

Visualizing Mobile Network Data

A User-Centred Design Approach Connecting Visual Analytics to Urban Public Transportation Planning

by **LAURA VERENA KLASEN** – defended on **29 OKTOBER 2020**

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Research Objectives

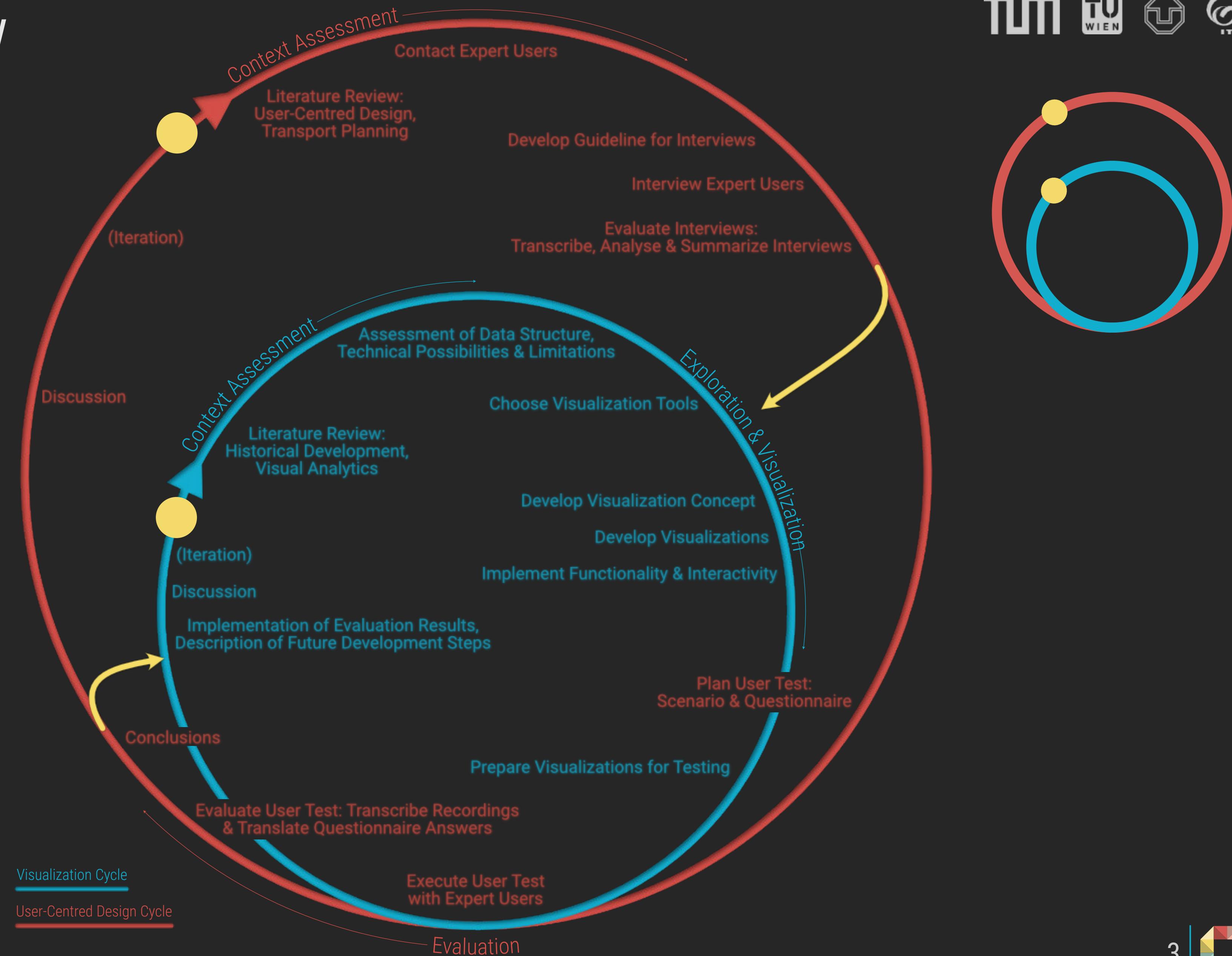
1. Exploration of different ways of visualizing spatiotemporal data for planning purposes
 - 1.1 Context assessment → HISTORICAL & CURRENT
 - 1.2 Exploration and Visualization of time-variable attributed flow data
2. Evaluation of the usefulness of a visualization concept for flow data and OD data for urban public transportation planning
 - 2.1 Assessment of current analysis practices in urban public transportation planning
→ USER NEEDS
 - 2.2 User-test of a visualization concept for flow data and OD data for the evaluation of its usefulness within urban public transportation planning



Workflow



Workflow

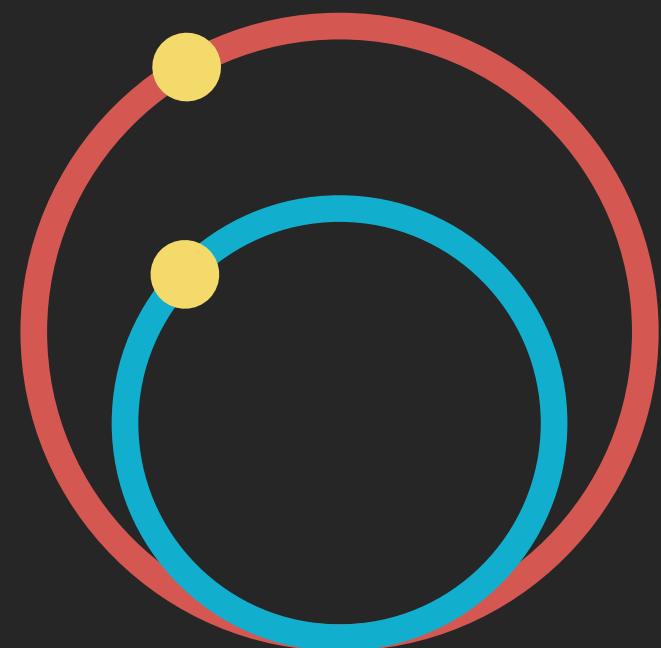


Literature – visual analytics

Visual Analytics can be defined as

“an iterative process that involves information gathering, data preprocessing, knowledge representation, interaction and decision making. The ultimate goal is to gain insight in the problem at hand which is described by vast amounts of scientific, forensic or business data from heterogeneous sources. To reach this goal, visual analytics combines the strengths of machines with those of humans.”

(Keim, Mansmann, Schneidewind, Thomas & Ziegler, 2008)



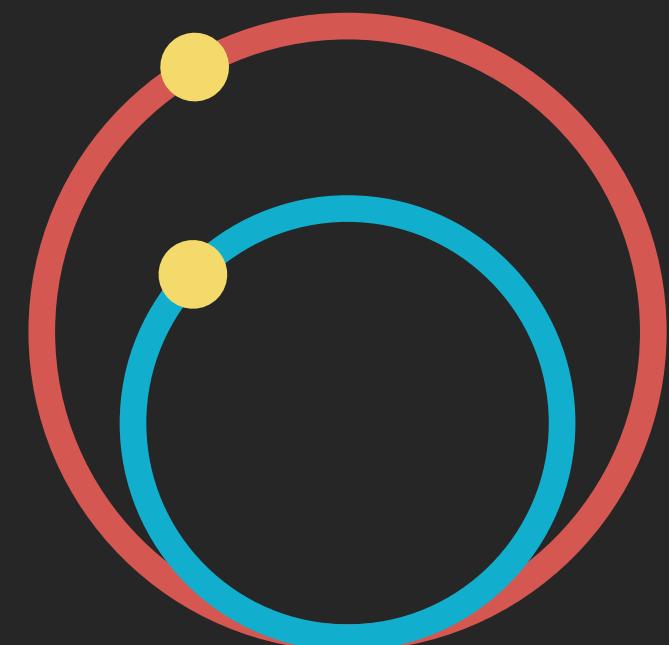
Literature Review:

User-Centred Design
Transport Planning

Historical Development
Visual Analytics



Literature – visual analytics



GOAL

visual exploration and analysis of **spatiotemporal data**

WAY TO GO

cartographic **map** + time graphs or temporal bar **charts**

...according to Andrienko et al. (2013, chapter 4)

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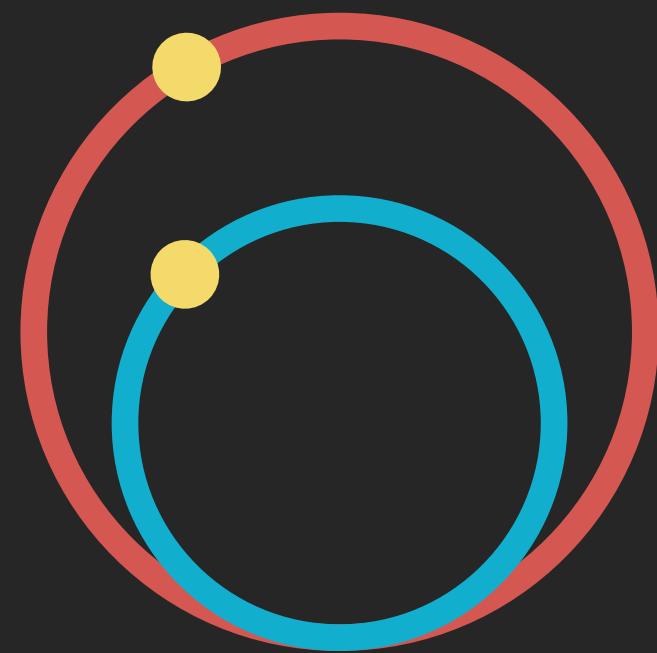
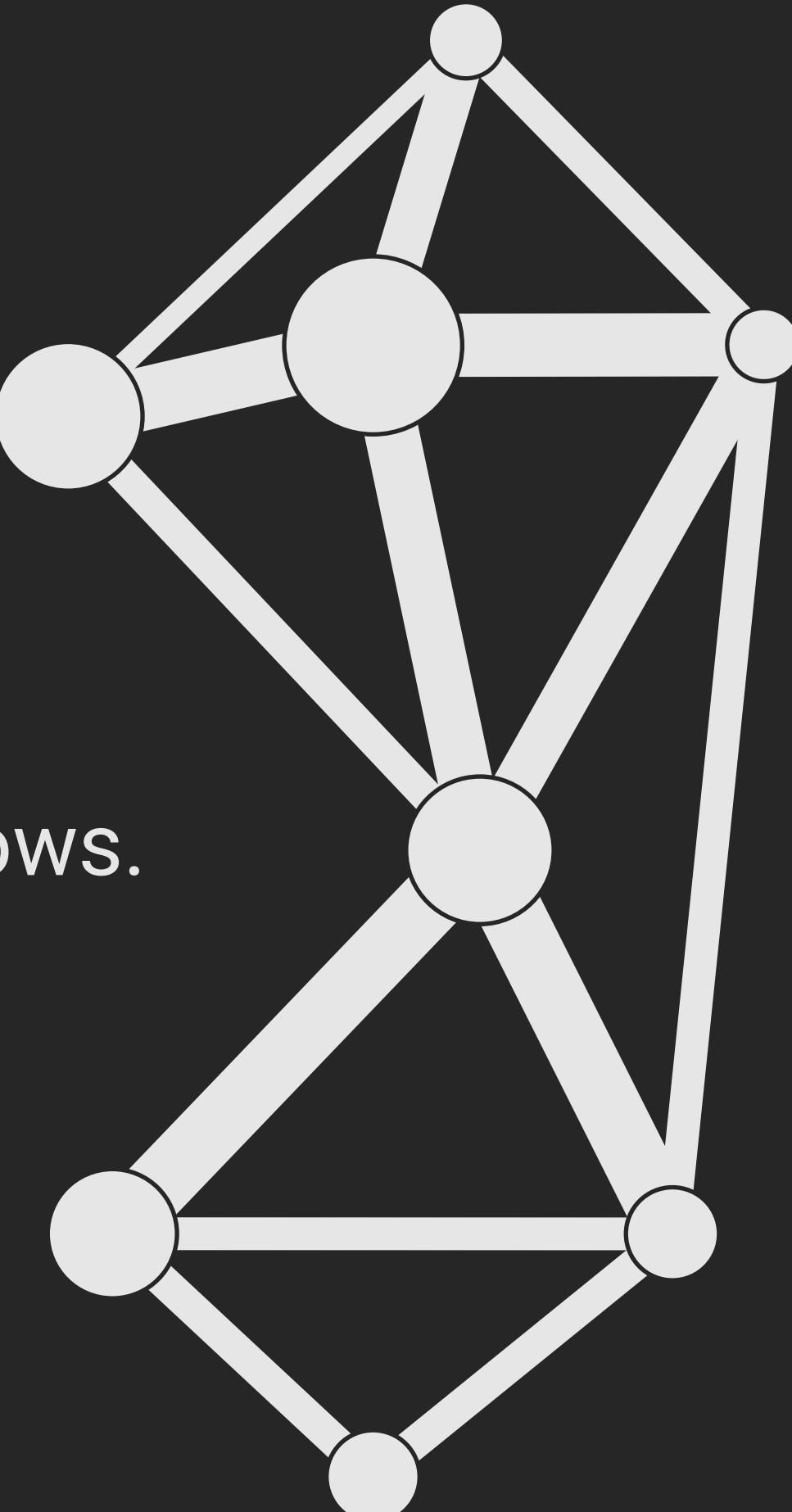
Literature – flow maps

MAPS

- substantial **contextual** information
- help relate data subsets to each other

FLOW MAP

- map showing aggregated movements, i.e. flows.



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Transport Planning

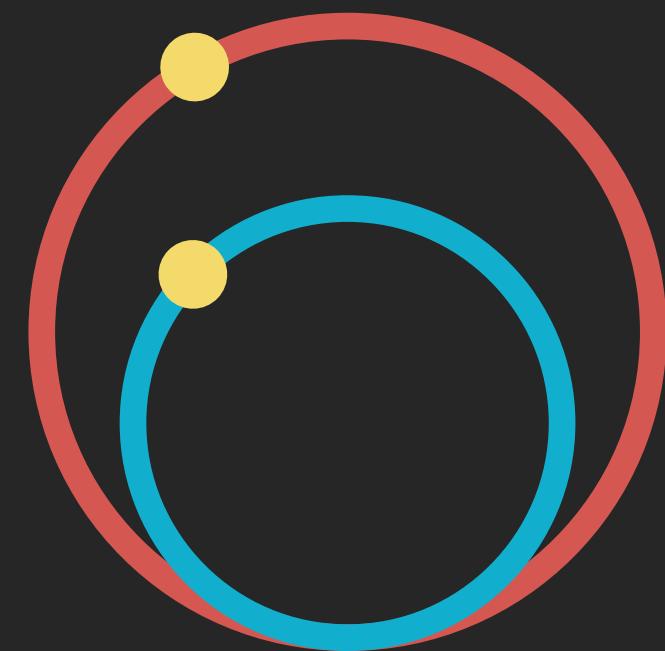
Historical Development
Visual Analytics



Literature – flow maps



Detail from a series of flow maps by Charles-Joseph Minard depicting the Circulation of Goods on French Railroads and Waterways between 1850 and 1862. Image taken from https://patrimoine.enpc.fr/document/ENPC01_4_10975, accessed 2020/09/18.



Literature Review:

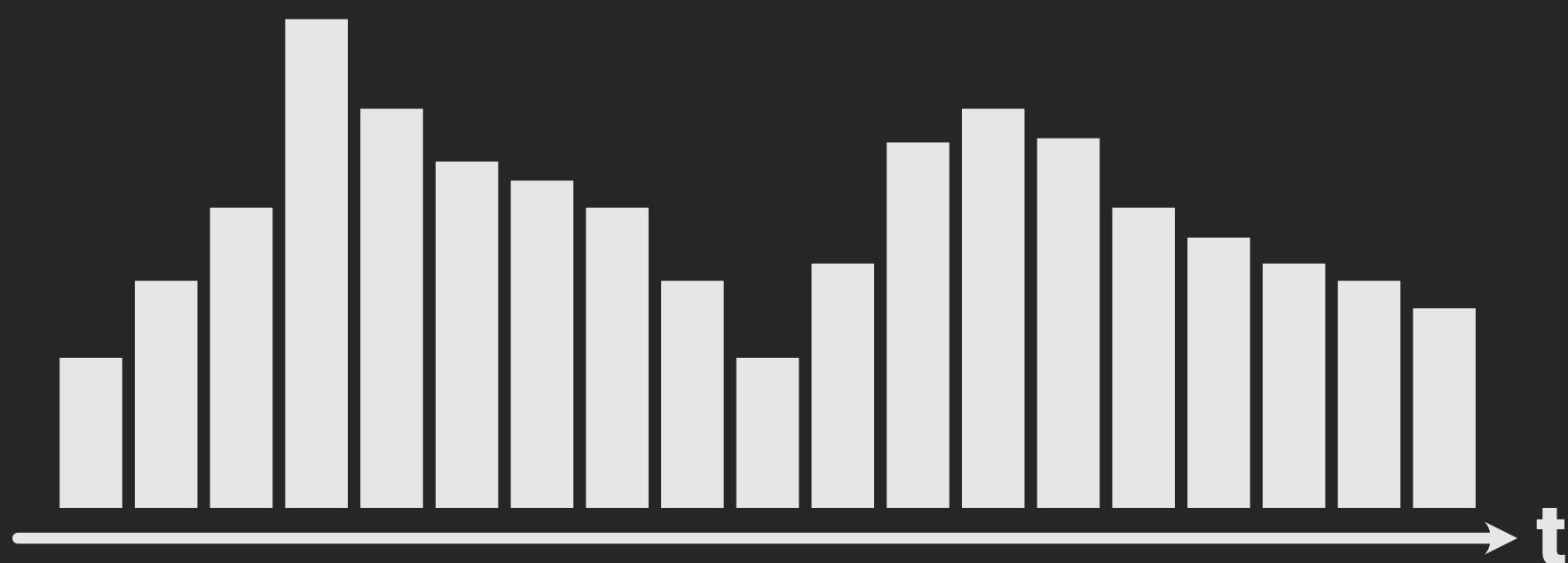
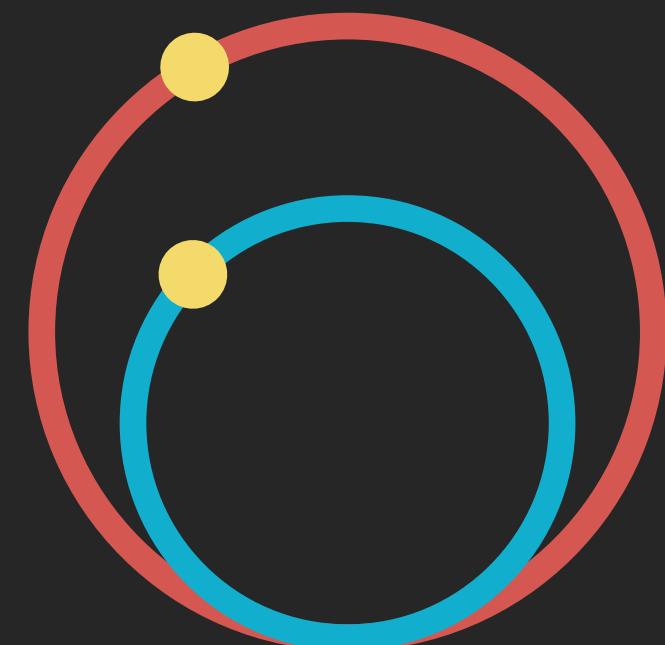
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Transport Planning

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Literature – temporal bar charts

TIME GRAPHS / TEMPORAL BAR CHARTS

- complementary temporal overview
- more complete understanding of the data



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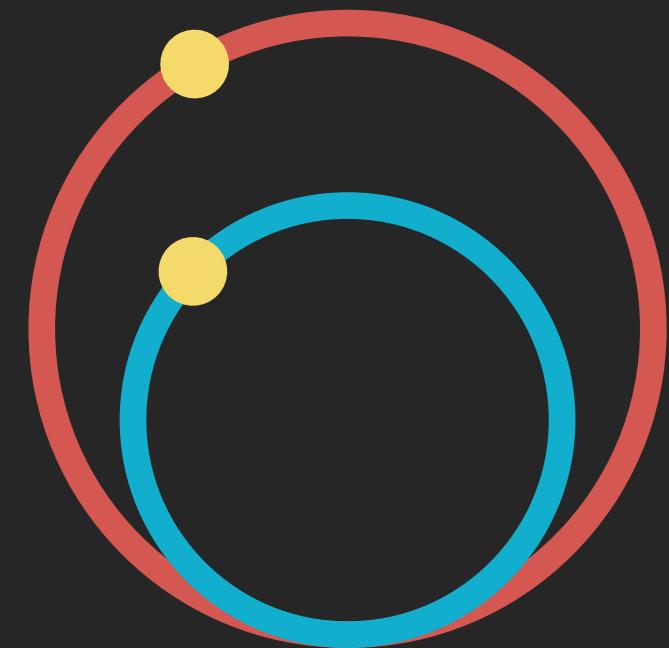
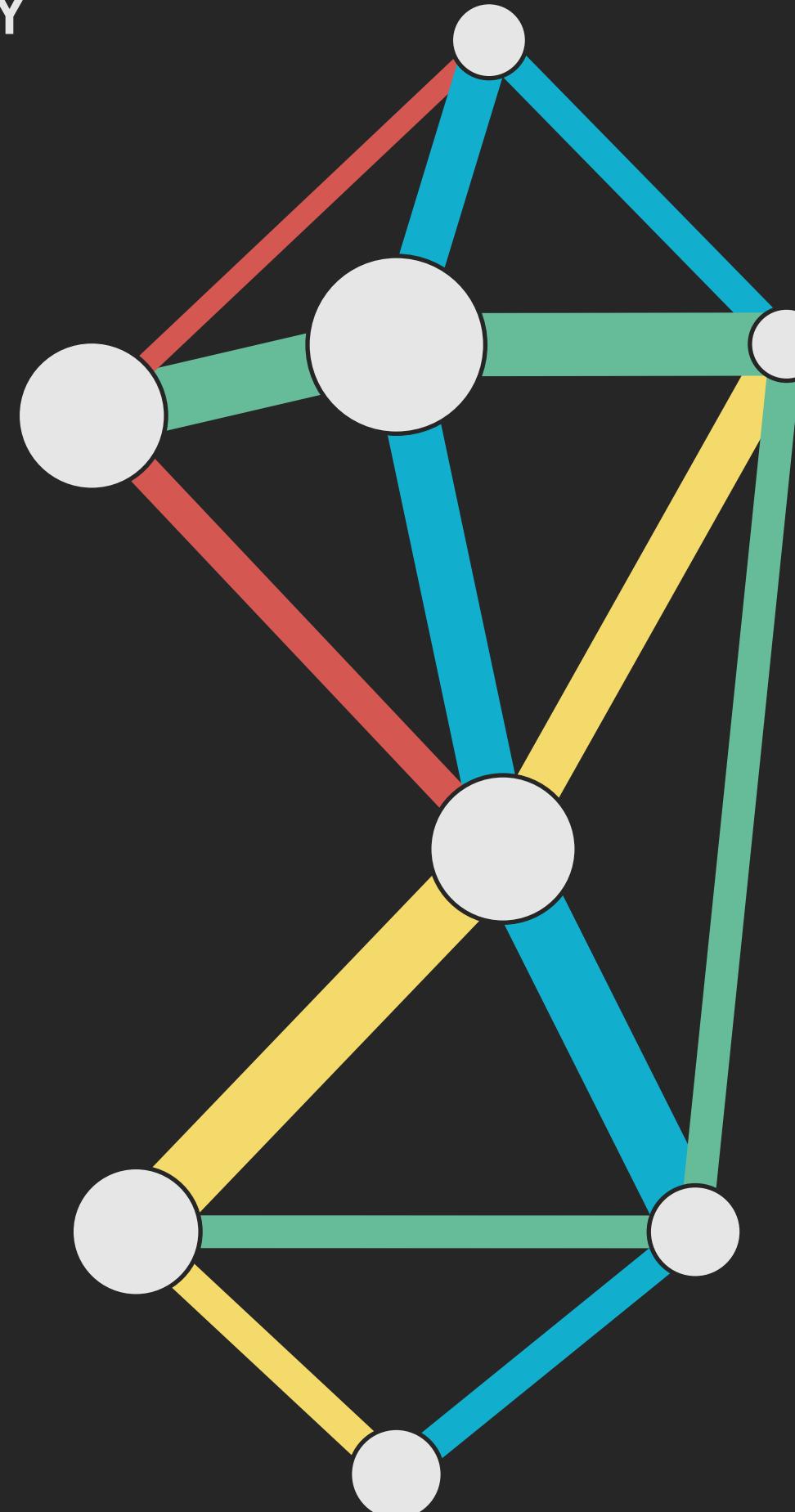
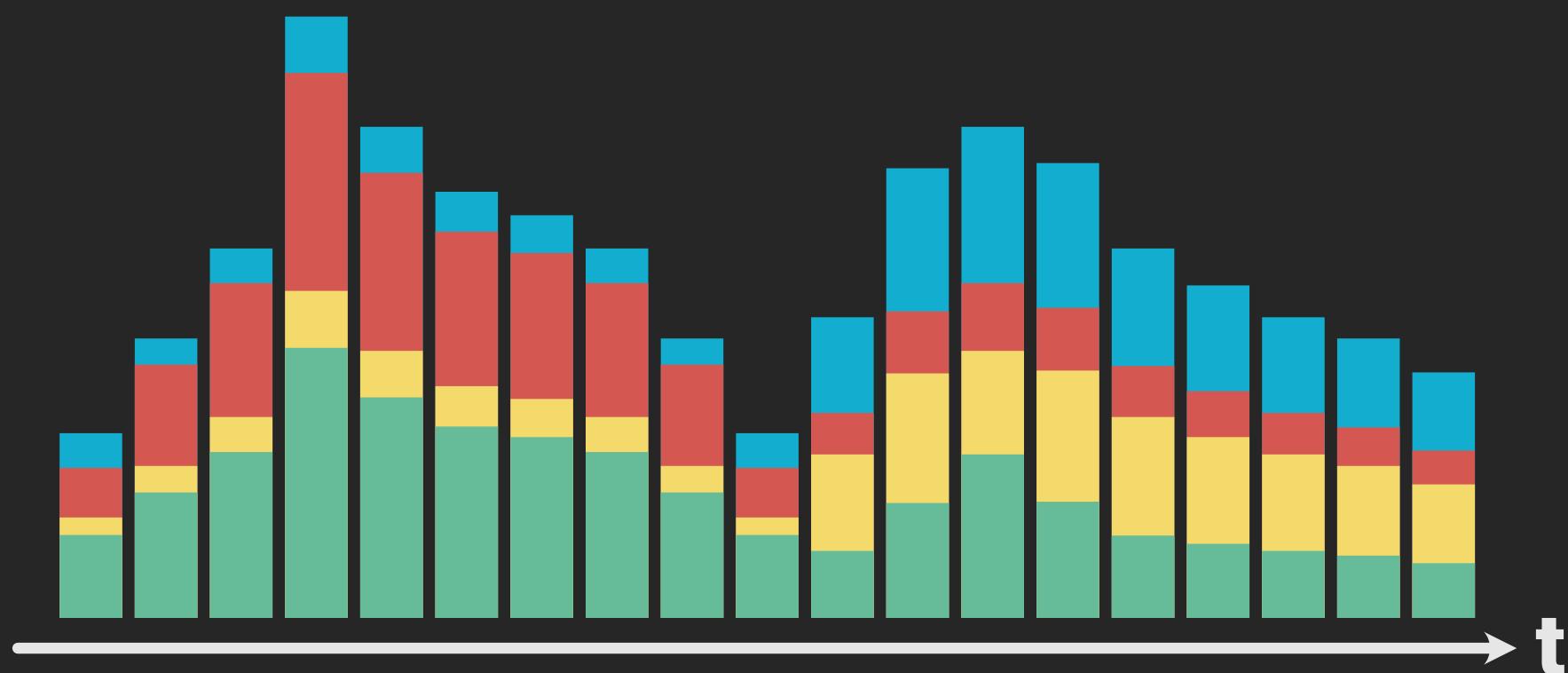
Literature – linked views

