally used pen and touch



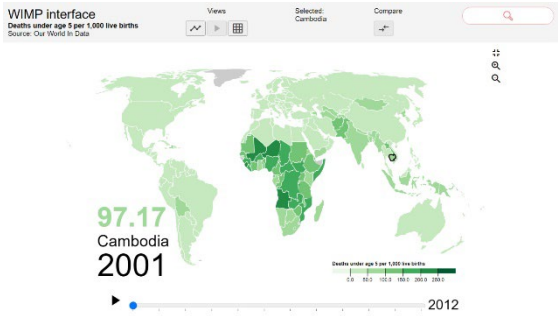
Results
Interaction patterns

1. On the tablet, participants used most views with larger maps. Pen selection on the map, panning on the bars.

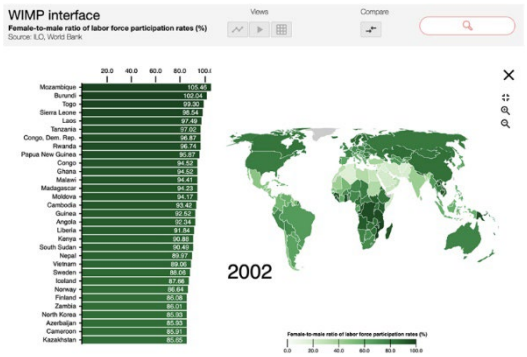
2. For time intervals, most used the line chart on the PC, and the comparison view on the tablet.

3. Hovering was key to solve most tasks on the PC.

Animation view



Detail view



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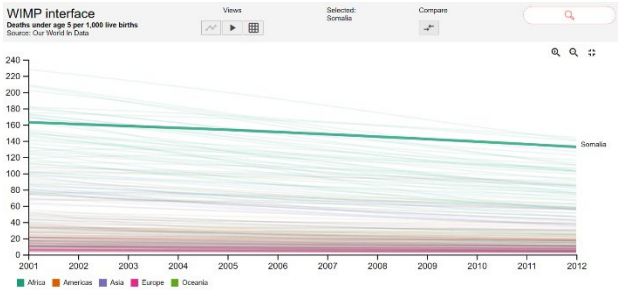
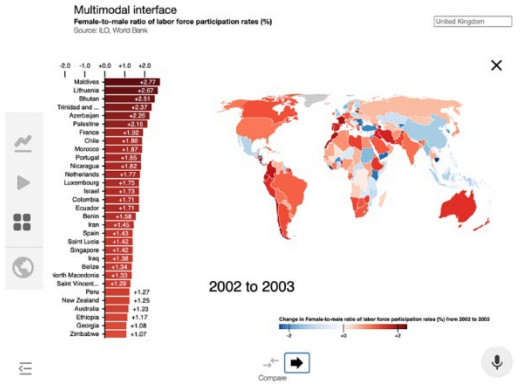
Lines view



Comparison view



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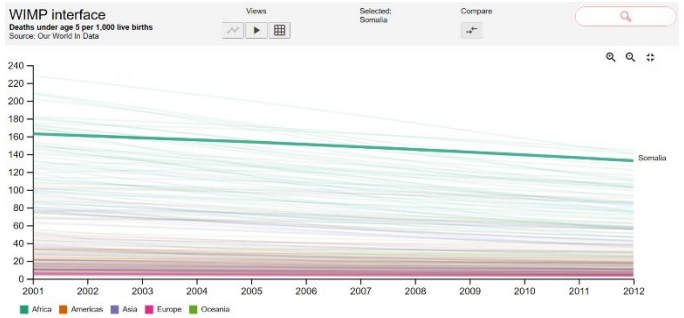

Recommendations
Interaction Design

1. The pen should be able to perform most interactions, and all **critical interactions** should be possible with the pen.

2. **Performance** depends on the modalities that suit better the combination of visualization and interaction techniques.


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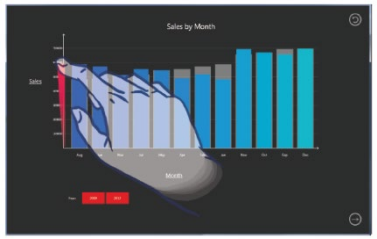


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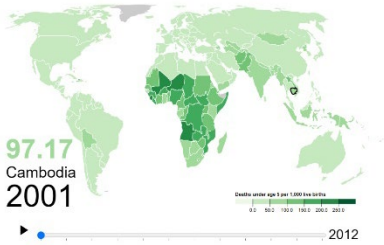
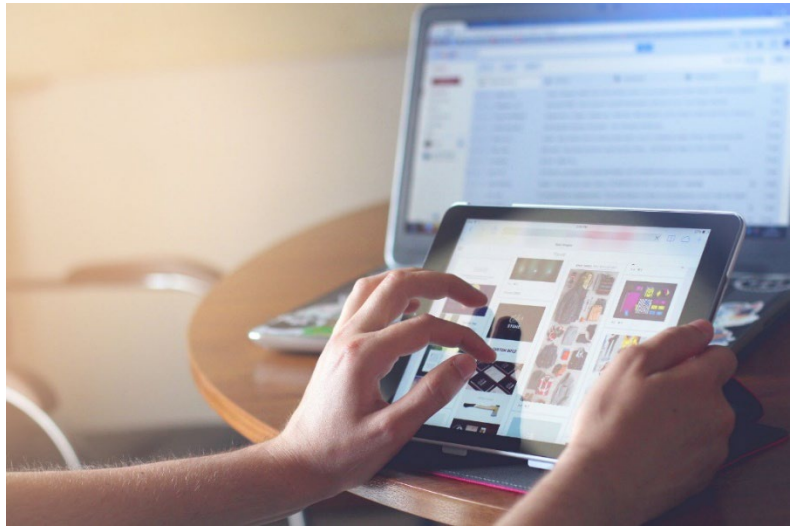


3. Leveraging speech interaction may lead to a more **engaging experience**, but other modalities should support the same actions to guarantee usability.

Conclusions

- Each modality fits best to specific actions and tasks
  - The pen was the most used and appreciated
- Participants had different interaction strategies to solve the tasks across conditions
- If multimodal tools are given, domain experts would consider including them into their workflow
- Designing with more modalities may help make visualizations more accessible



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- A. Srinivasan and J. Stasko, "Orko: Facilitating Multimodal Interaction for Visual Exploration and Analysis of Networks," in IEEE Transactions on Visualization and Computer Graphics, vol. 24 (2018).
- Accuracy icons created by Andika Syaif.
- Logos by Tableau Software, Datawrapper GmbH, Google Inc., and Apple Inc.
- Touch, pen, keyboard, mouse, log, and speech icons created by Freepik – Flaticon.
- Person and time icons created by Ilham Fitrotul Hayat.

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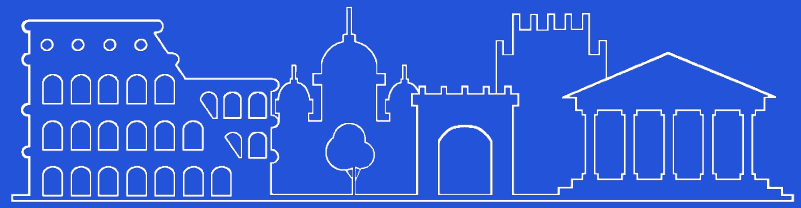

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