LINK MULTIPLE VISUALIZATIONS & INTERACTIVITY

→ different aspects of the same dataset

→ visual **consistency**

→ reduces visual clutter & occlusion



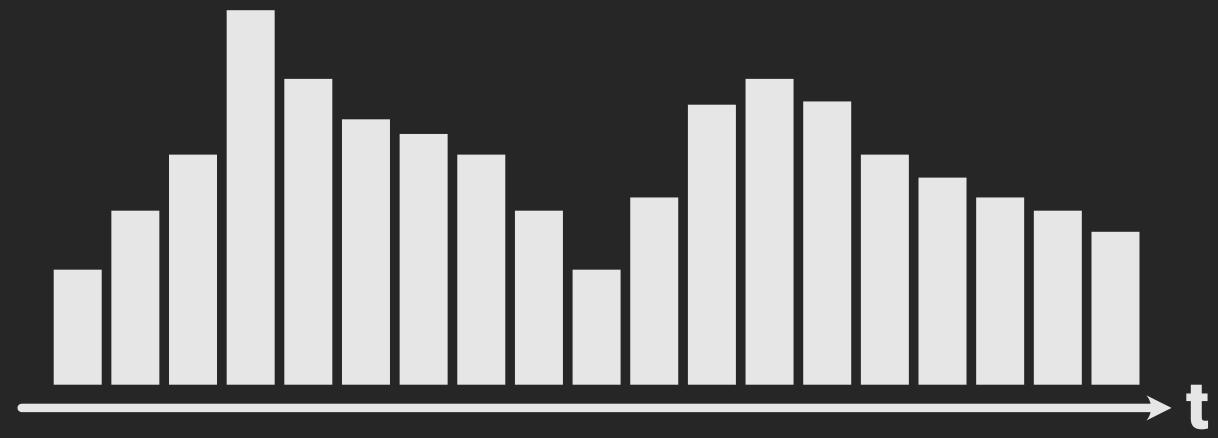
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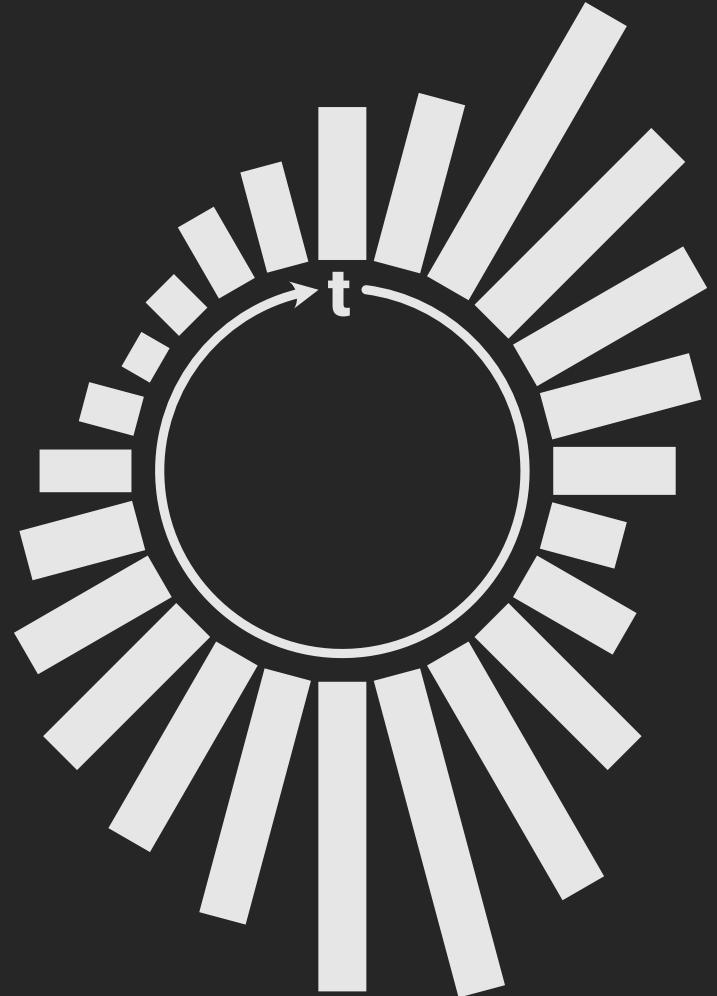
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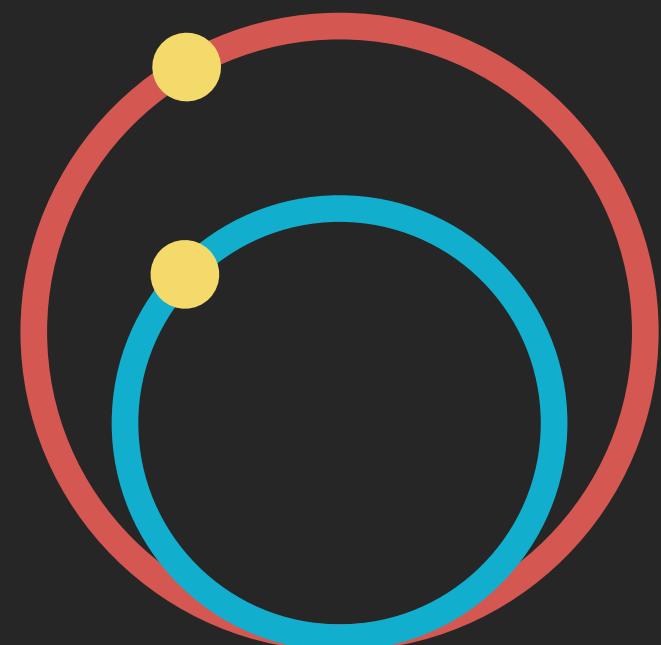
Literature – visual analytics



LINEAR TIME



CYCLIC TIME

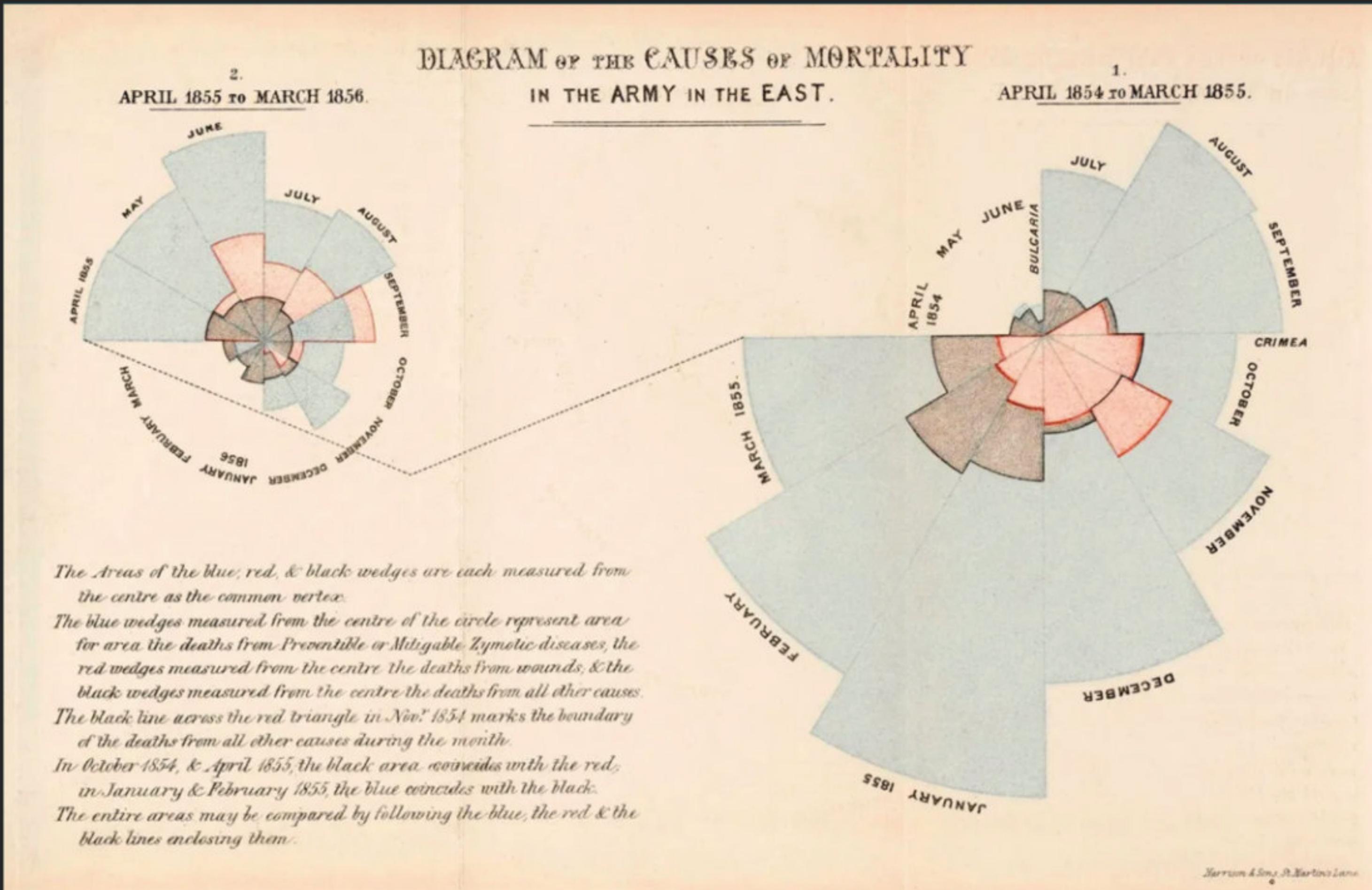


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Literature – coxcomb / rose charts



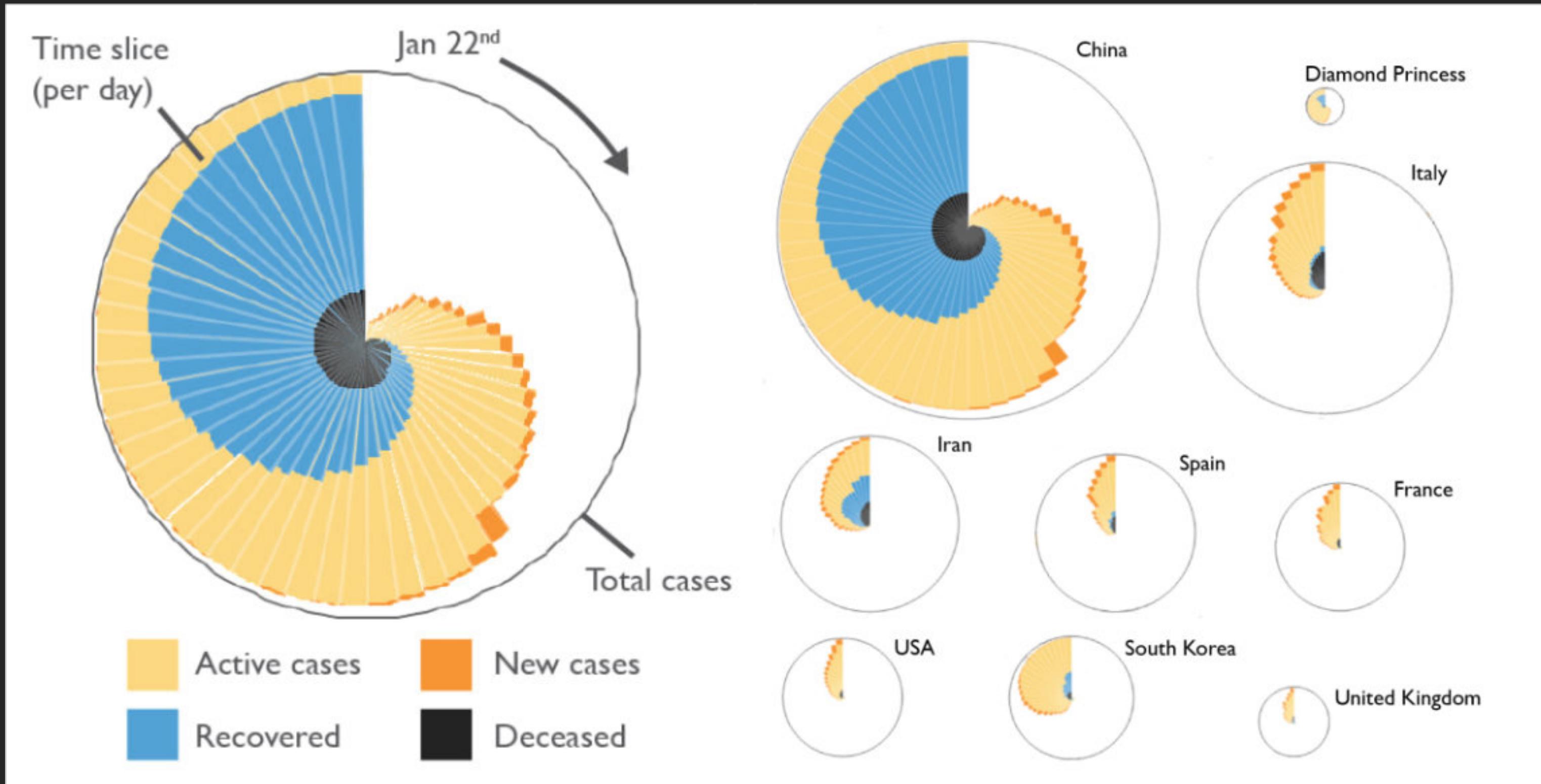
Coxcomb Chart from 1857 by Florence Nightingale showing the Causes of Mortality in the Army during the Crimean War. Image taken from <https://www.brainpickings.org/2017/10/09/w-e-b-du-bois-diagrams>, accessed 2020/06/18.

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Literature – coxcomb / rose charts



Coxcomb diagrams by Kenneth Field showing Covid-19 cases. Images taken from <https://www.esri.com/arcgis-blog/products/arcgis-pro/mapping/mapping-coronavirus-coxcombs>, accessed 2020/10/02

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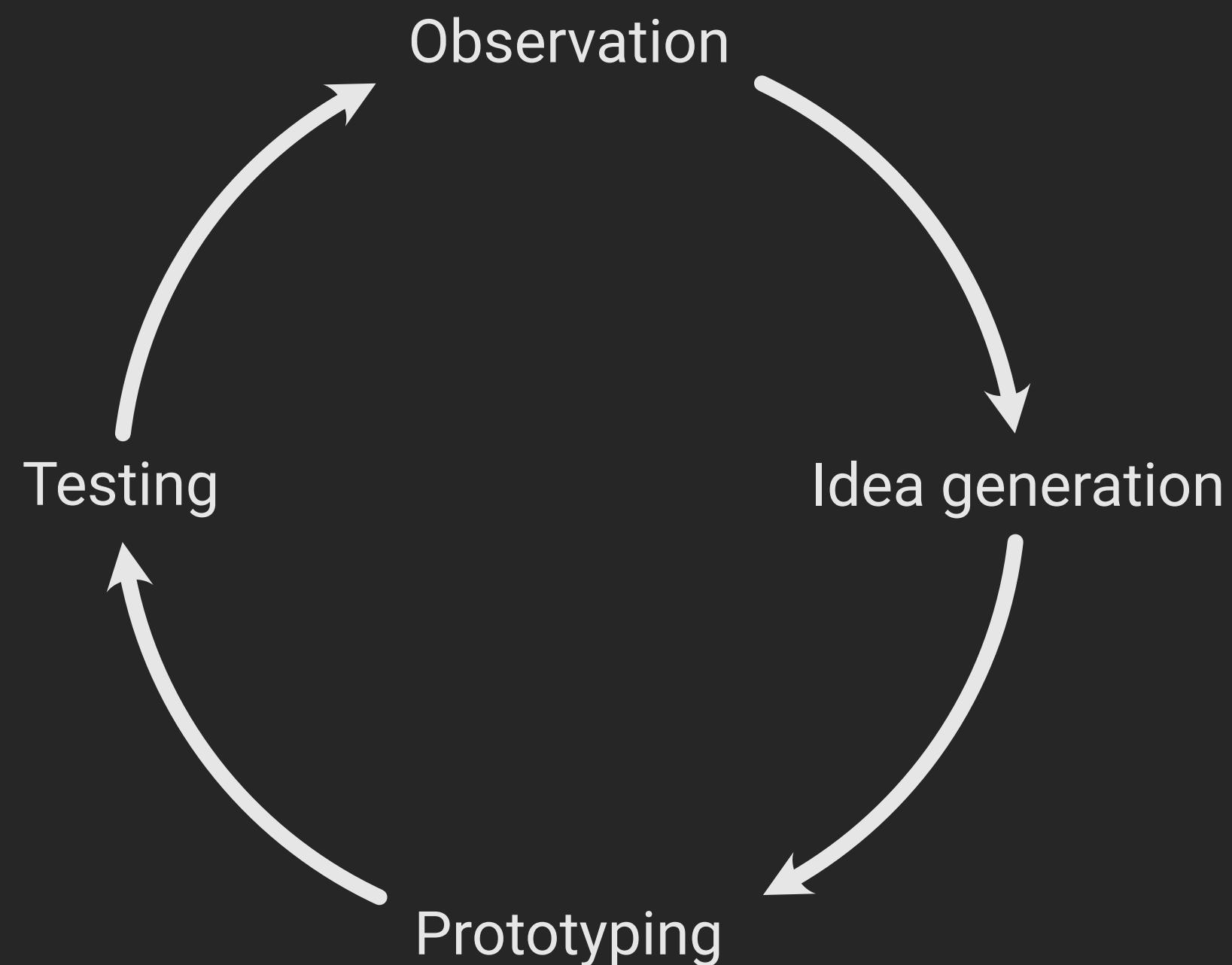
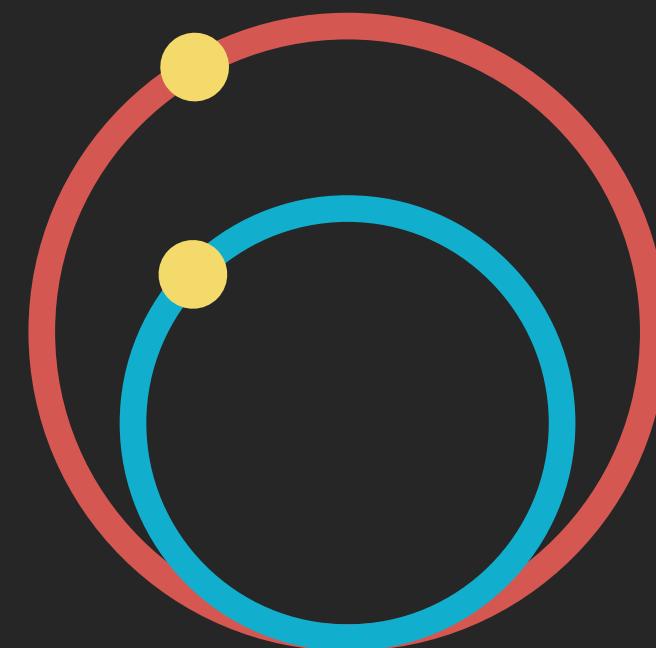


Literature – user-centred design cycle

User-Centred Design (or Human-Centred Design) can be defined as the

“process that ensures that the designs match the needs and capabilities of the people for whom they are intended”

(Norman, 2013, p. 9).



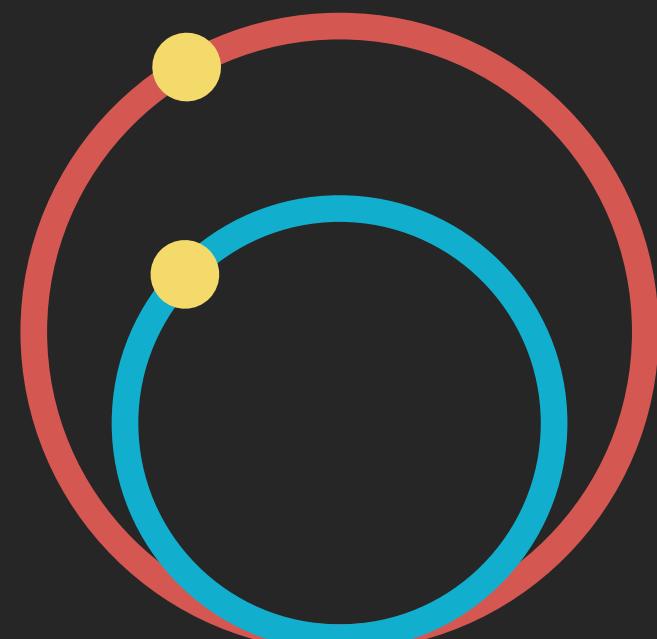
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Literature – UCD methods

OBSERVATION & IDEA GENERATION

- Literature
- Expert user interviews



TESTING

- Thinking aloud
- Questionnaire
- Group Discussions

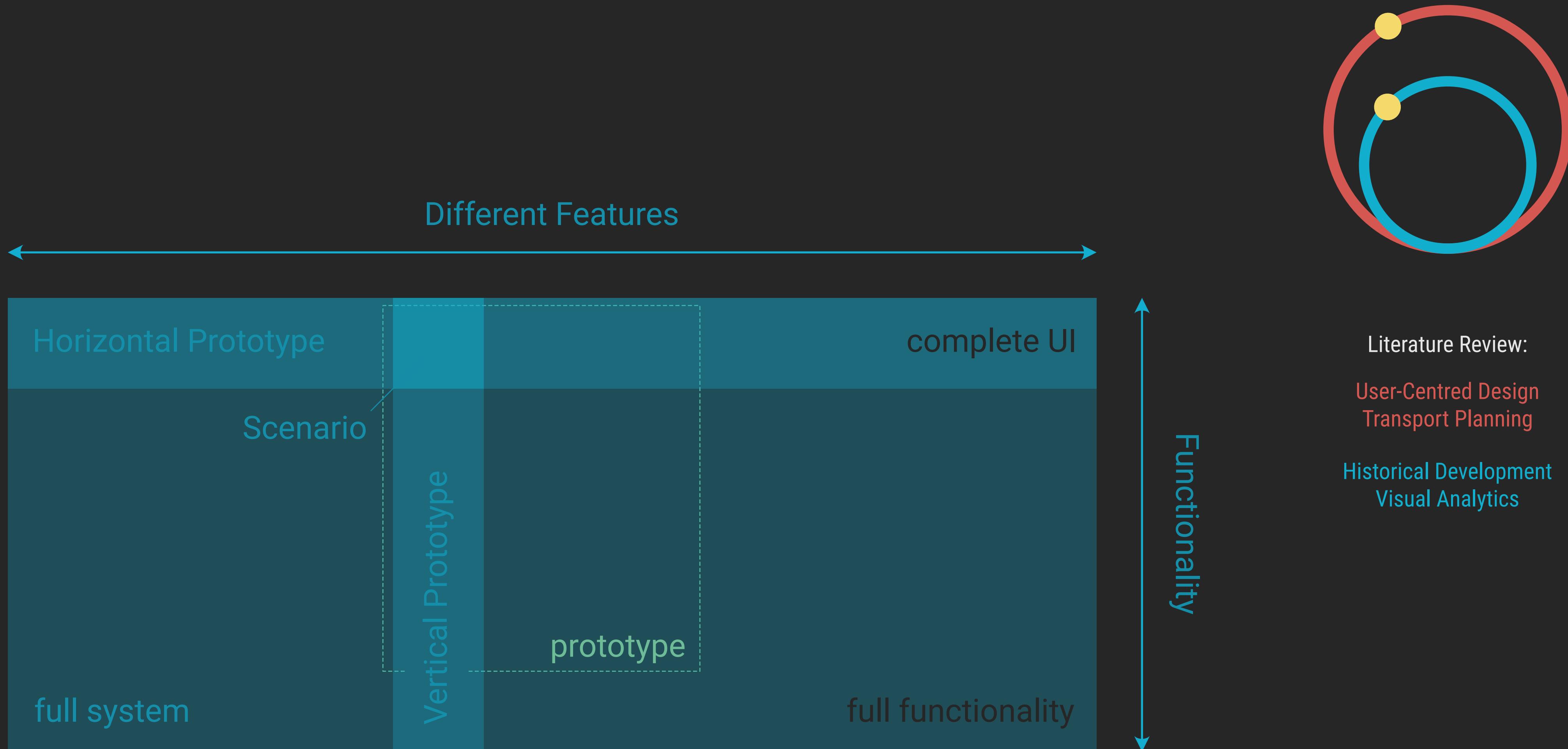
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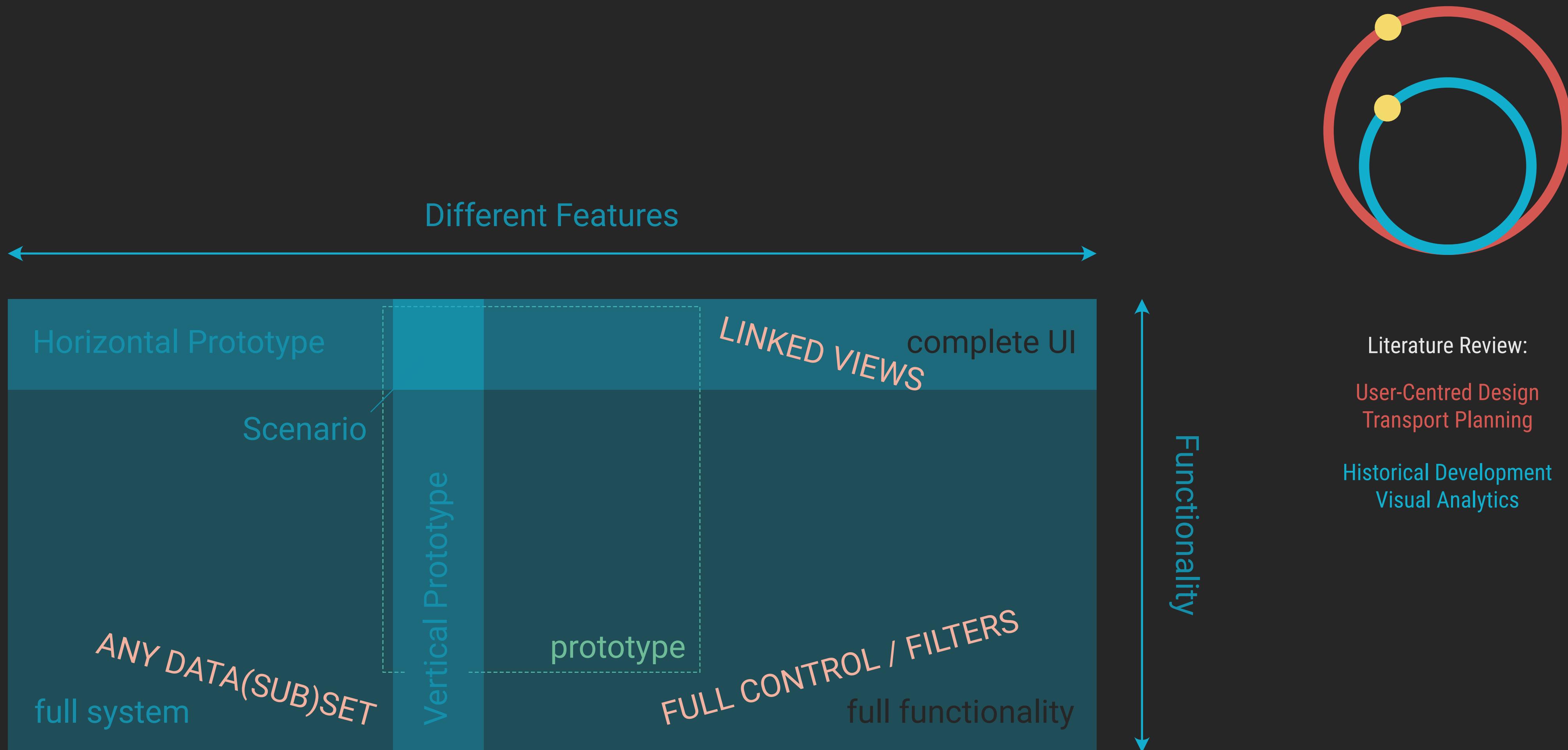
Literature – UCD prototyping



Prototyping schema based on Nielsen (1993, p. 94)



Literature – UCD prototyping

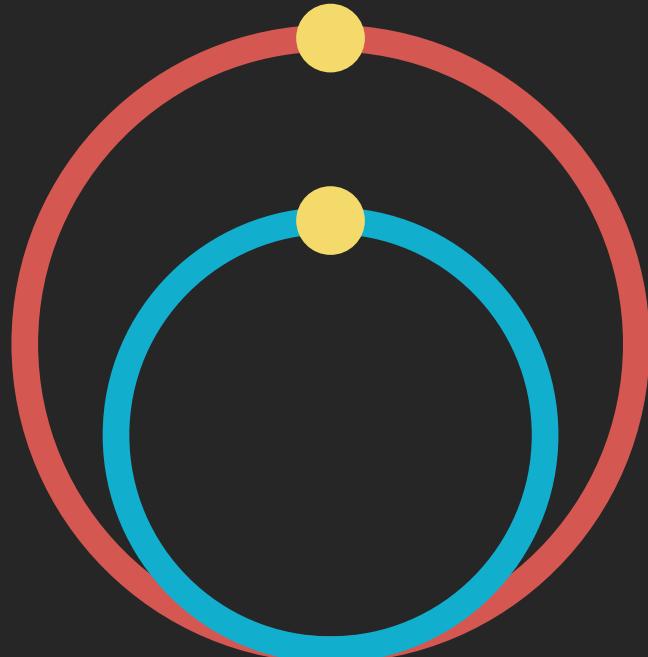


Prototyping schema based on Nielsen (1993, p. 94)



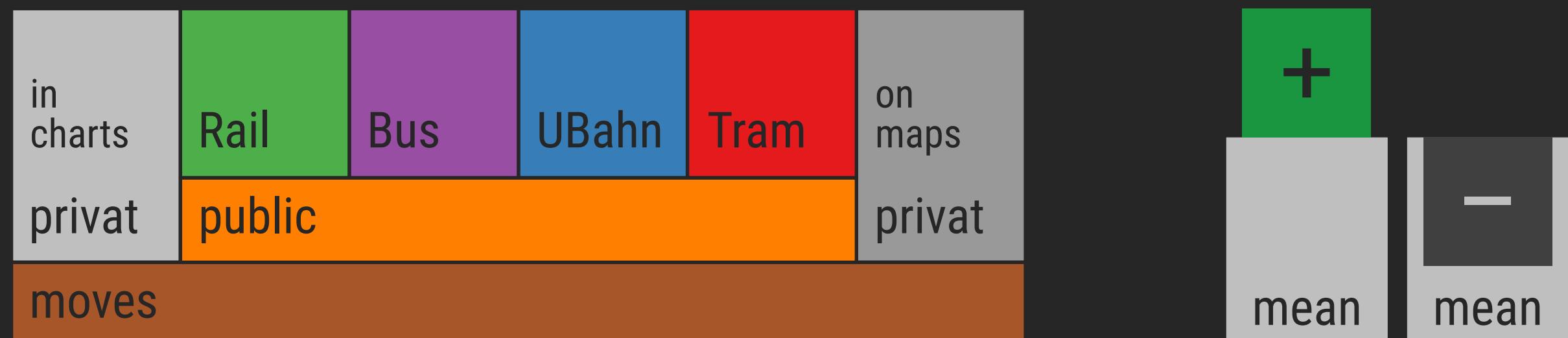
Context – data structure

- one week of data
- flow data & origin-destination (OD) data
- preprocessed & aggregated
- mode of transportation: Rail / Bus / Ubahn / Tram / privat



Contact Expert Users

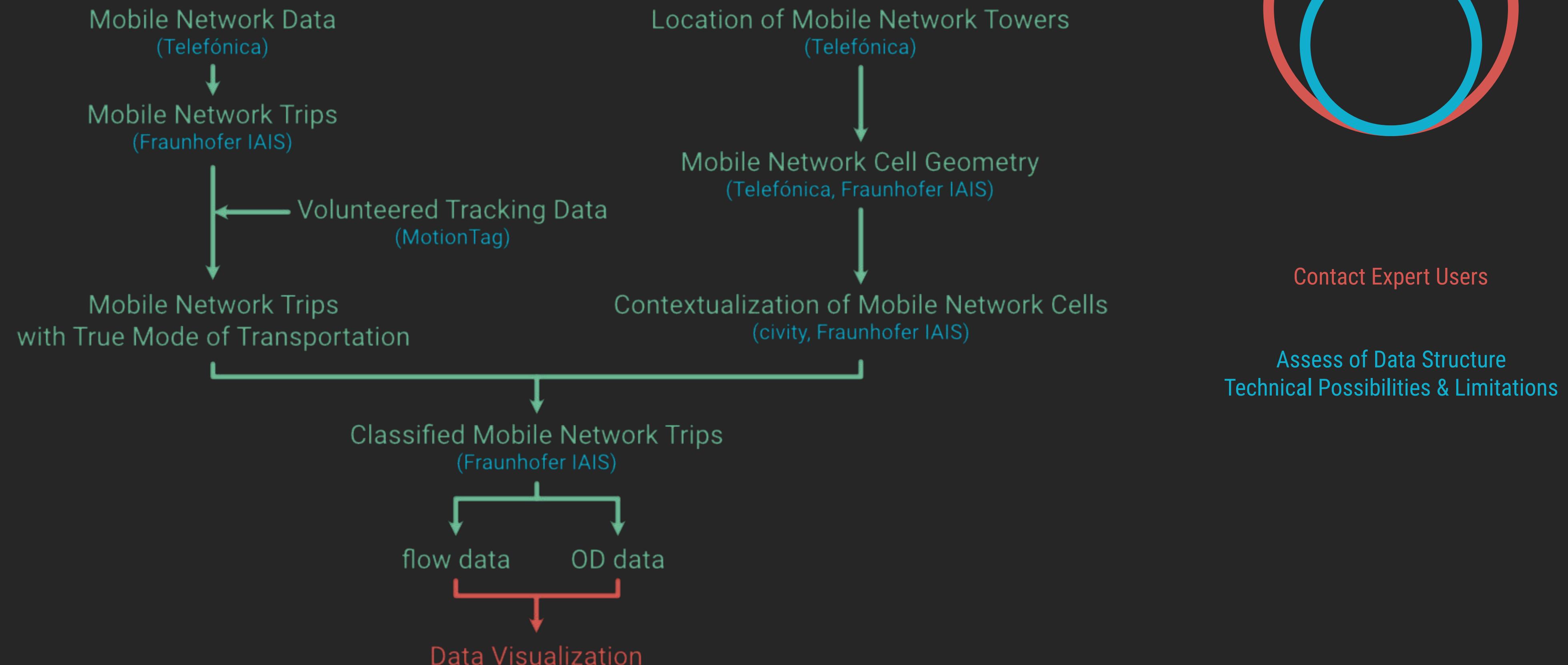
Assess of Data Structure
Technical Possibilities & Limitations



Colour scheme based on a palette by Colorbrewer (Brewer, 2013). The colours that were used for different modes in maps and bar charts during the first and third stages of the user test scenario (left) and to represent anomalies in the second and fourth stages of the user test scenario (right).



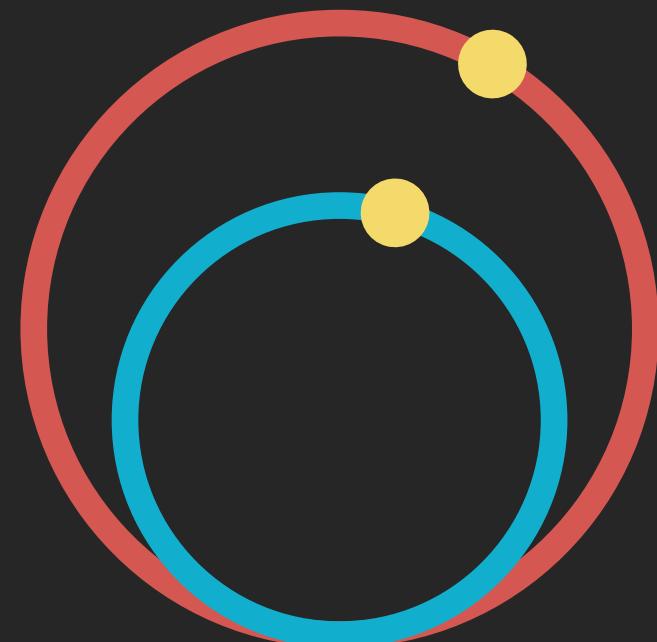
Context – data structure



Interviews

GUIDELINE

- How are you presently working?
- What do you want to find out?



RESULTS

- Few visualizations & limited interactivity
- First experience with dashboard interface
- Missing: OD information / special days / private traffic.

Execute Expert Interviews

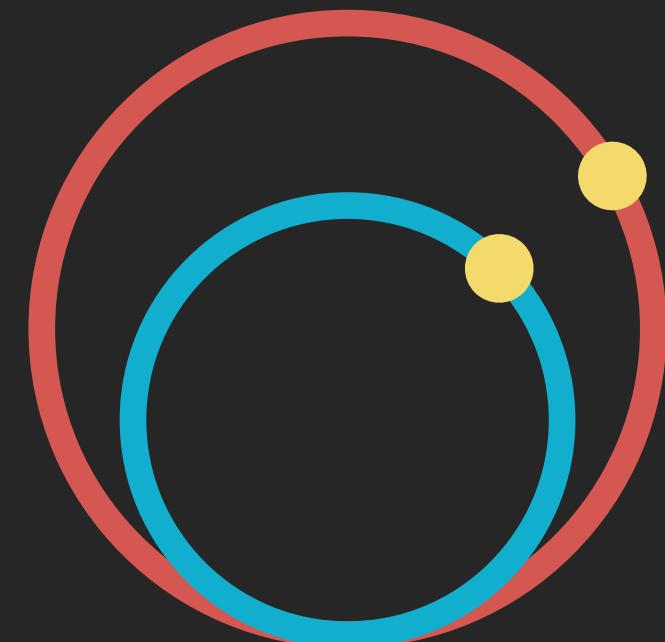
Choose Visualization Tools



Visualization Concept

UI

- Spatial & temporal overview: flow map & temporal bar charts
- Interlinked visualizations
- Synoptic and comparative modes



ANALYTIC SCENARIO:

4 STAGES	SYNOPTIC	COMPARATIVE	
FLOW DATA	1	2	where
OD DATA	3	4	from + to
	explore data	“special day”	understand

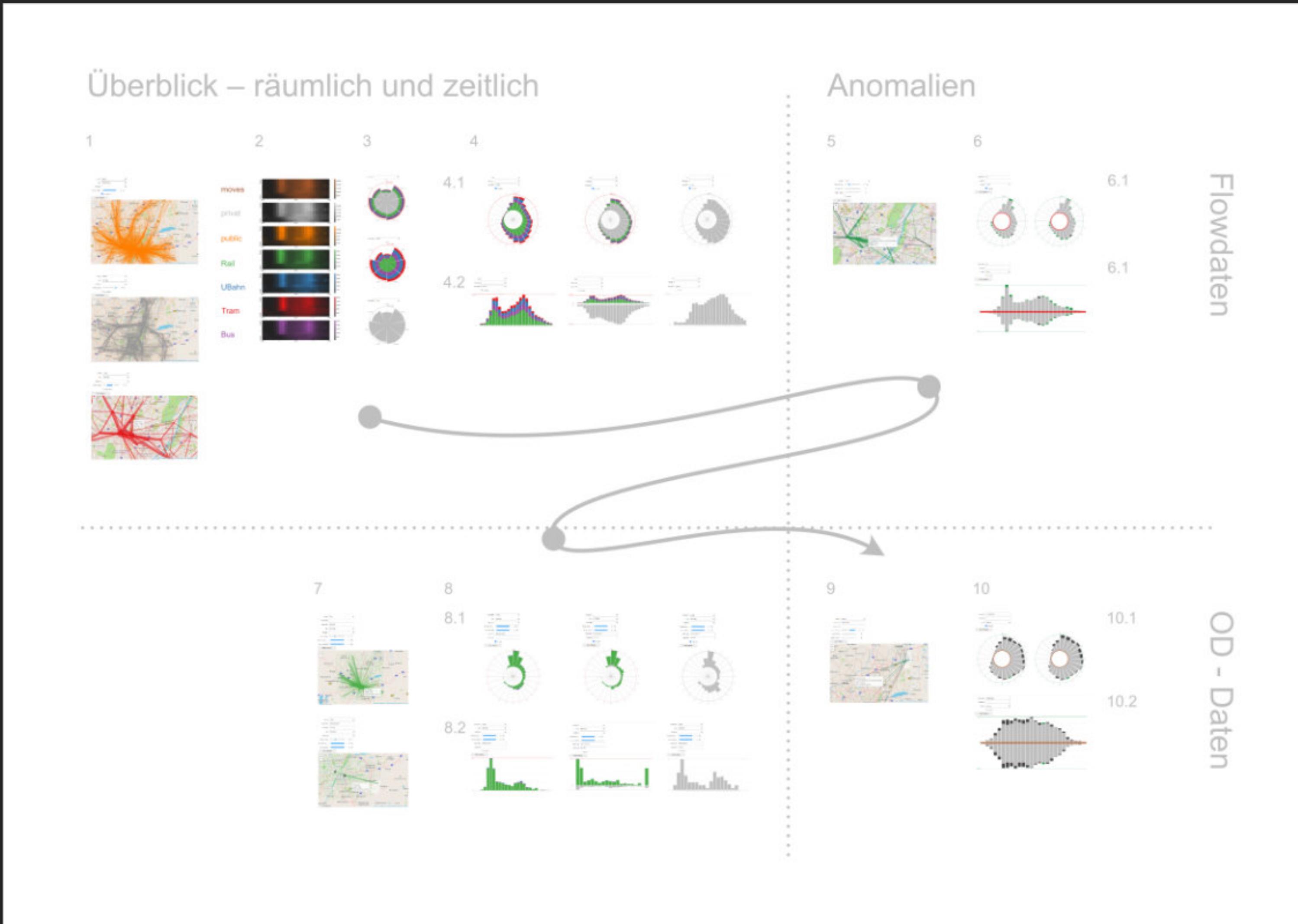
Evaluate Interviews

Develop Visualization Concept

Develop Visualizations, implement Functionality & Interactivity



Visualization Concept



Evaluate Interviews

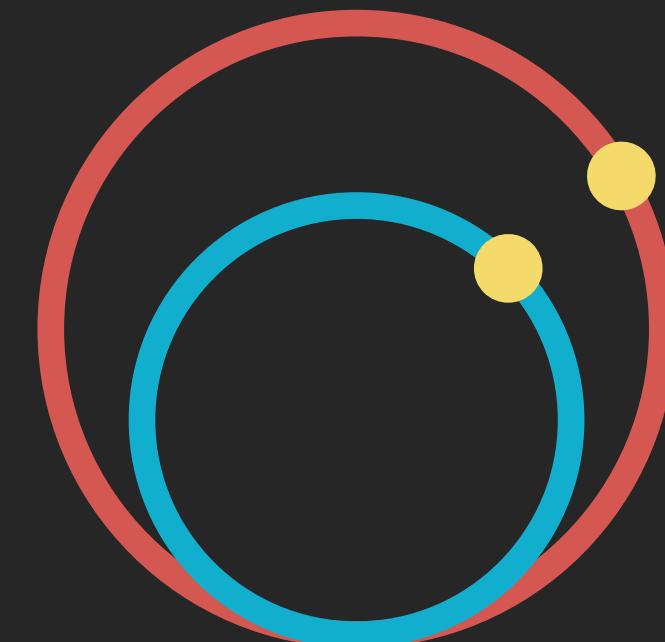
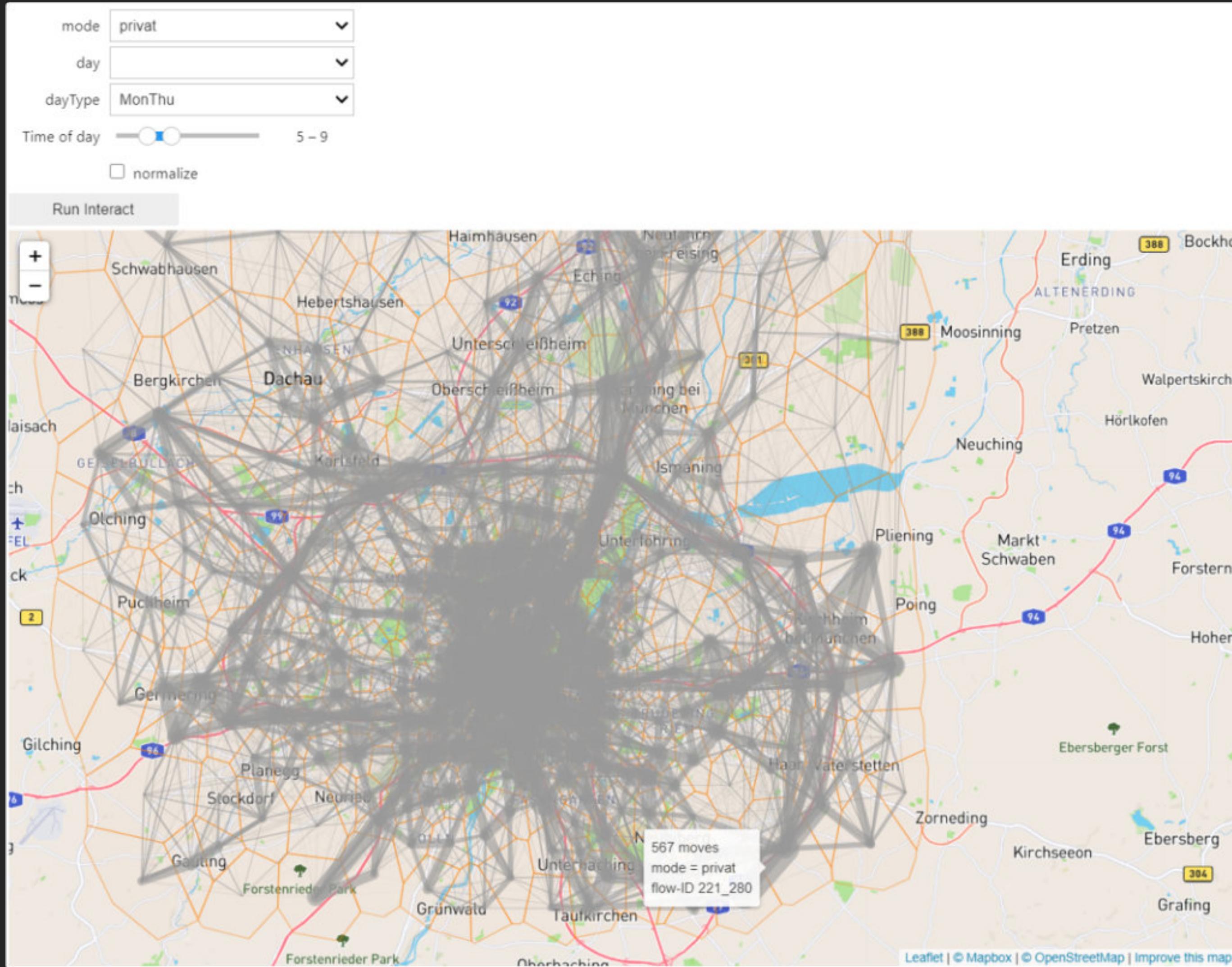
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Visualization Concept

	O	A vs B	
F	1S	1T	2S
OD	3S	3T	4S
	2T	4T	



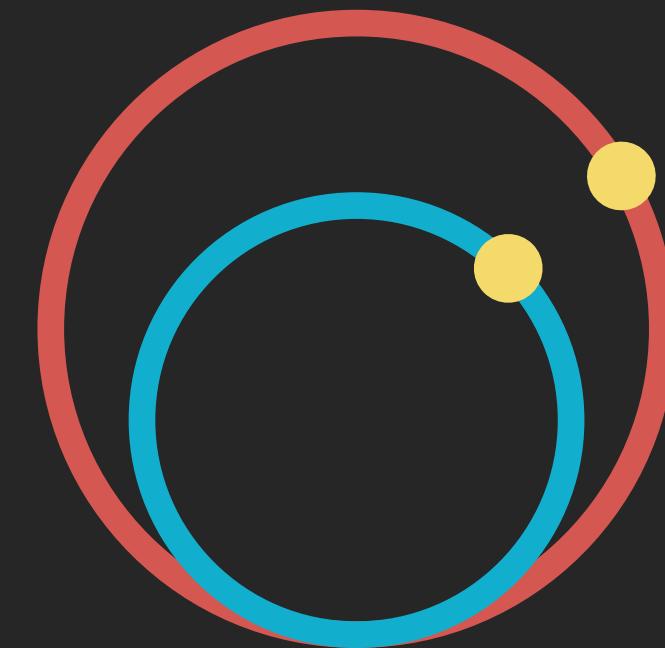
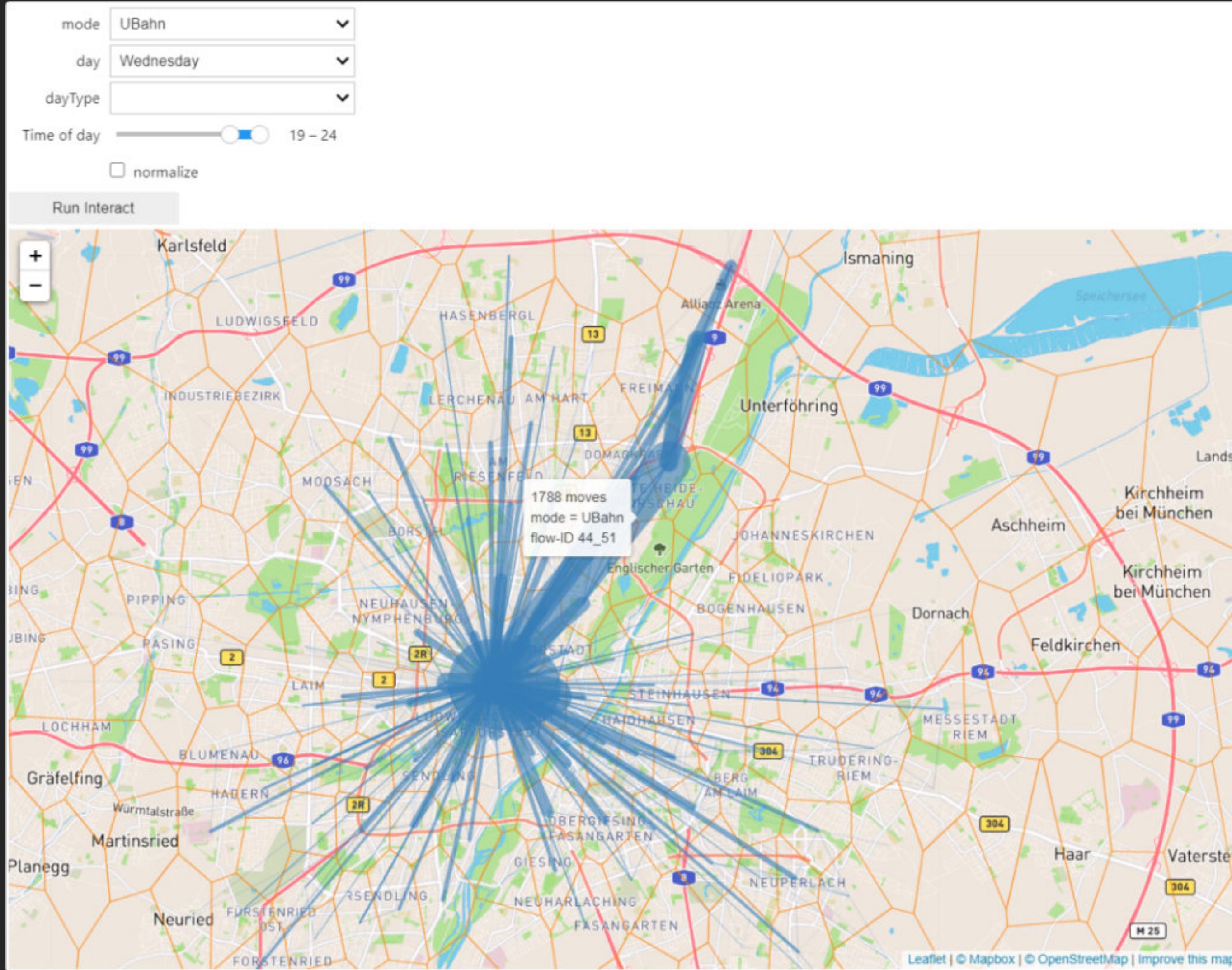
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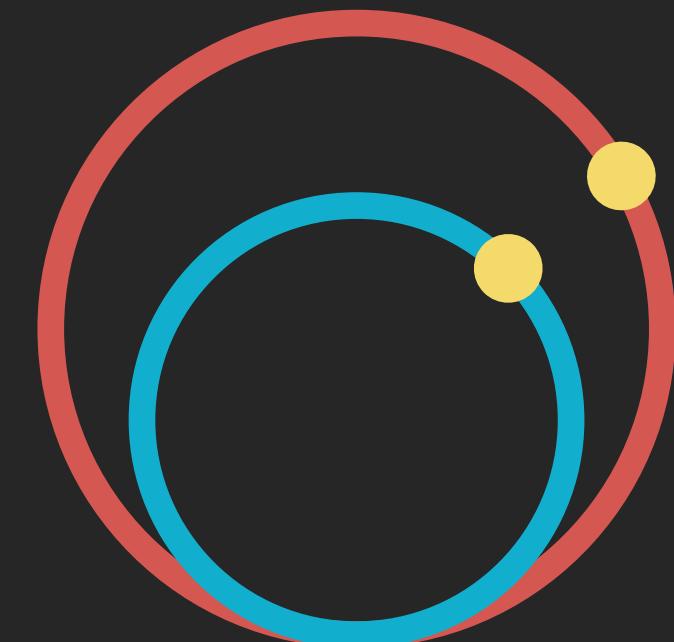
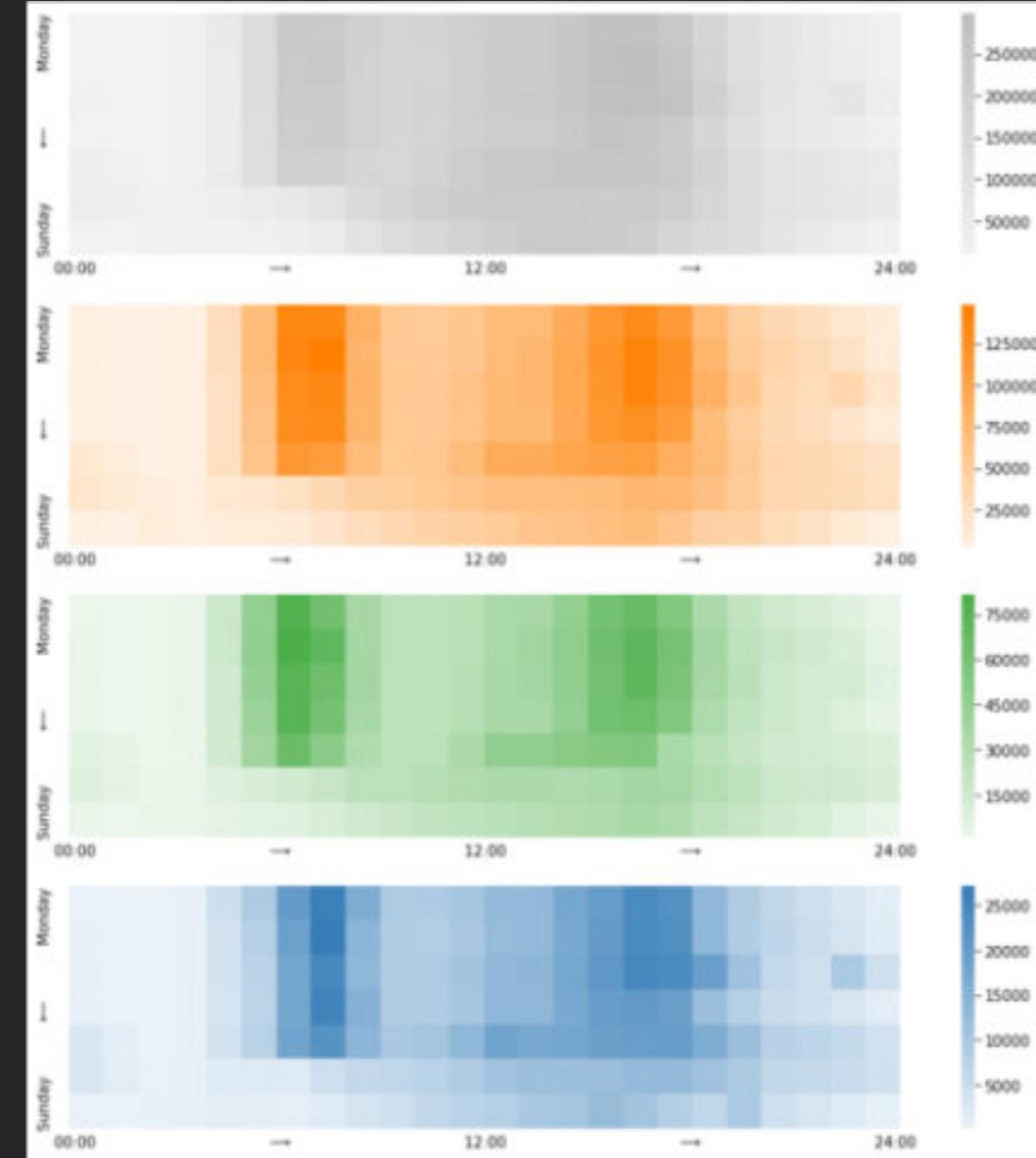
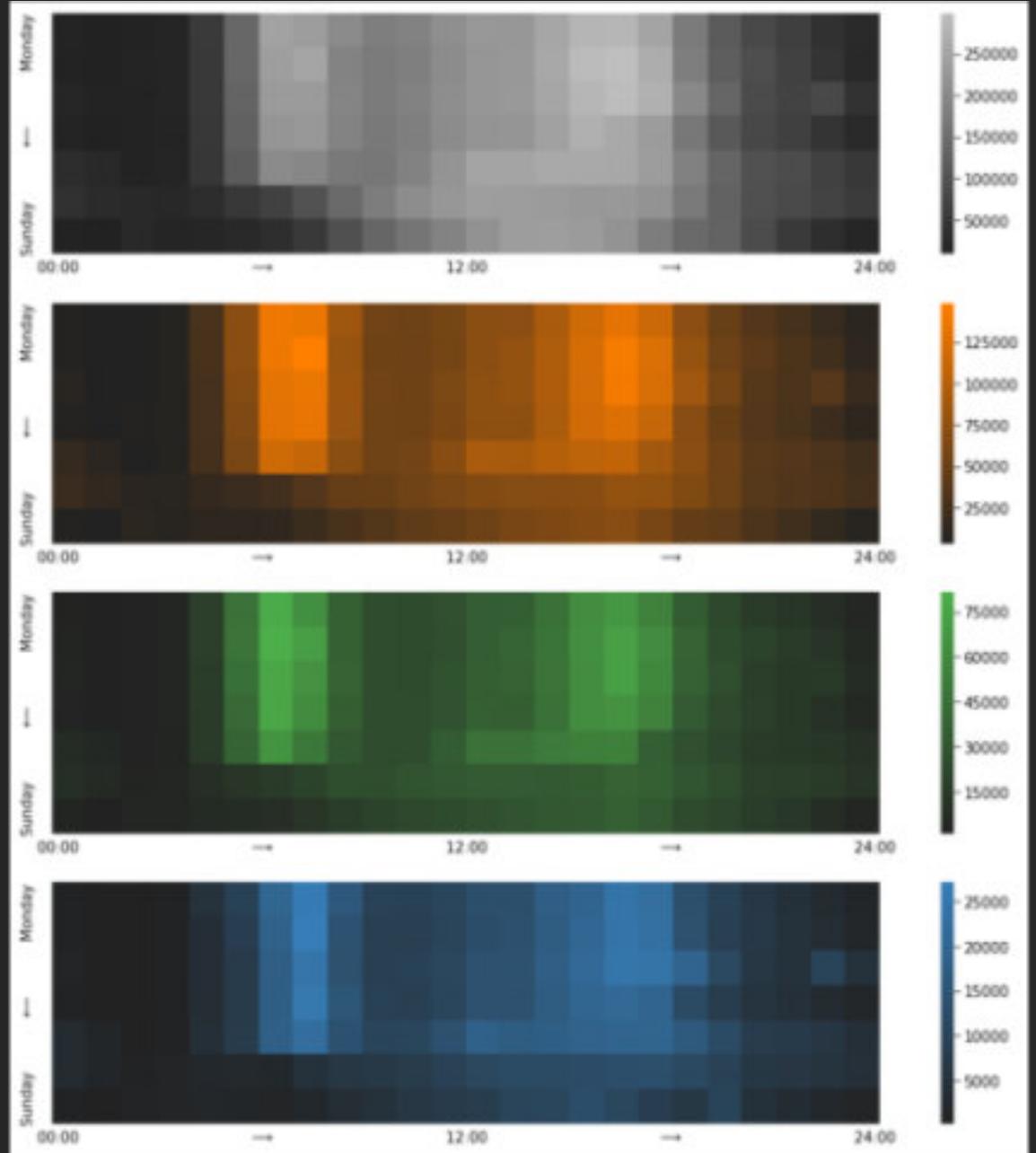
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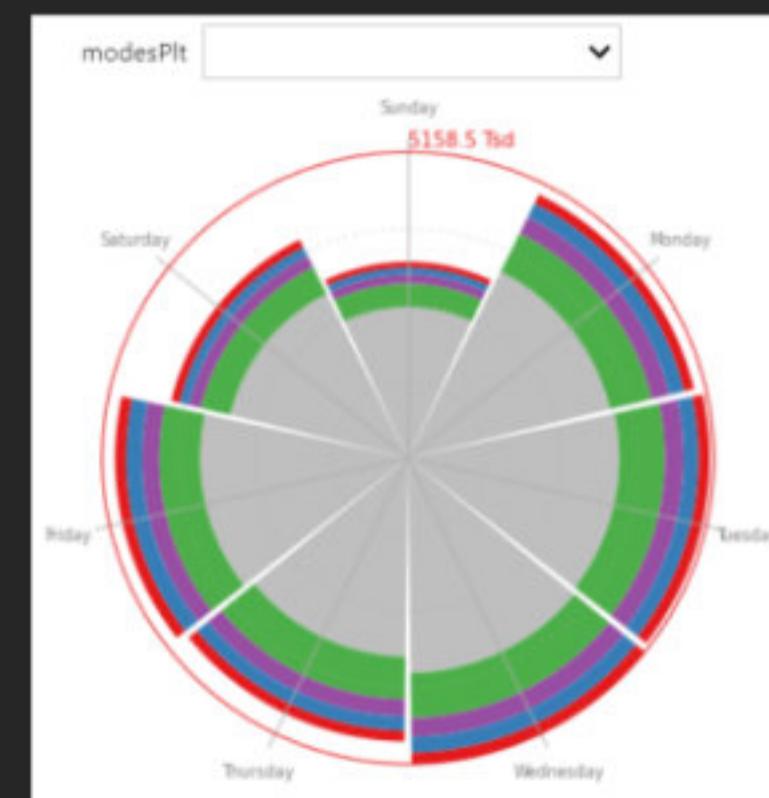
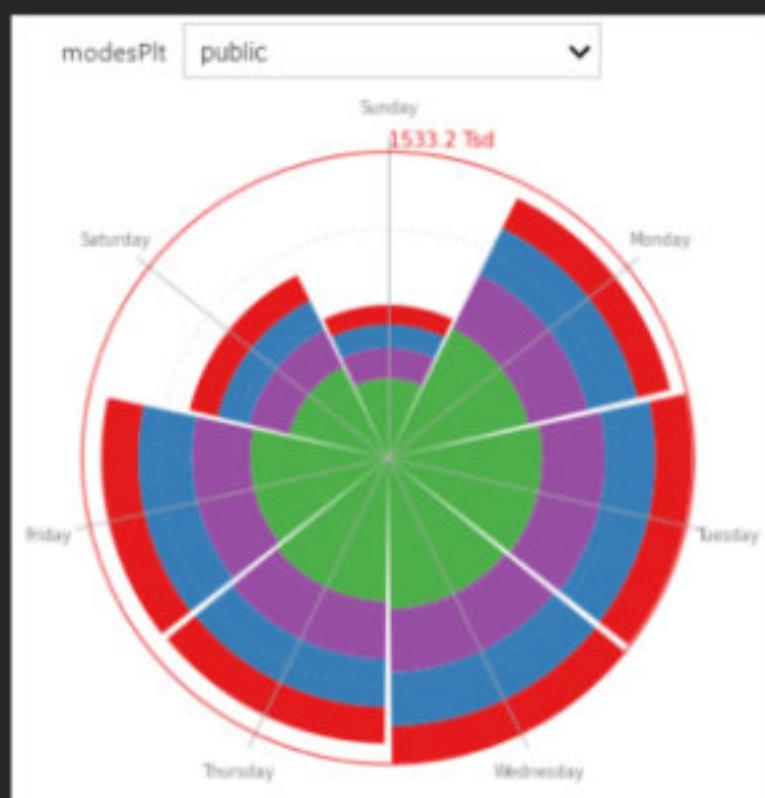
	O	A vs B	
F	1 S	1 T	2 S
OD	3 S	3 T	2 T
	4 S	4 T	



Evaluate Interviews

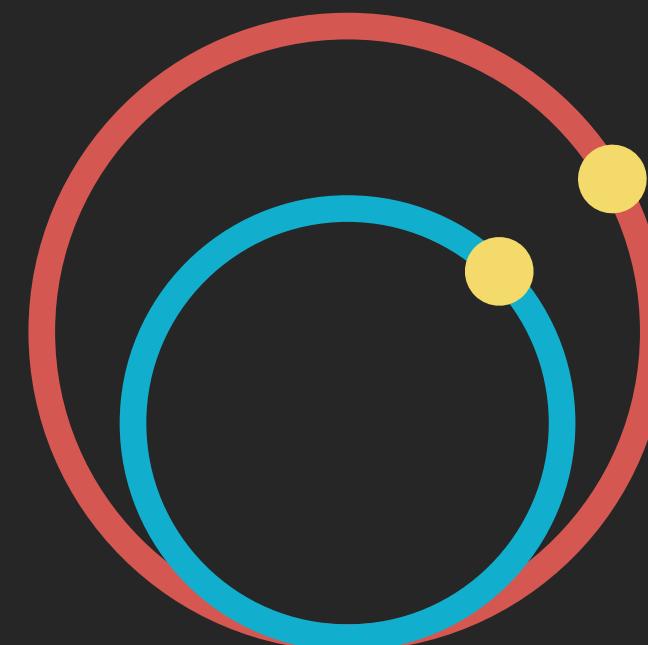
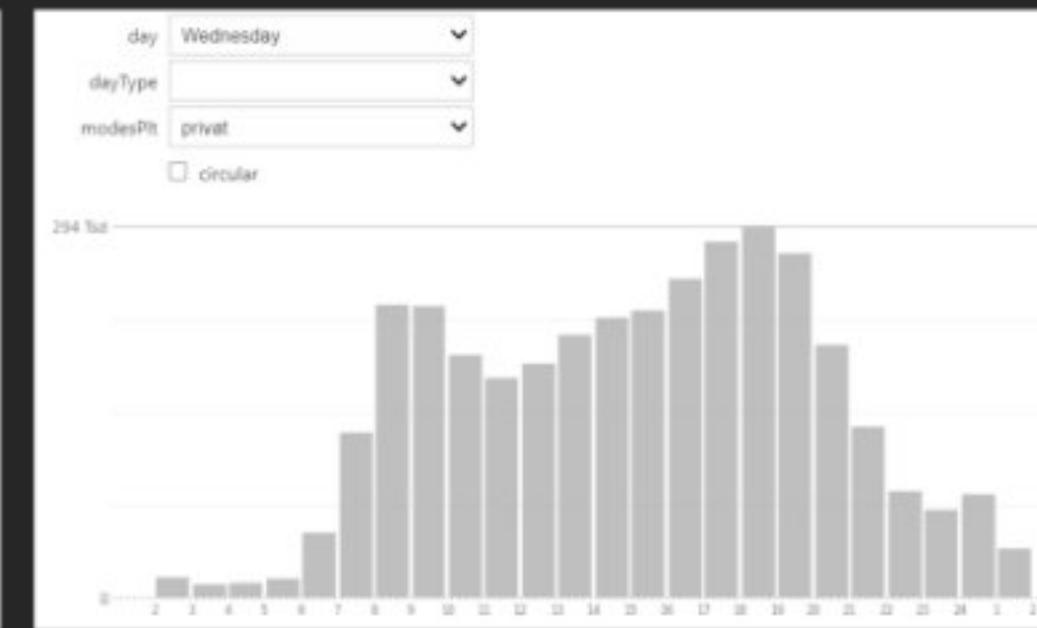
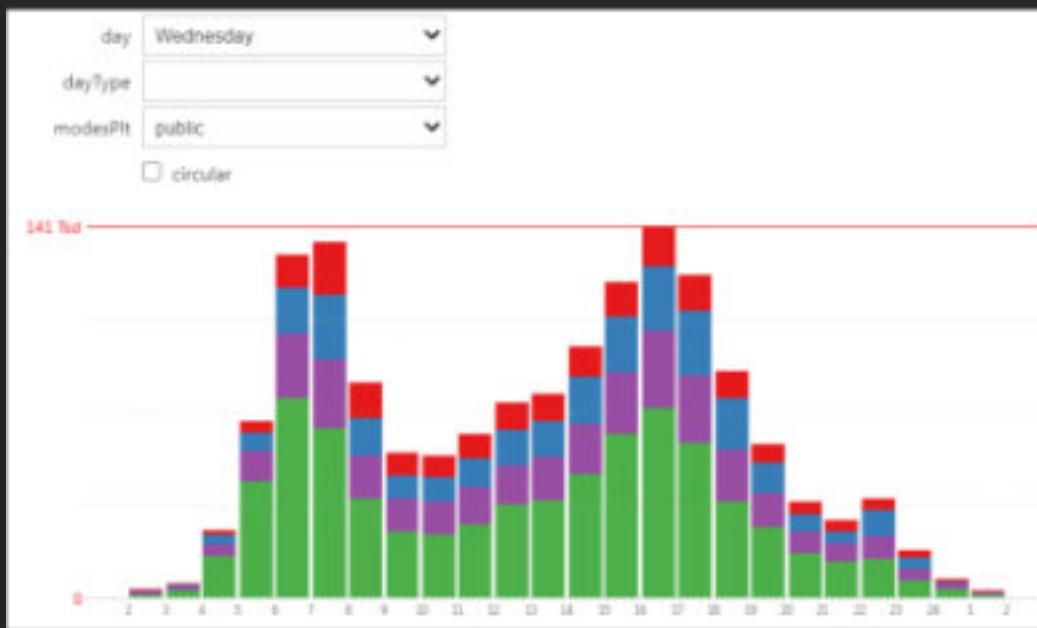
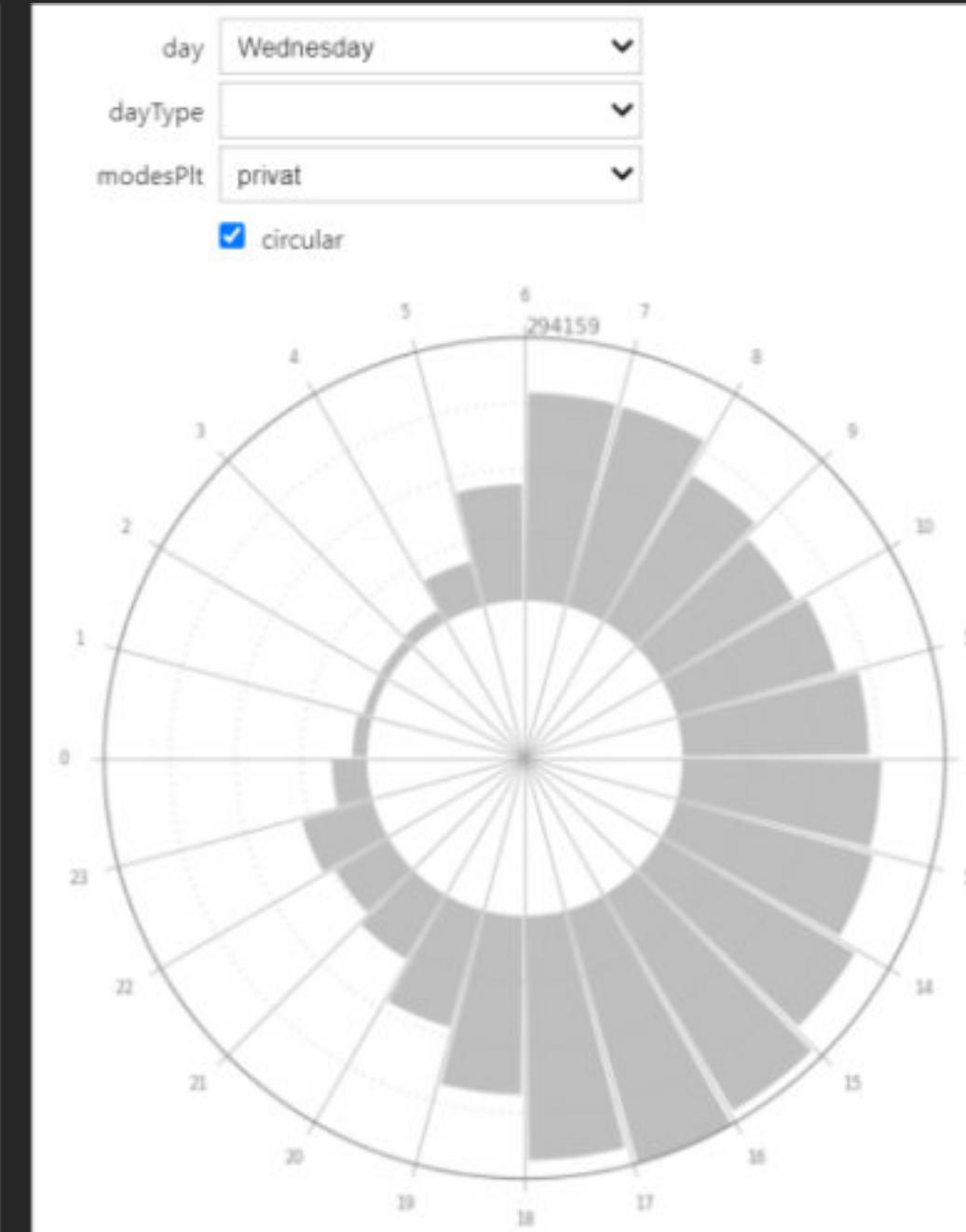
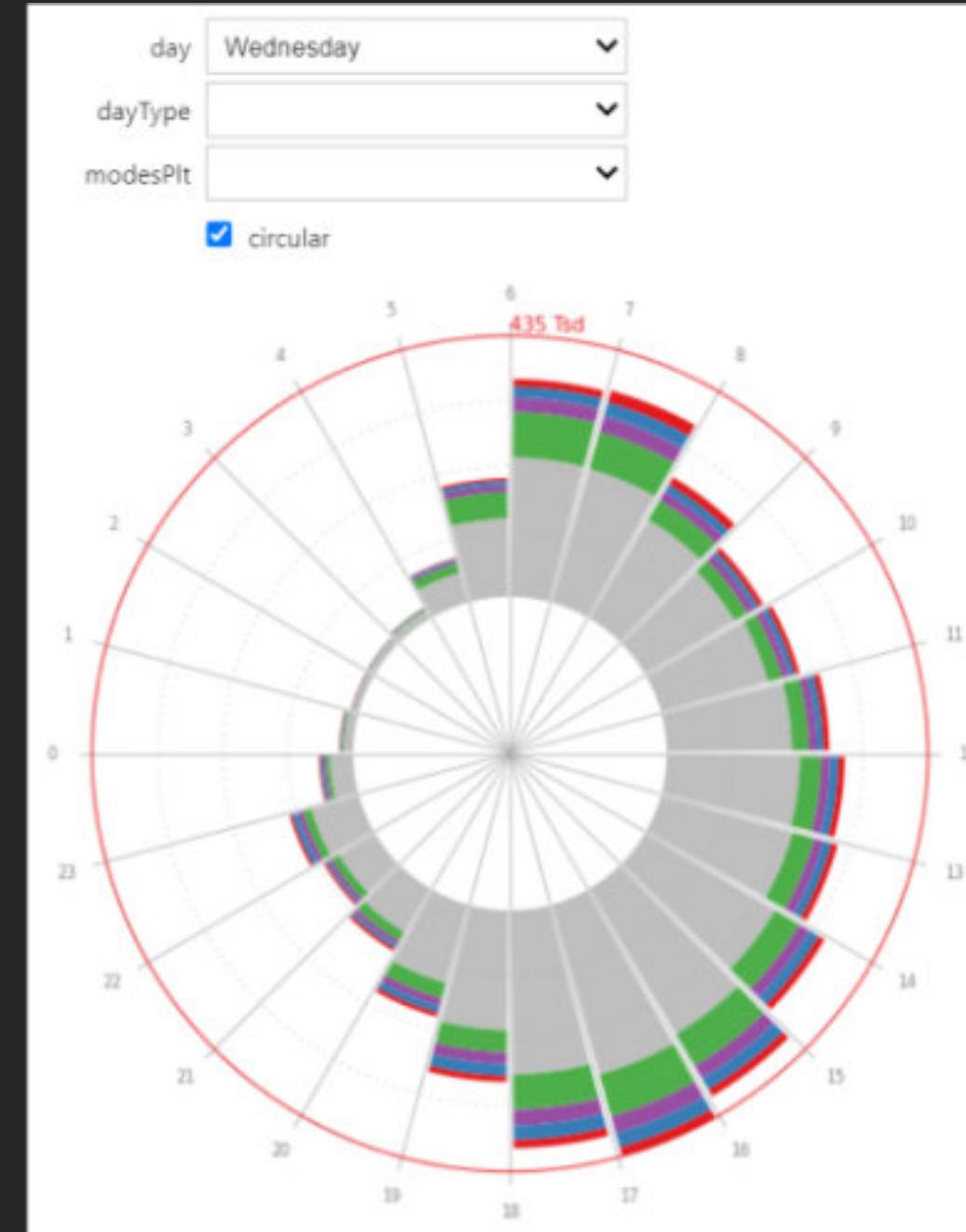
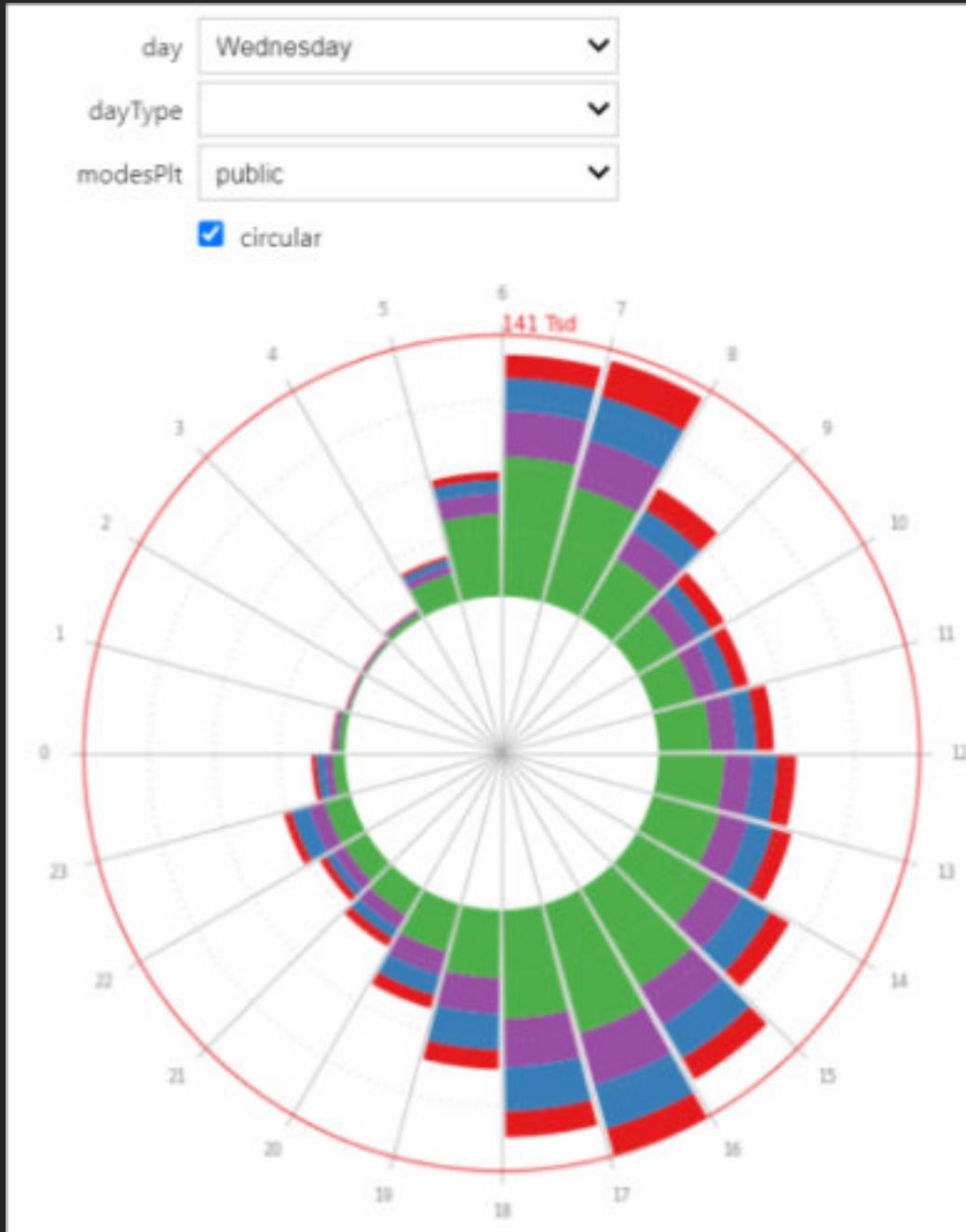
Develop Visualization Concept

Develop Visualizations, implement Functionality & Interactivity



Visualization Concept

	O	A vs B
F	1 S	1 T
OD	3 S	3 T



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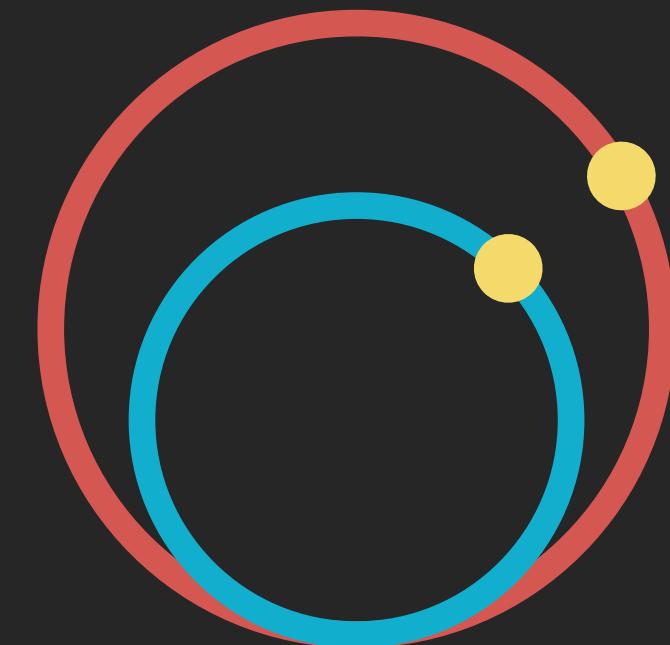
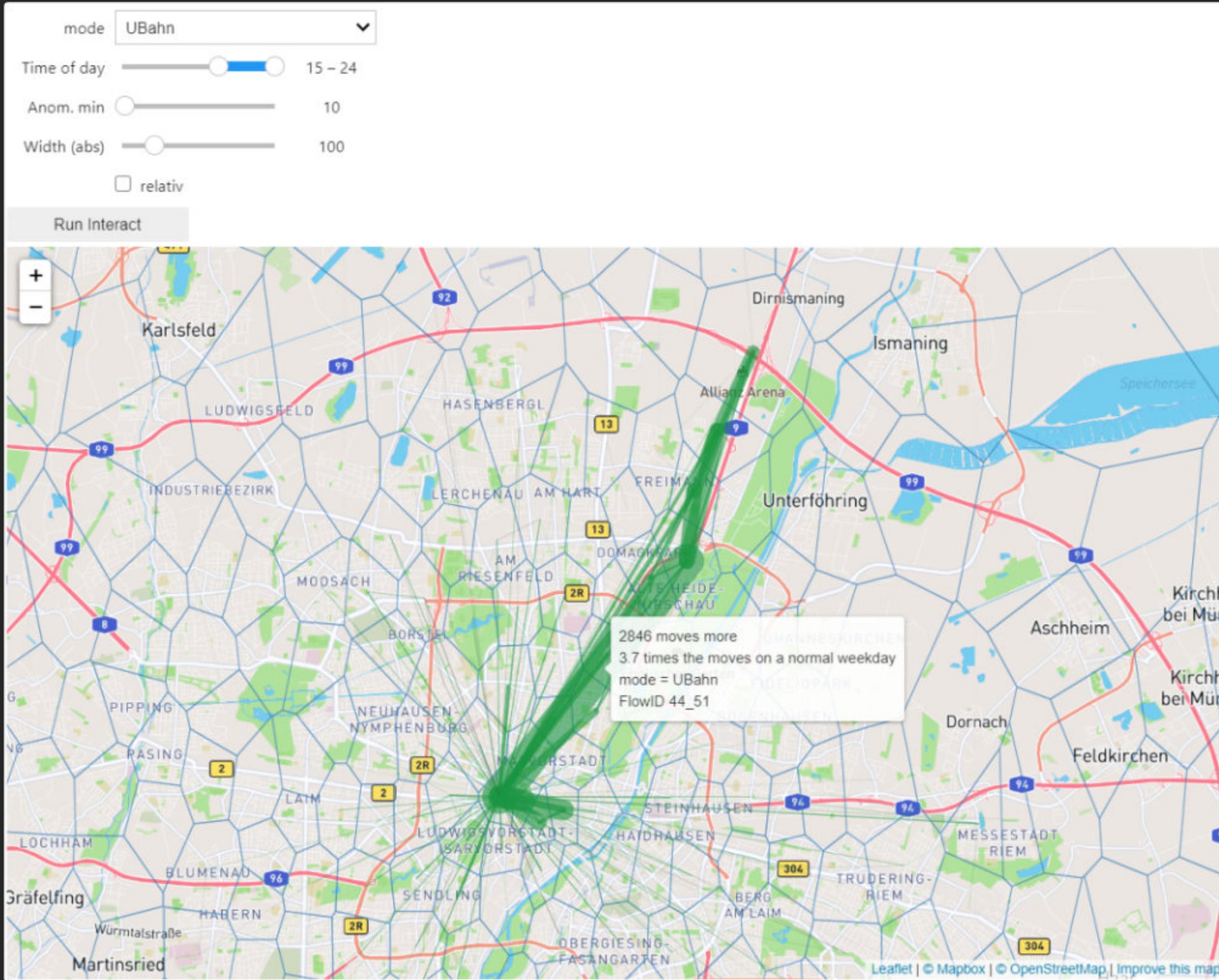
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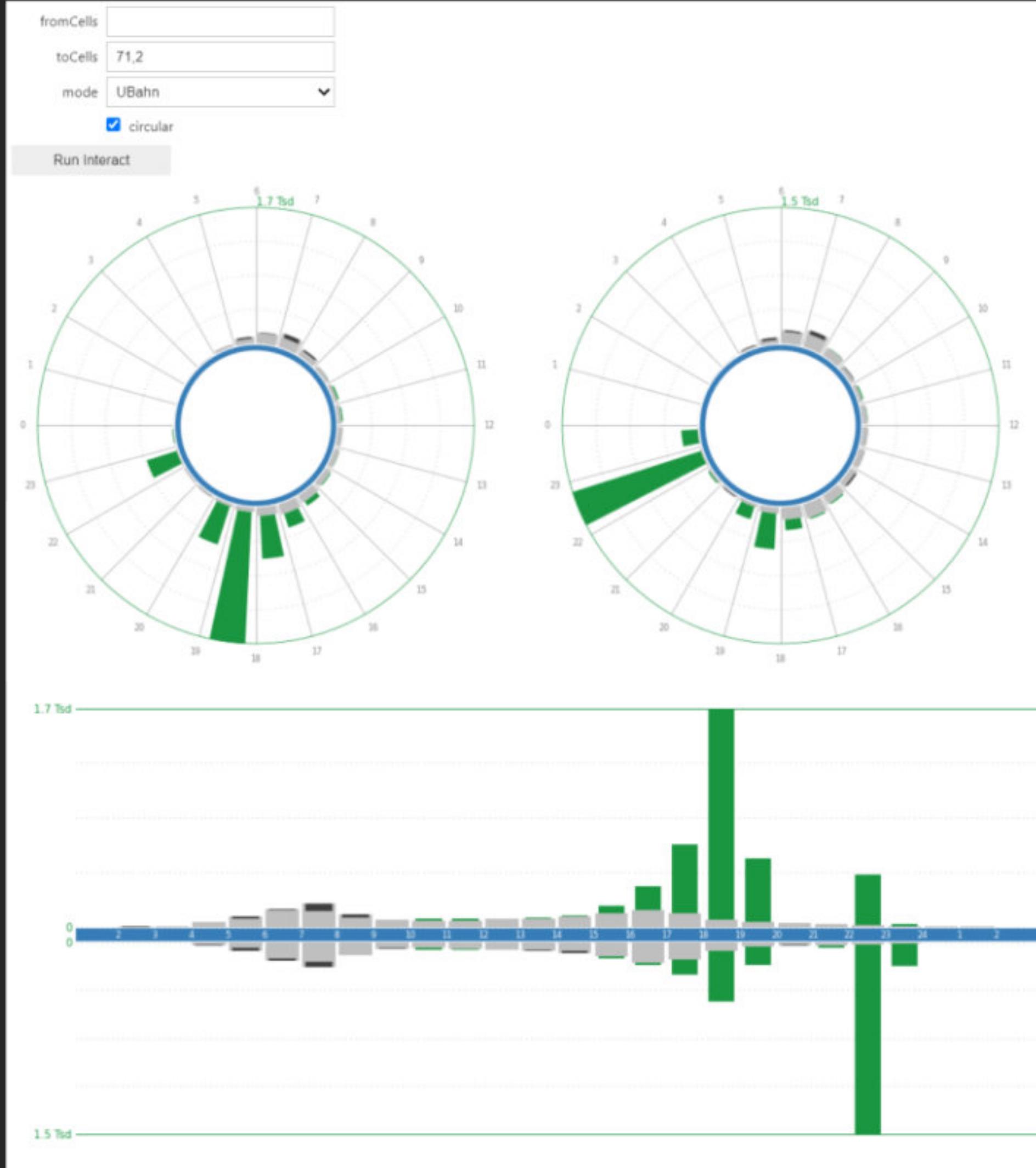


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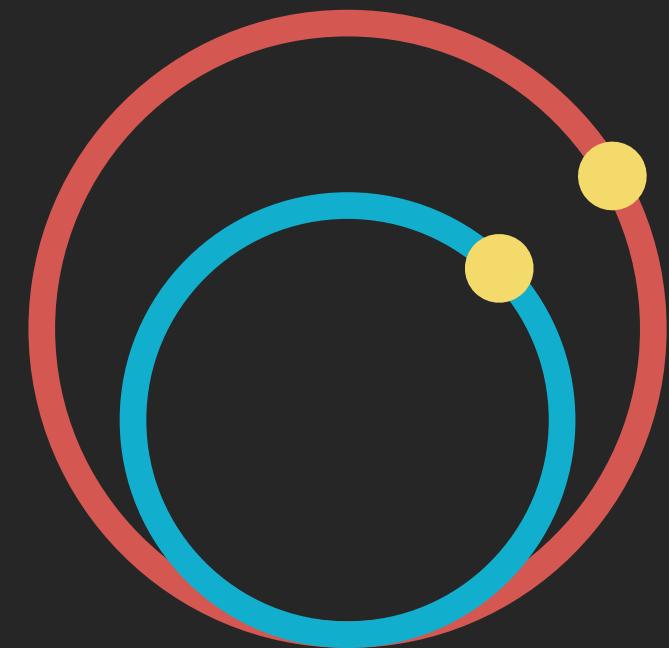
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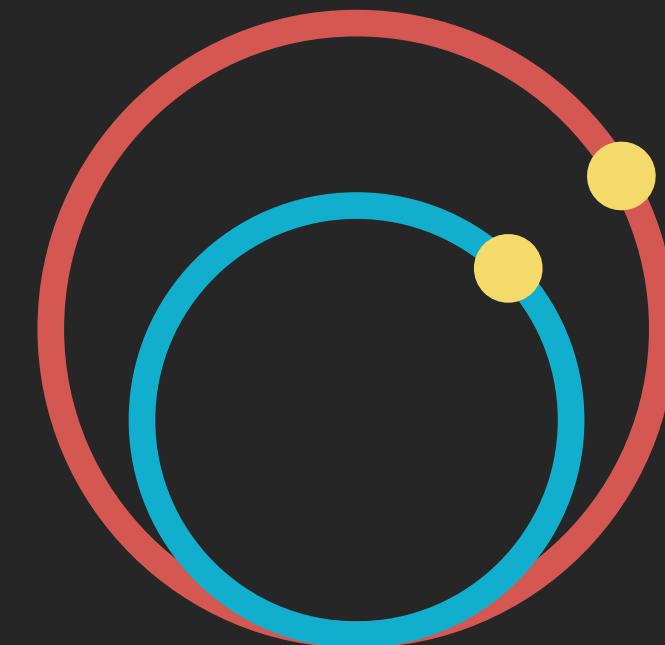
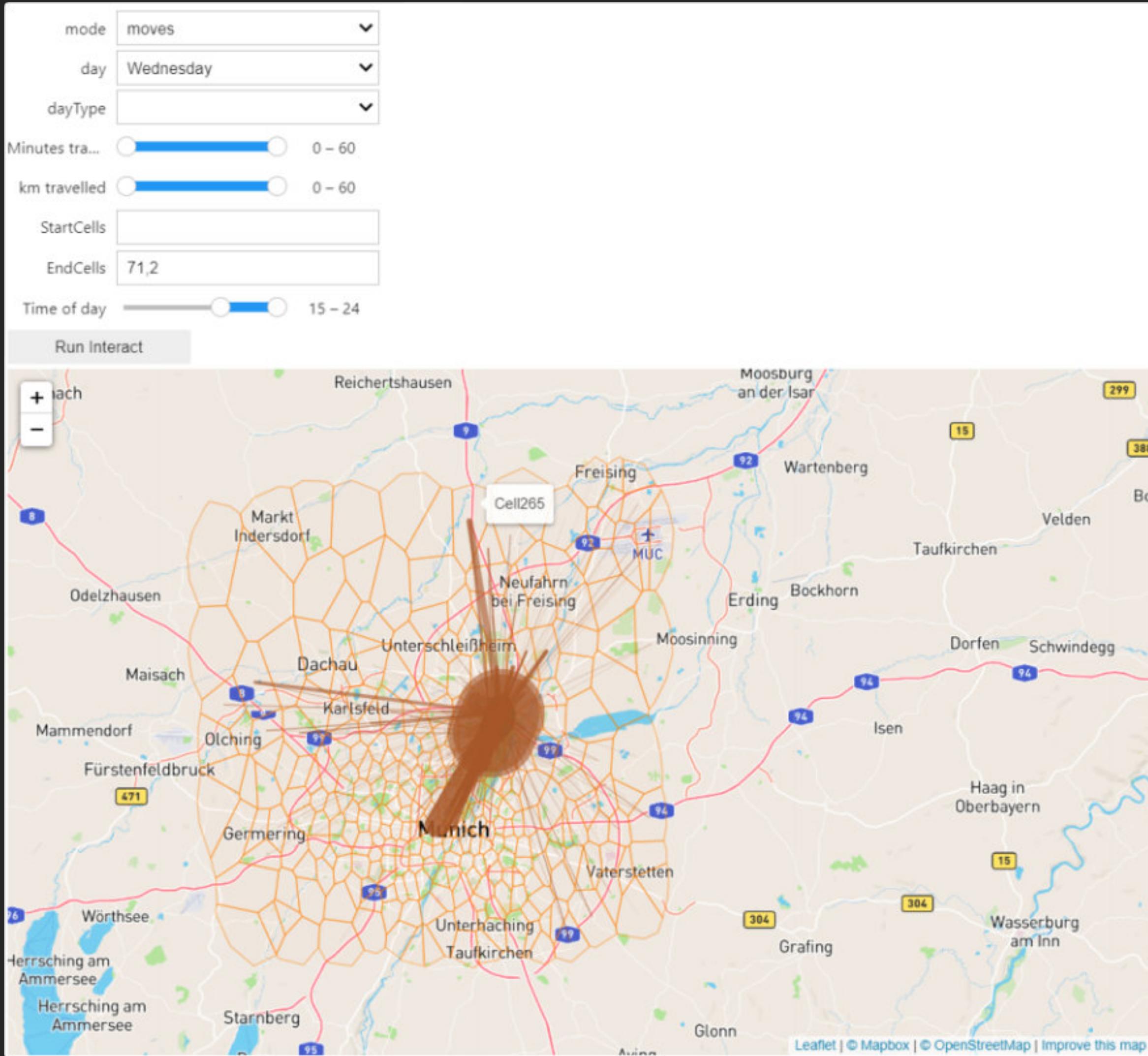
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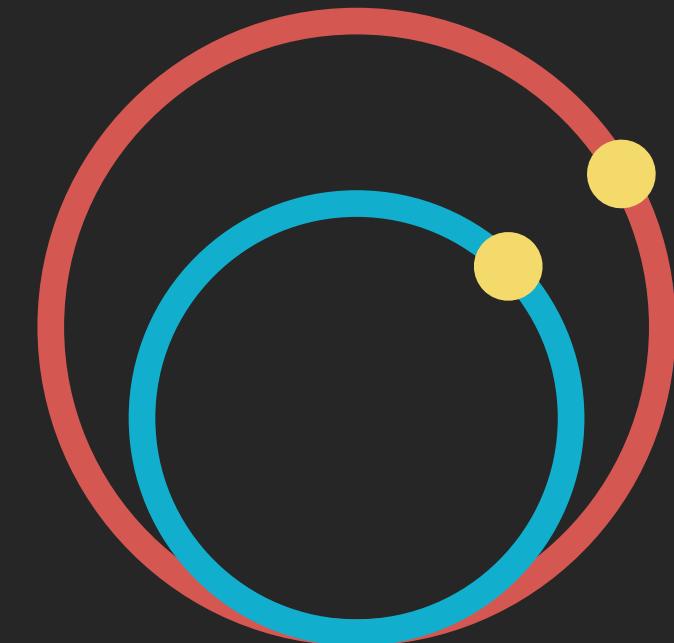
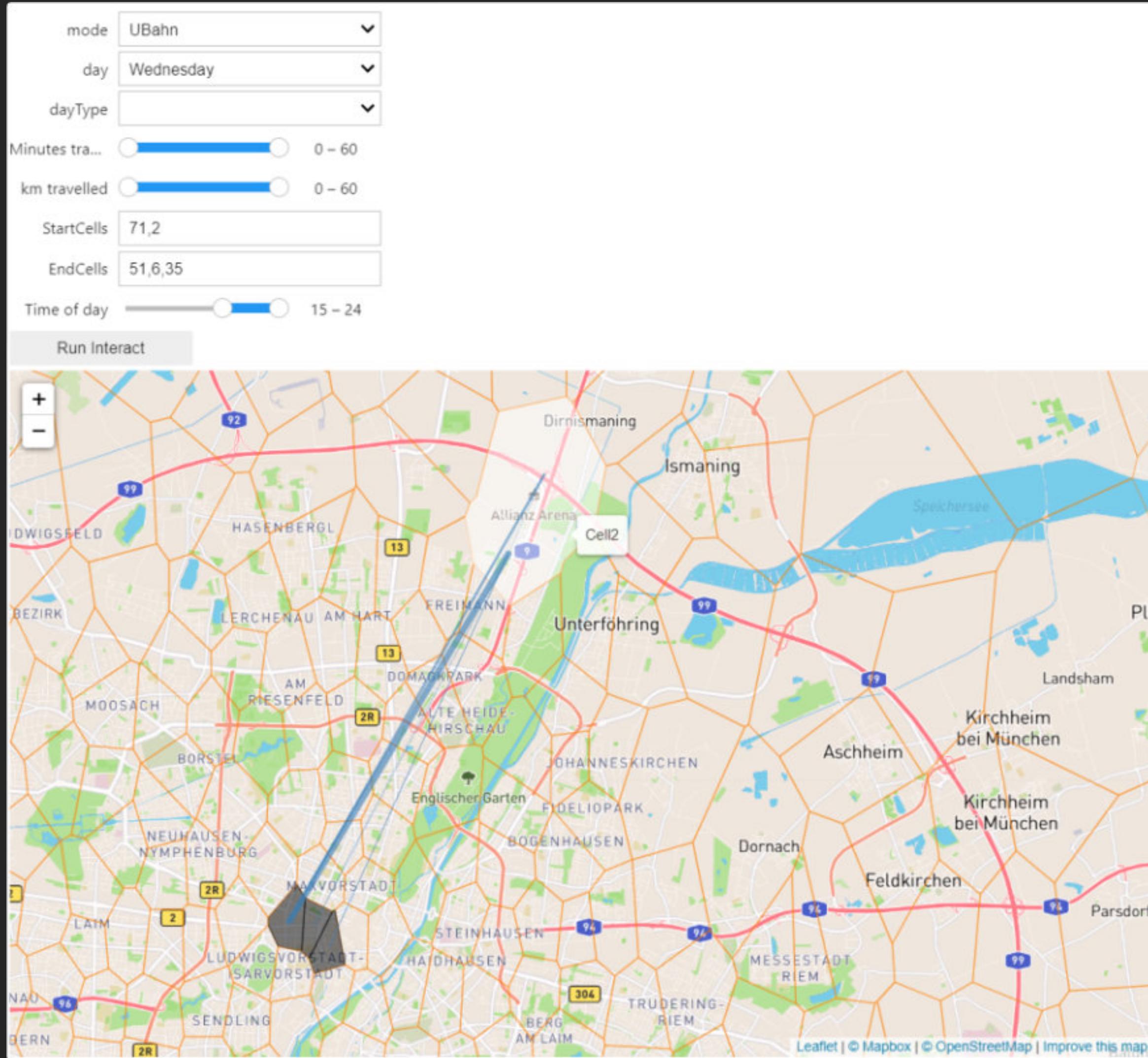
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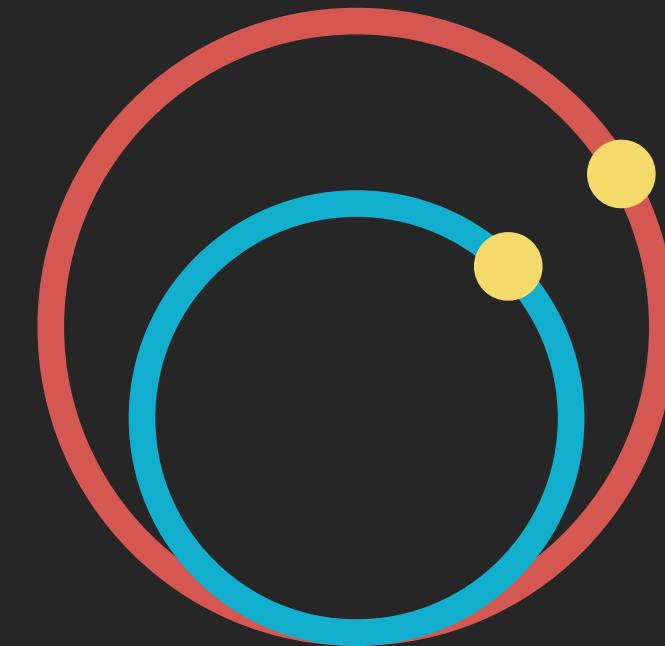
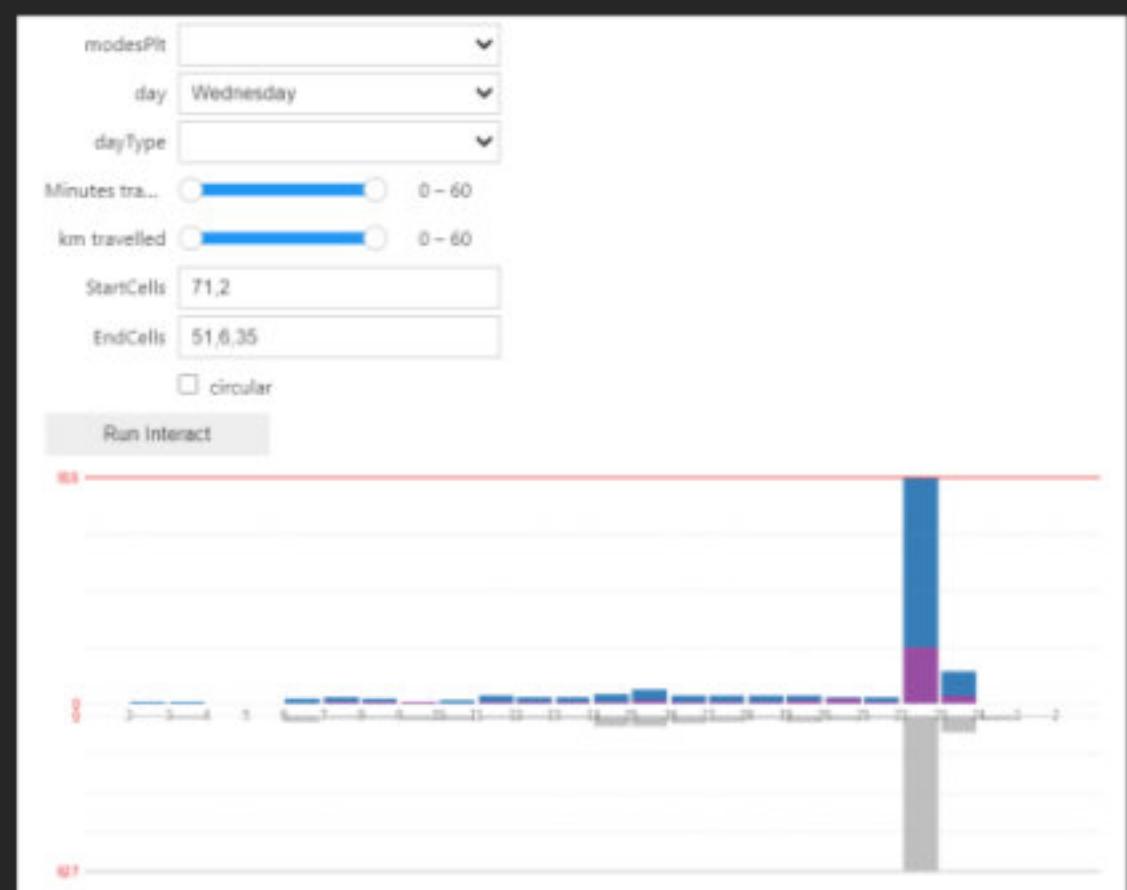
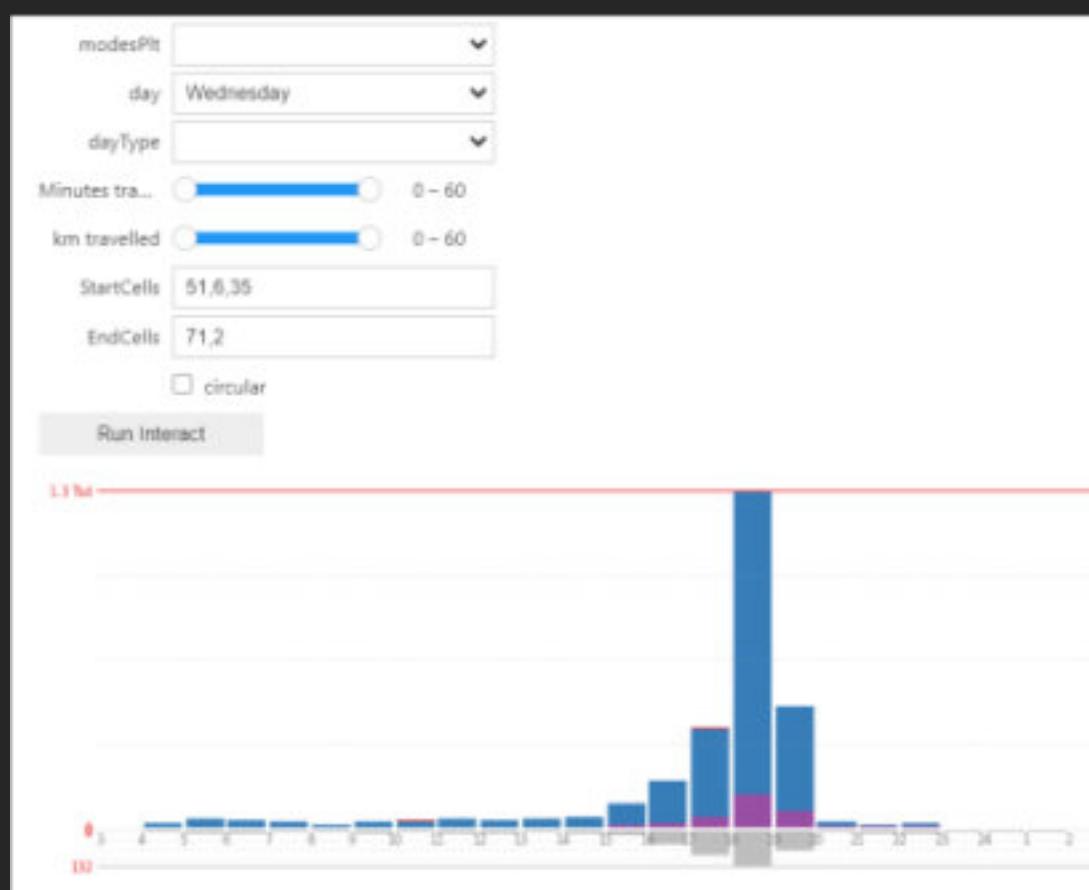
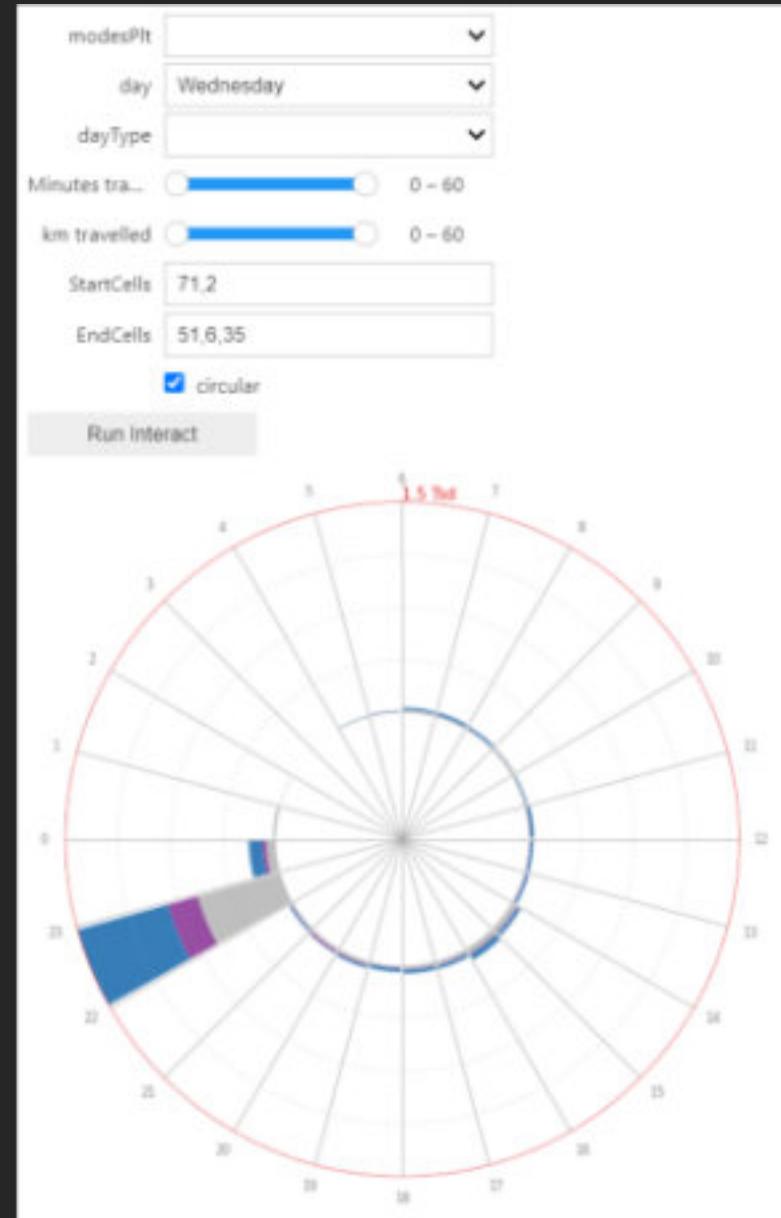
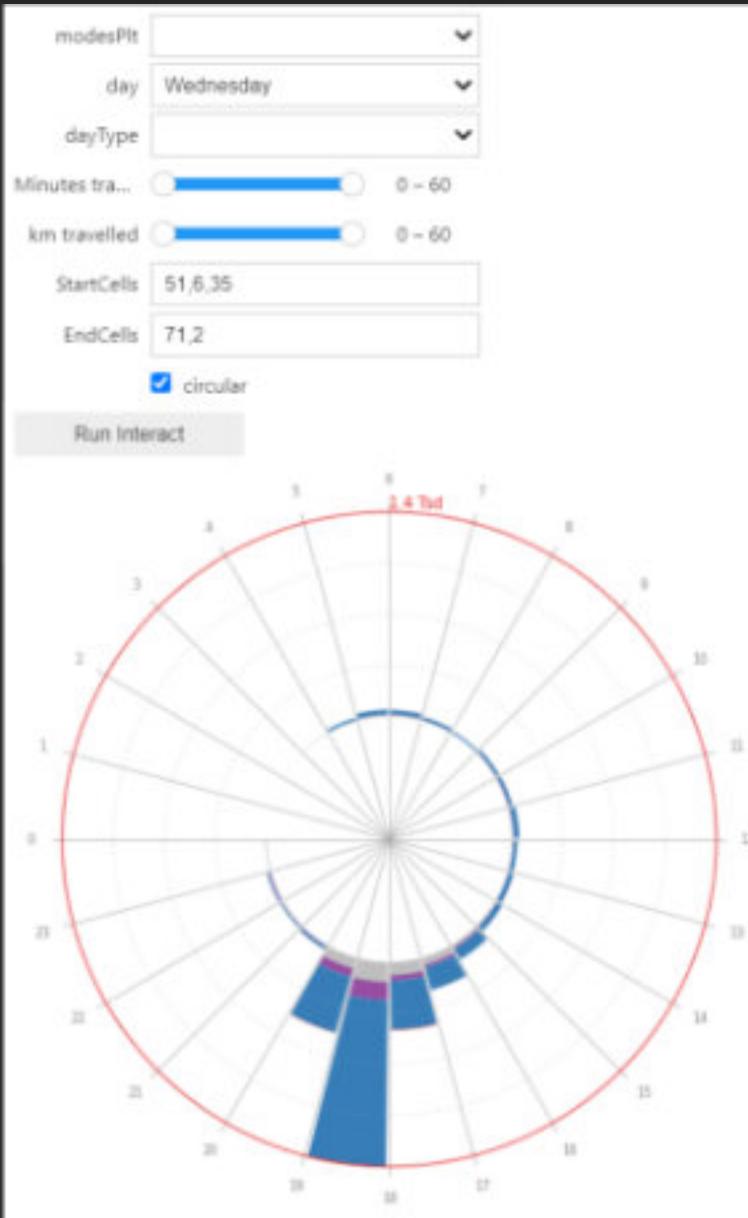
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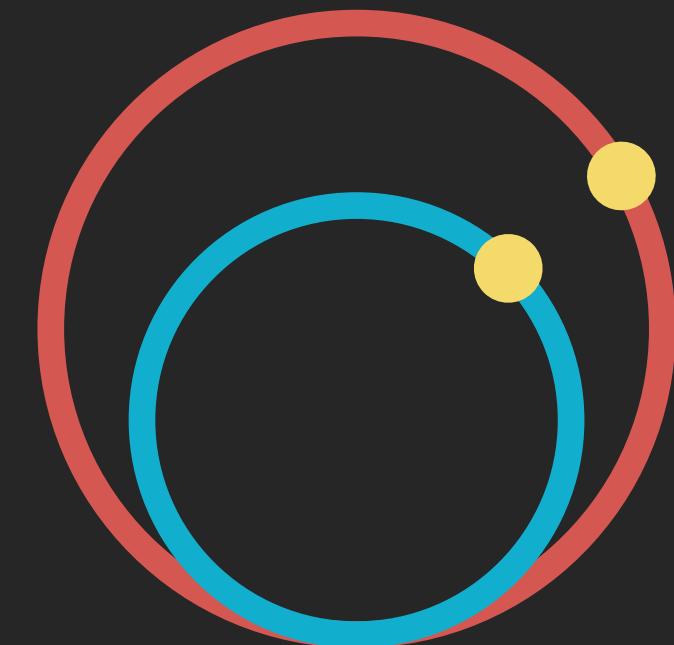
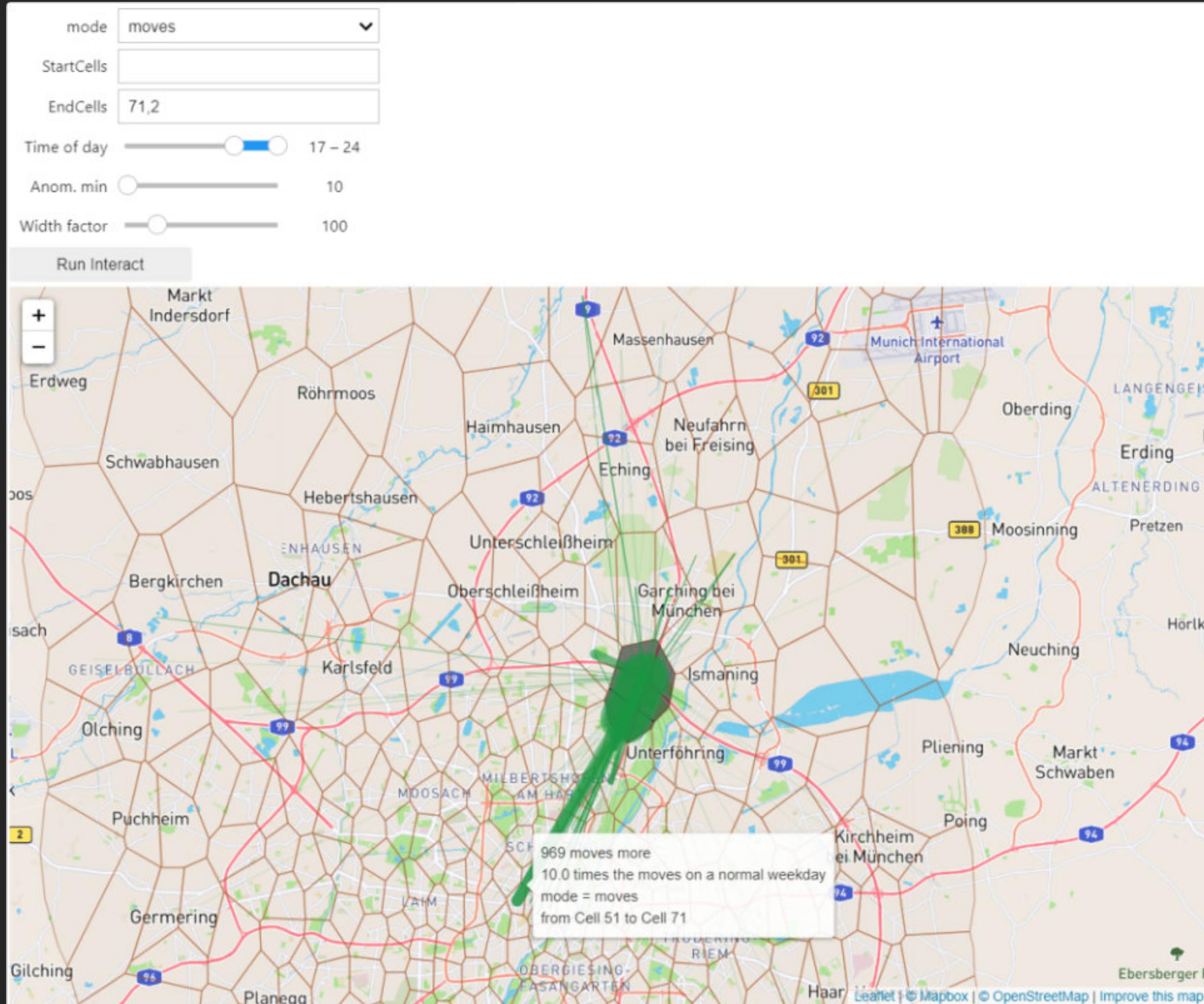
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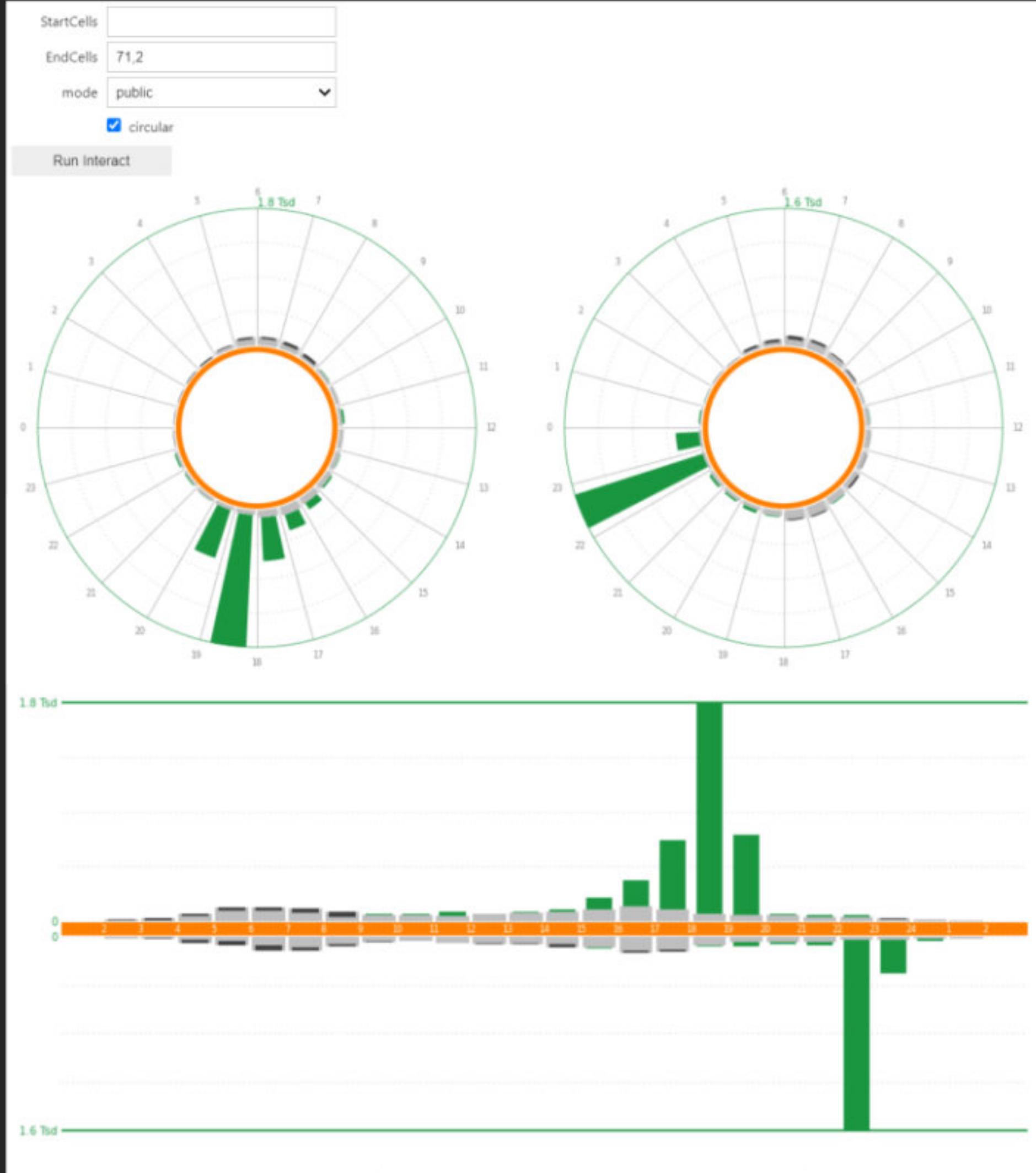
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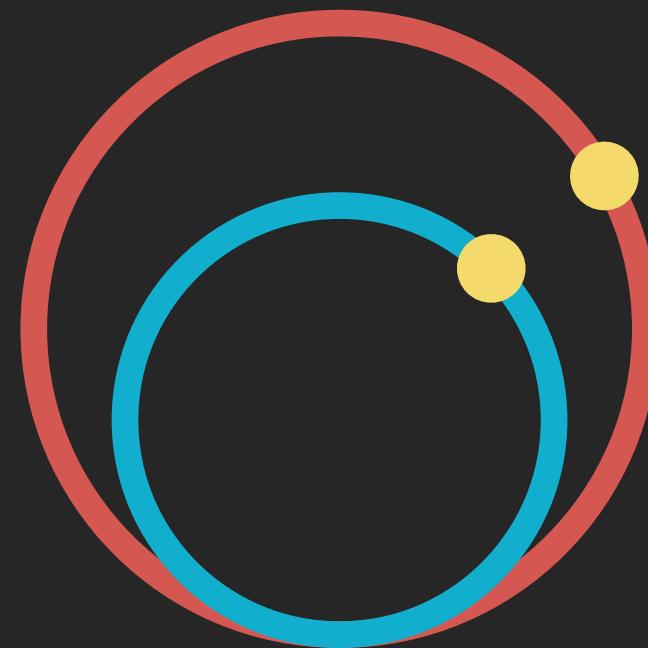
Develop Visualizations, implement Functionality & Interactivity



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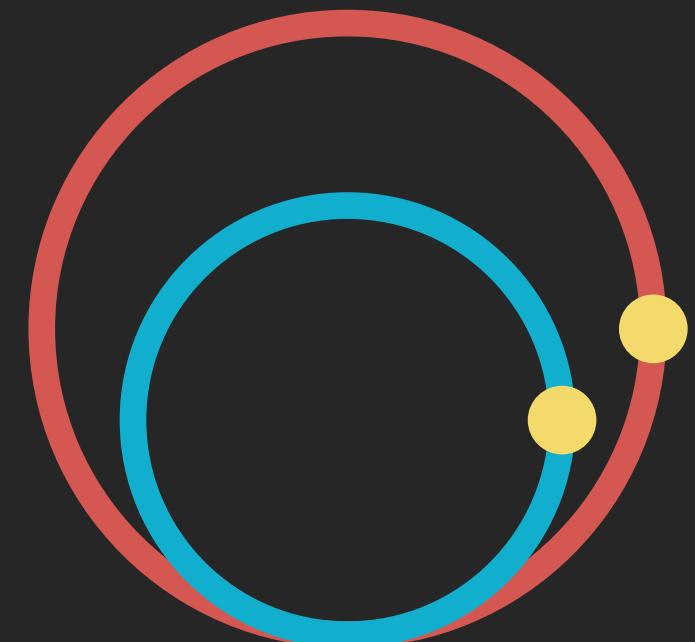
Develop Visualizations, implement Functionality & Interactivity



User Test – preparation

SET-UP

- two small groups of colleagues
- projector, mouse, guided walk-through
- JupyterLab simulating a working interface



QUESTIONNAIRE

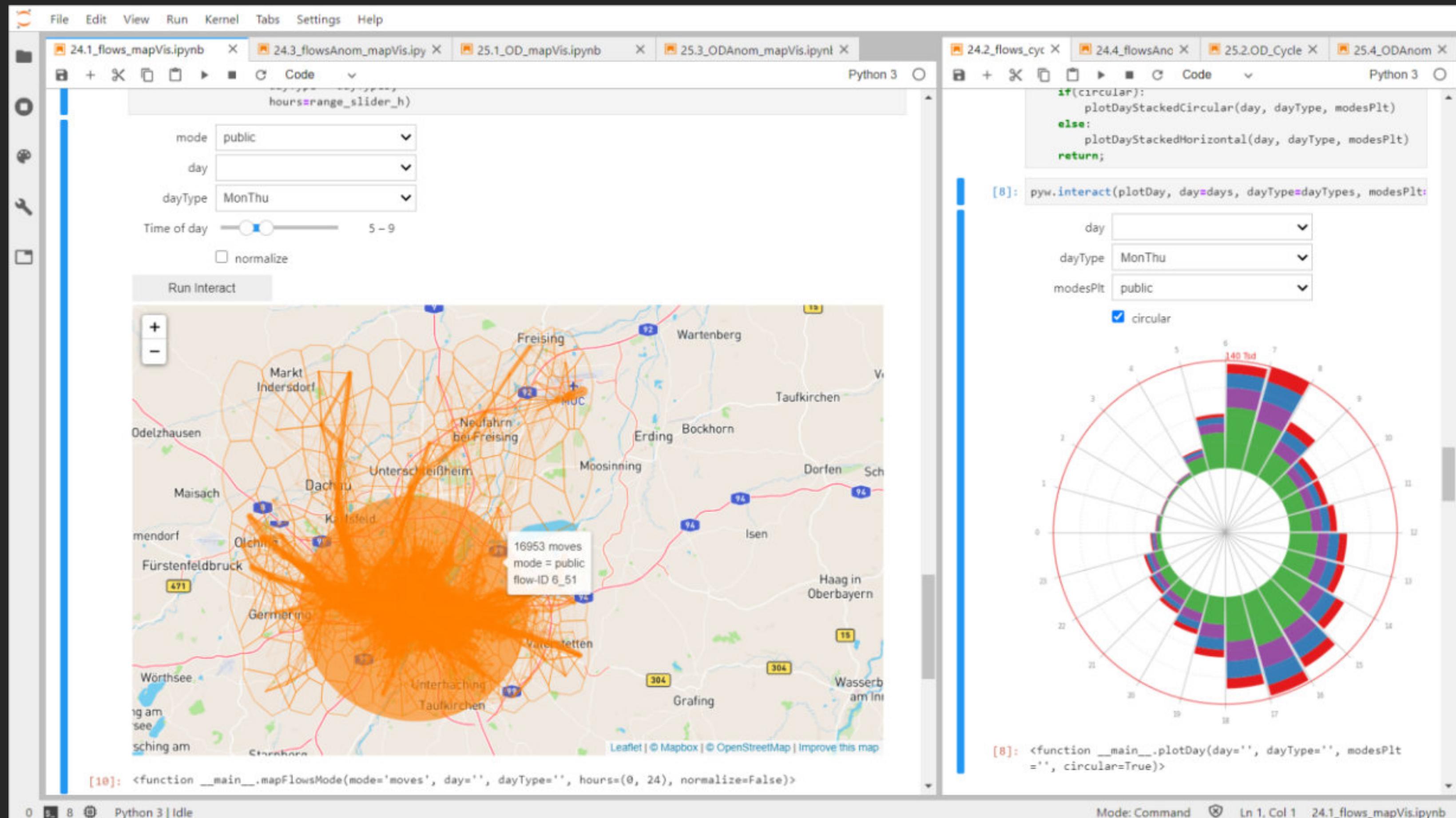
- “quantitative” questions & open qualitative questions
- Encourage reflection, get individual responses

Plan and Prepare User Test:
Scenario & Questionnaire

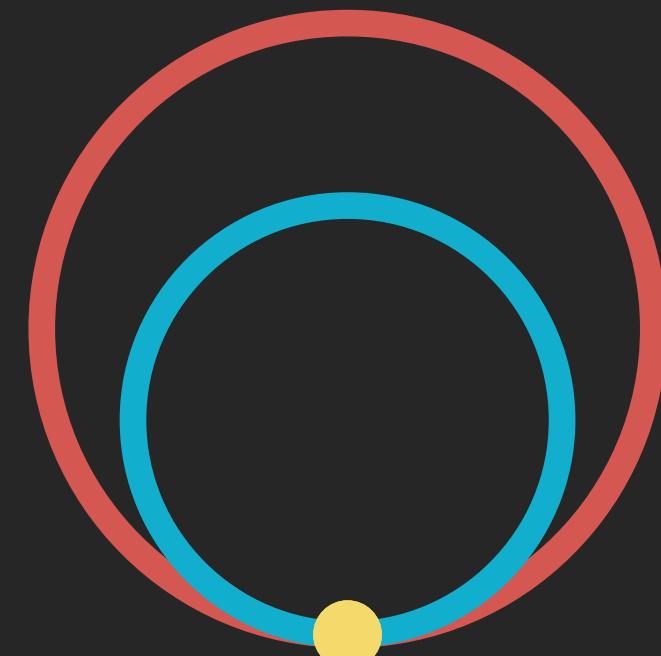
Prepare Interface for User Test



User Test – execution



Execute User Test
with Expert Users



Evaluation & Results

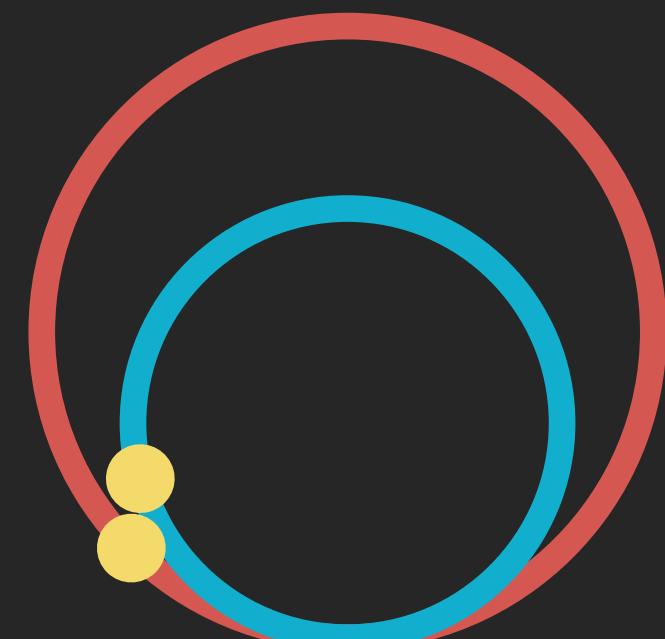
DATA

- data resolution & abundance
- further modal breakdown
- intermodality & travel chains

VISUALIZATION

- further decluttering / dynamic aggregation
- total numbers in bar charts, placement of peak hour
- further (interactive) legend

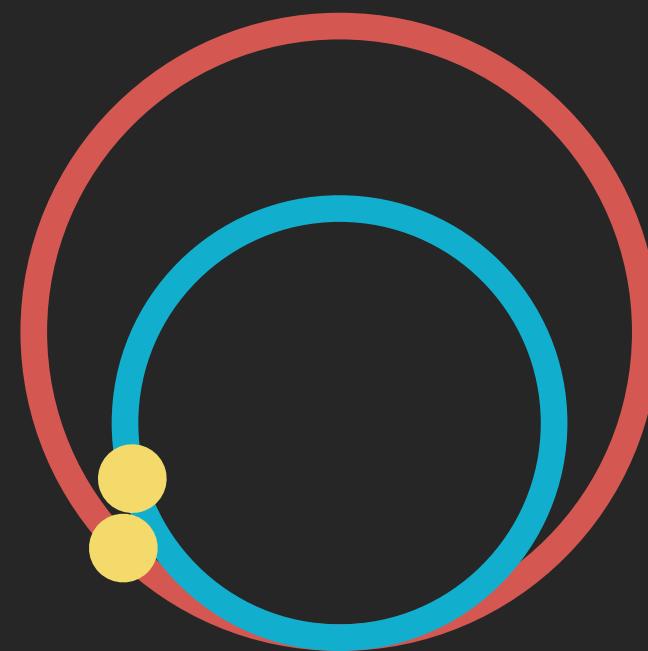
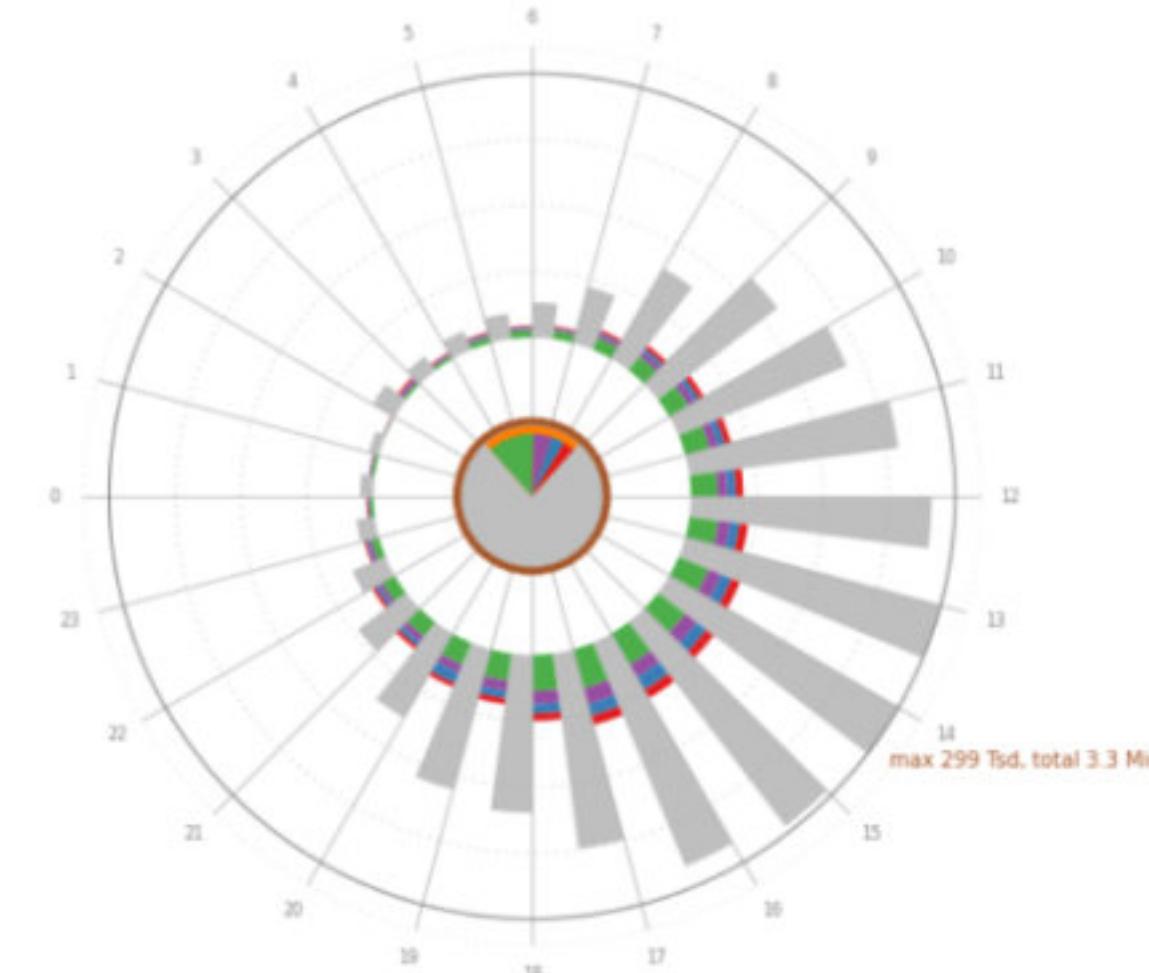
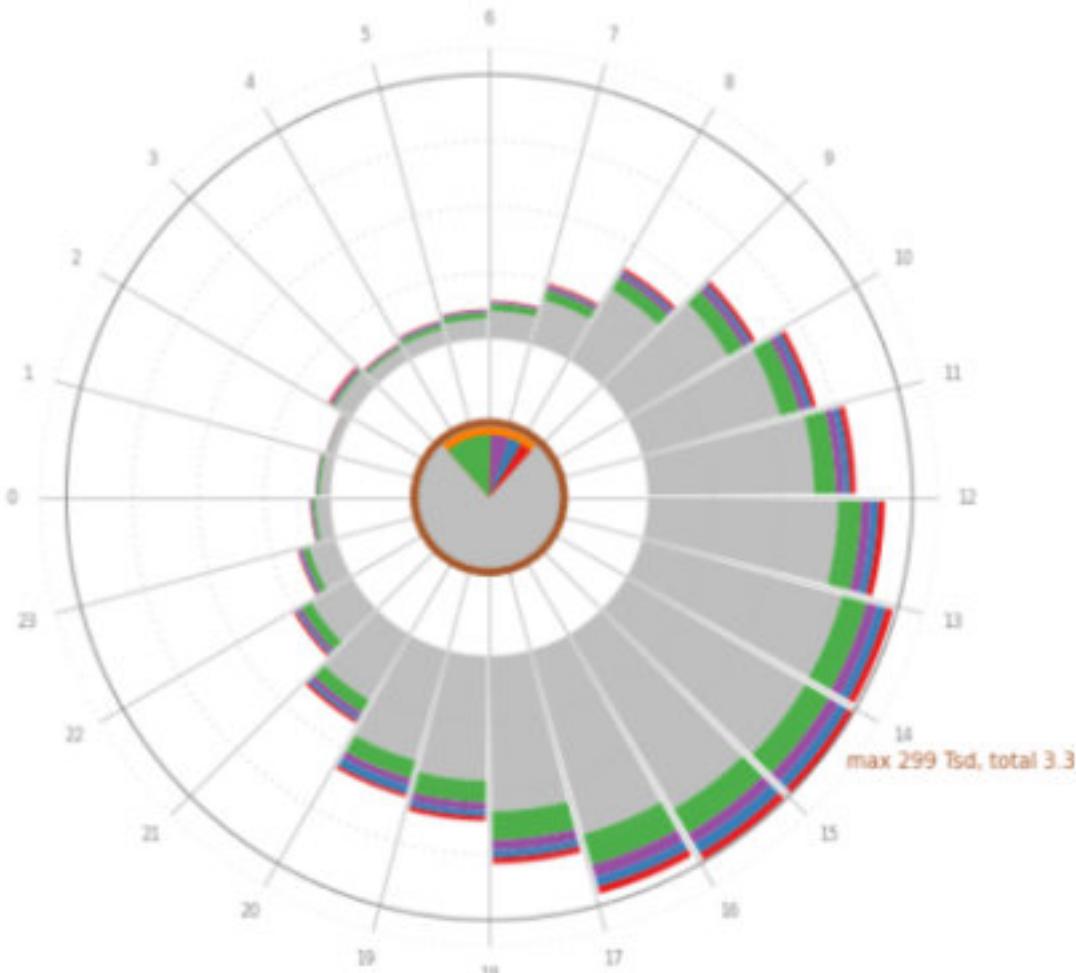
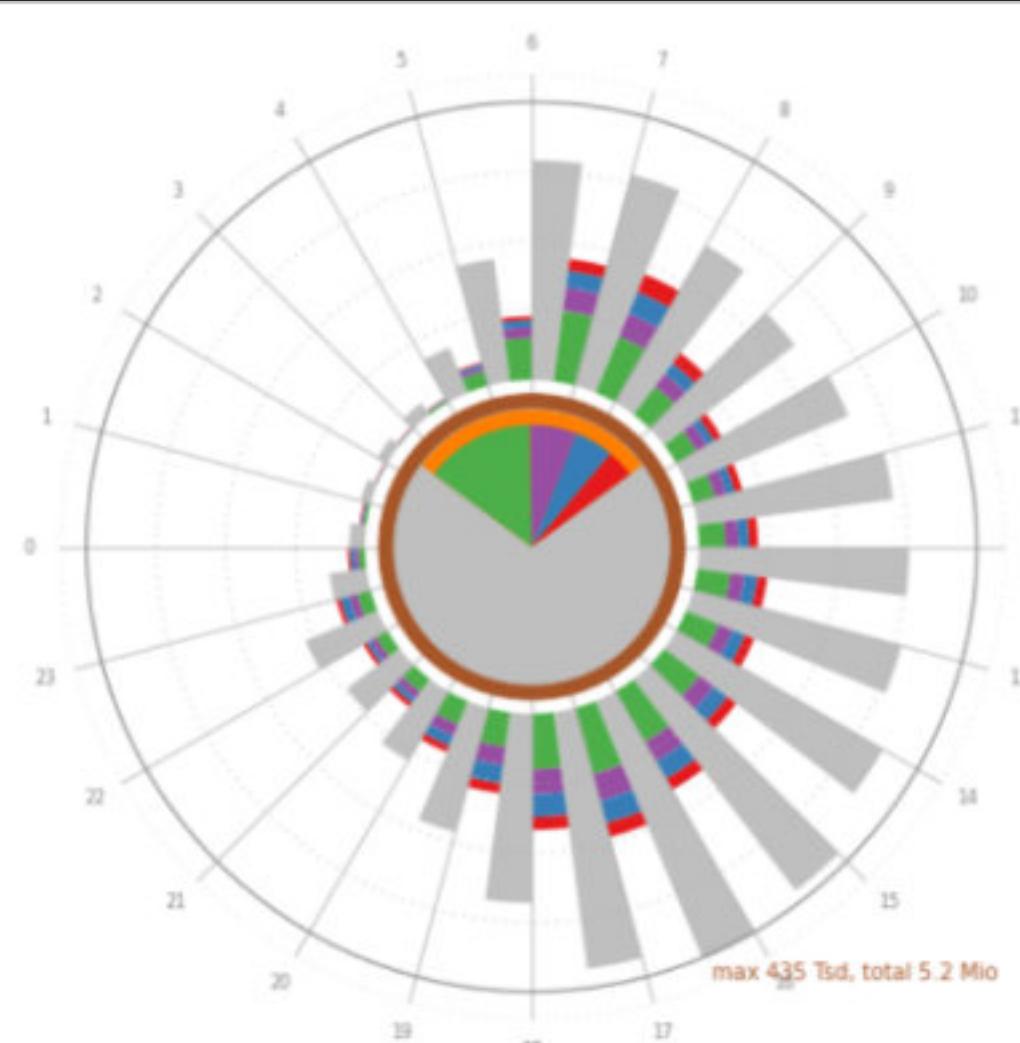
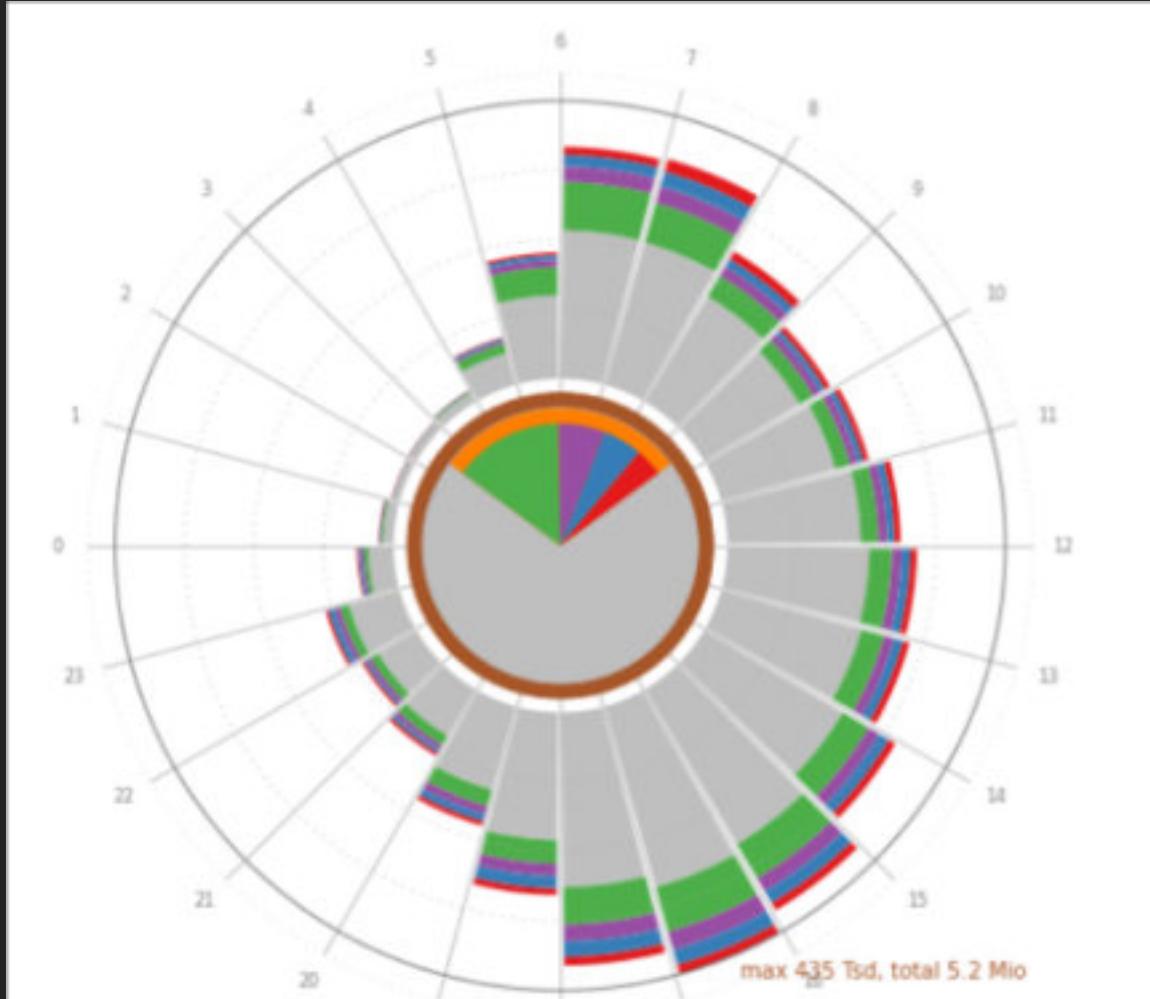
IN GENERAL VERY HELPFUL: FACILITATES NEW POSSIBLE ANALYTIC TASKS



Evaluate User Test

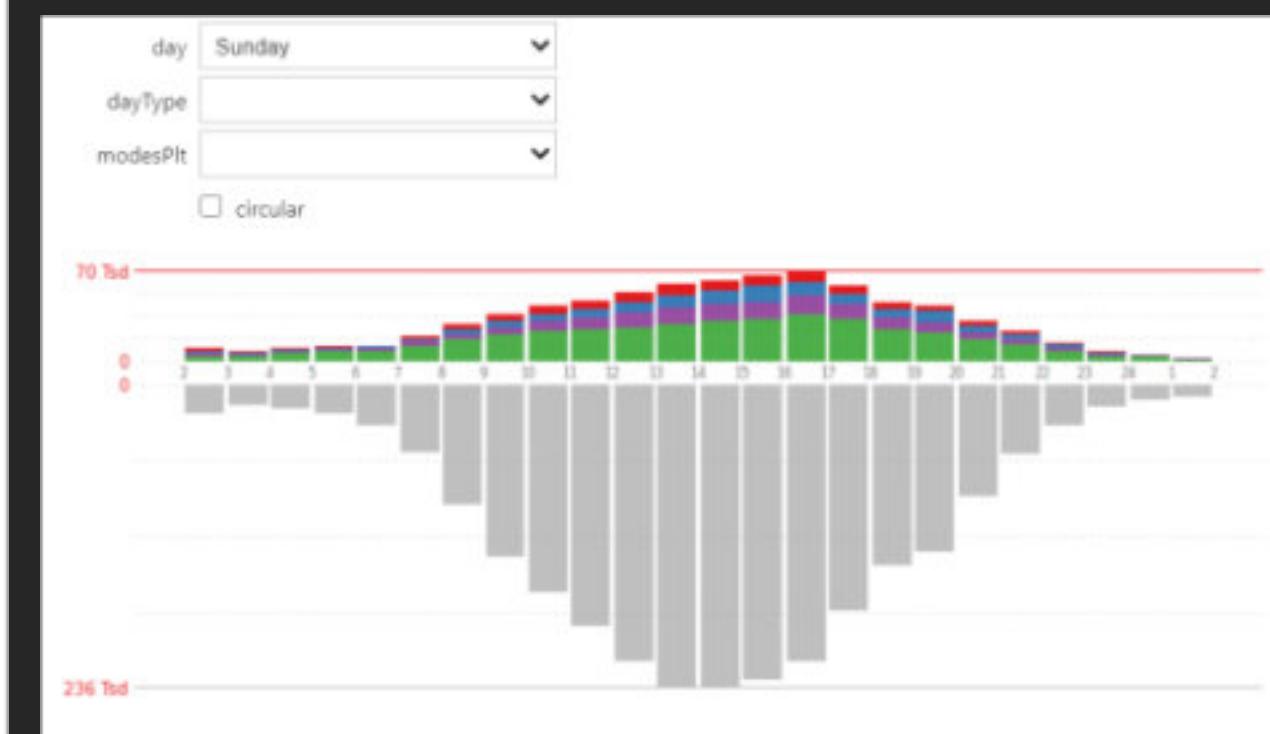
Implement Changes
according to Results of Evaluation

Implementation of Changes



Evaluate User Test

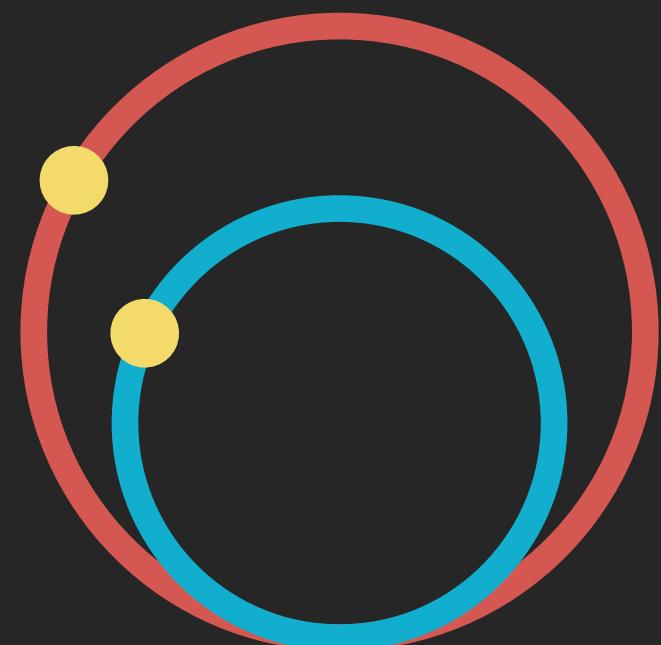
Implement Changes
according to Results of Evaluation

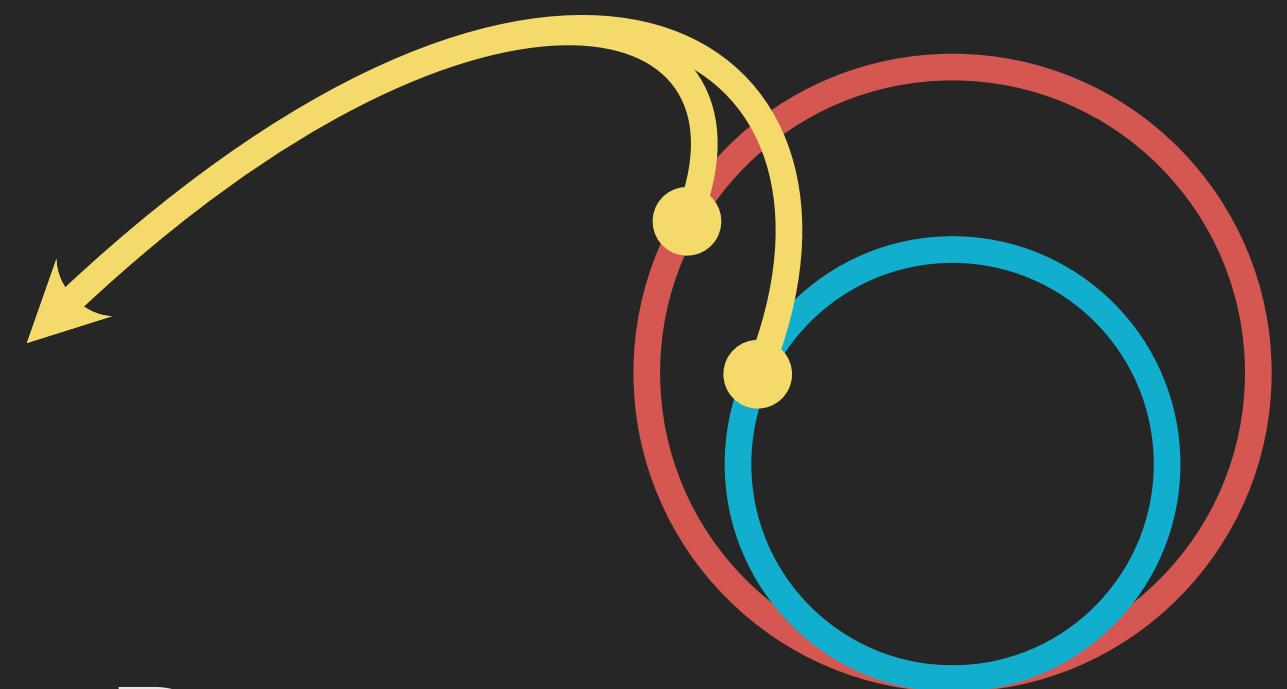


Conclusion & Outlook

- The incorporation of attributed flow data stemming from mobile network data can help improve and expand the current analytic framework in public transportation planning.
- Further design cycles are needed.
- Collaboration between Visual Analytics and Public Transportation Planning can help contribute to an efficient, climate-friendly and resilient future of urban regions.

Discuss & Conclude

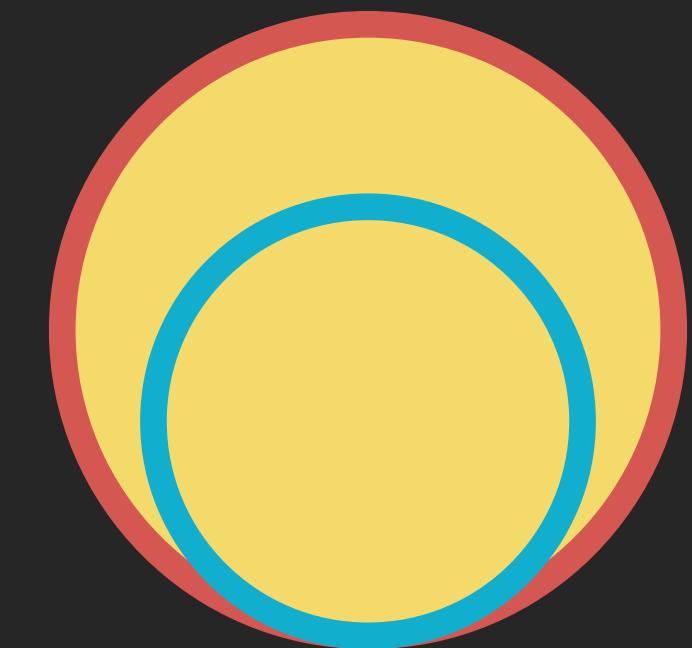




Visualizing Mobile Network Data

A User-Centred Design Approach Connecting
Visual Analytics to Urban Public Transportation Planning

by **LAURA VERENA KLASSEN** – defended on **29 OKTOBER 2020**



THANK YOU!

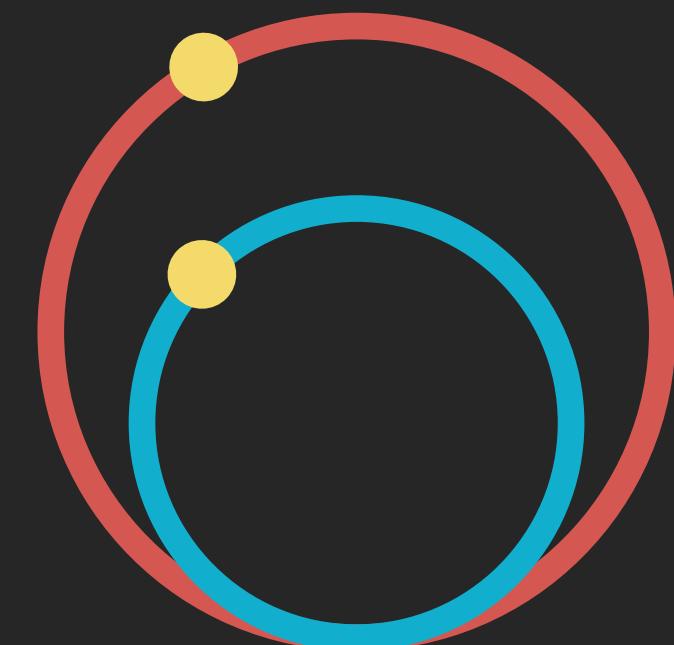
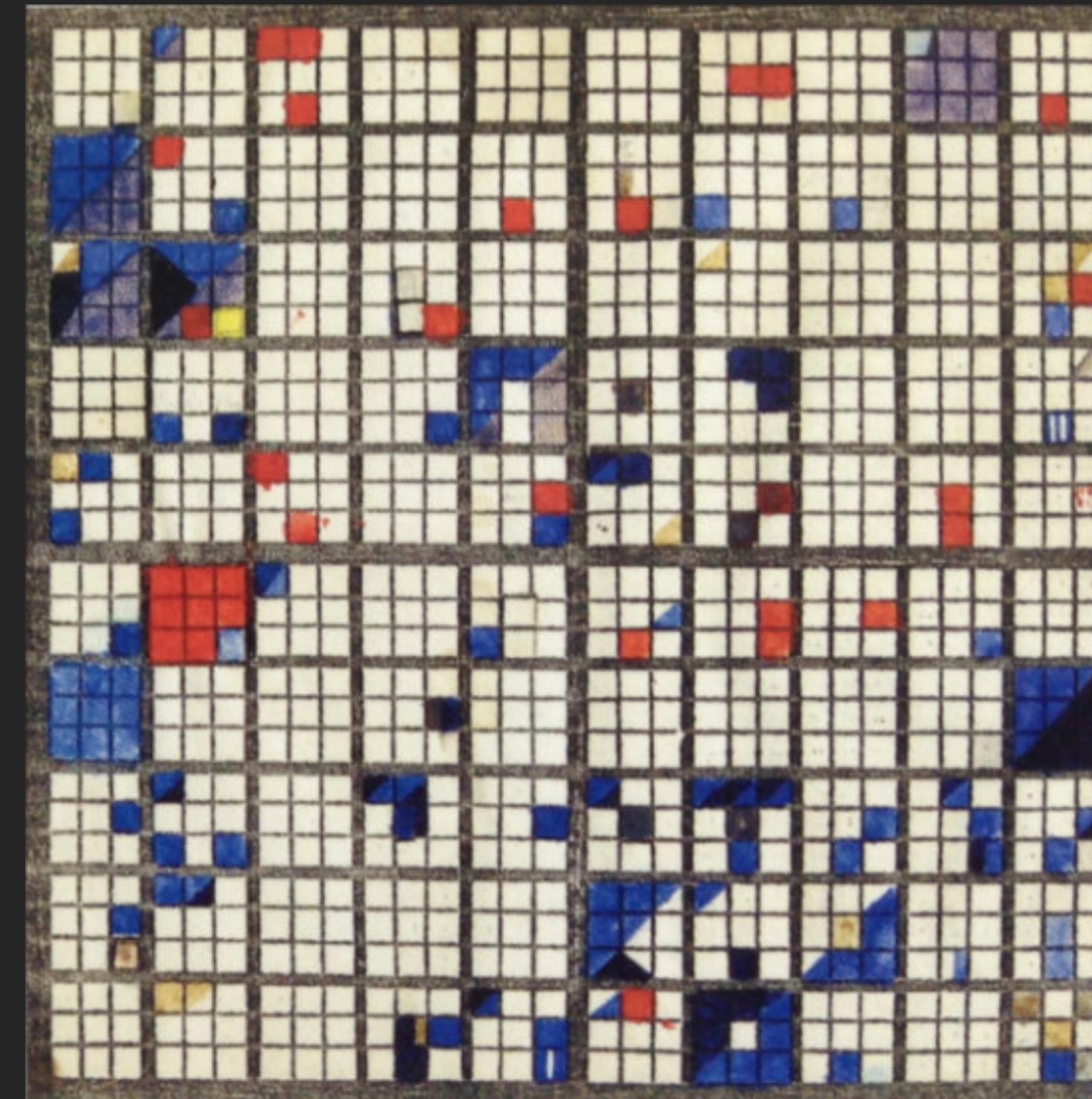
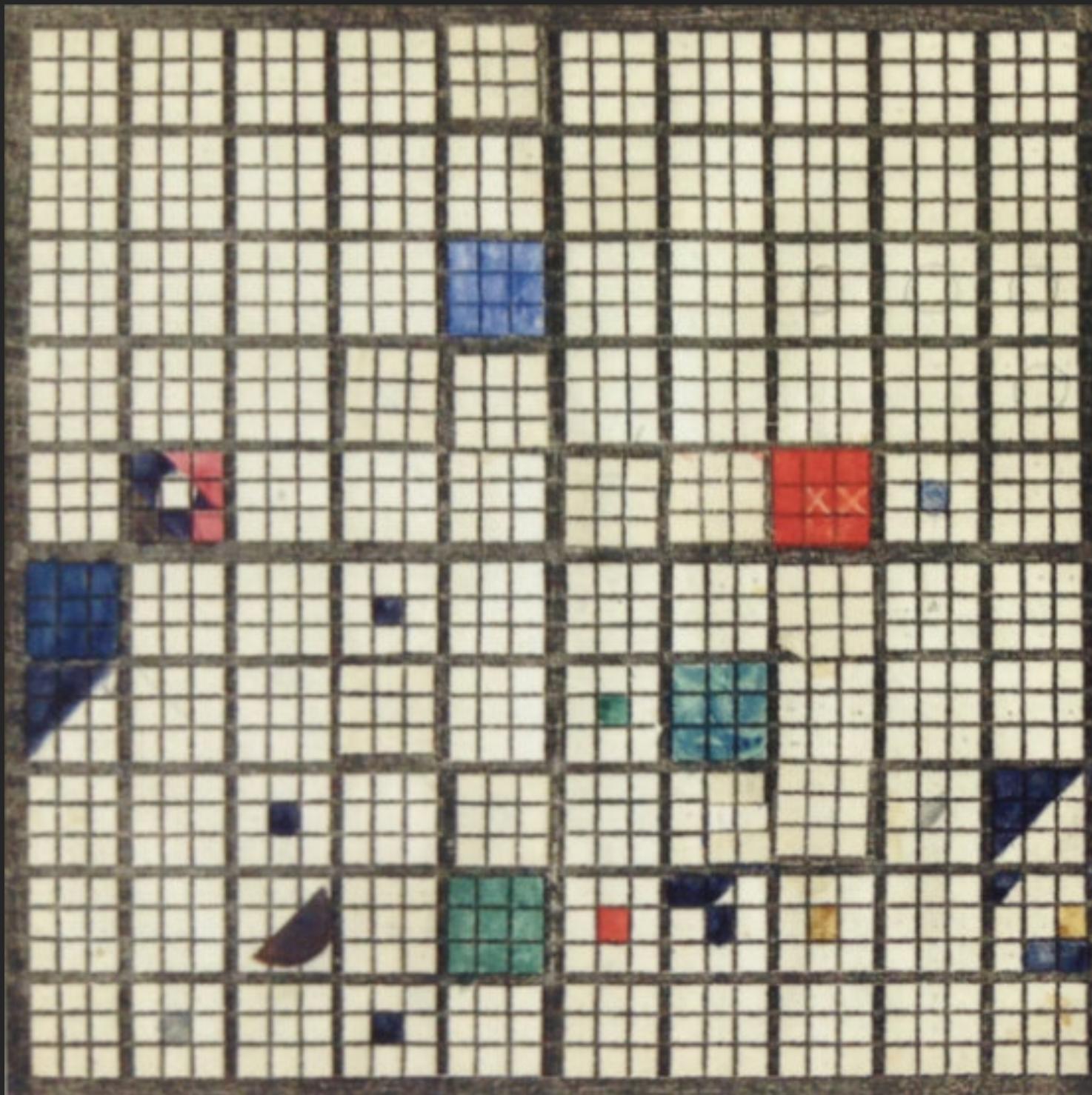


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Extra | Literature – heat maps



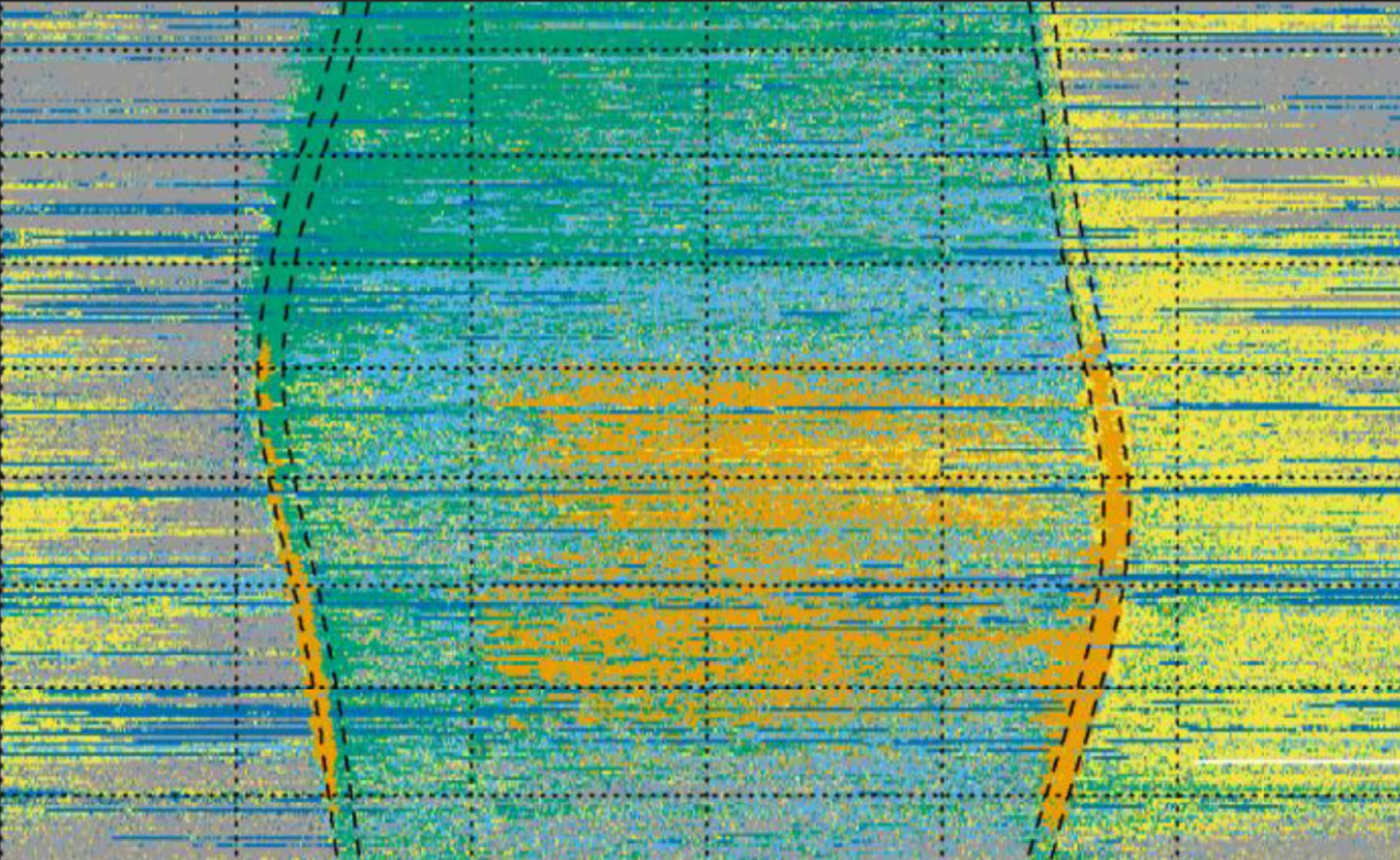
Literature Review:

User-Centred Design
Transport Planning

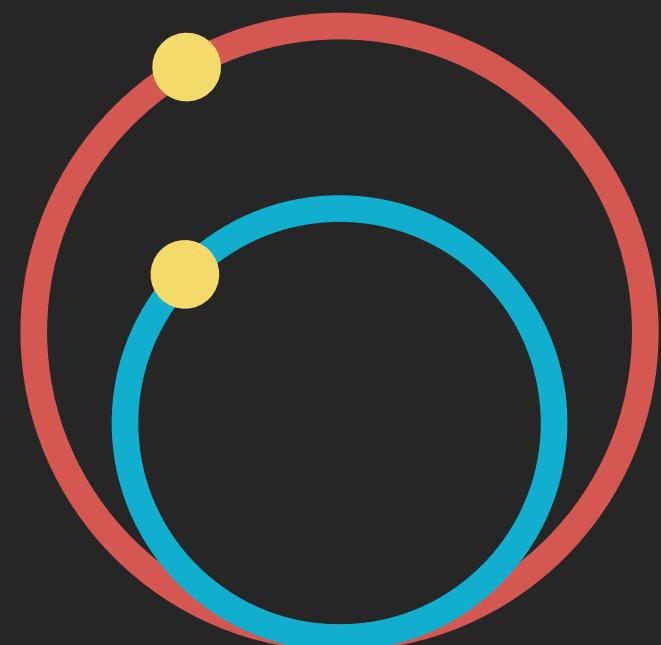
Historical Development
Visual Analytics

The Polish-American System of Chronology, Reproduced with Some Modifications, from General Bem's Franco-Polish Method published by Elizabeth Palmer Peabody in 1850. Used as a mnemonic device, every set of nine squares is filled with coloured shapes according to the types of events that happened in a given year. Figure taken from Rosenberg and Grafton (2012, p. 205)

Extra | Literature – heat maps



Detail from a plot of a sound recording at the Woondum National Park in Queensland, Australia, by Yvonne F. Phillips. Each minute in the recording is assigned a class corresponding to its dominant acoustic state. Different colours represent different classes: green for birds, yellow for orthoptera, orange for cicadas, blue for rain, light blue for wind, gray for quiet and pink for aircrafts. The curved lines represent civil-sunrise, sunrise, sunset and civil sunset. (Phillips, 2018, p. 123)



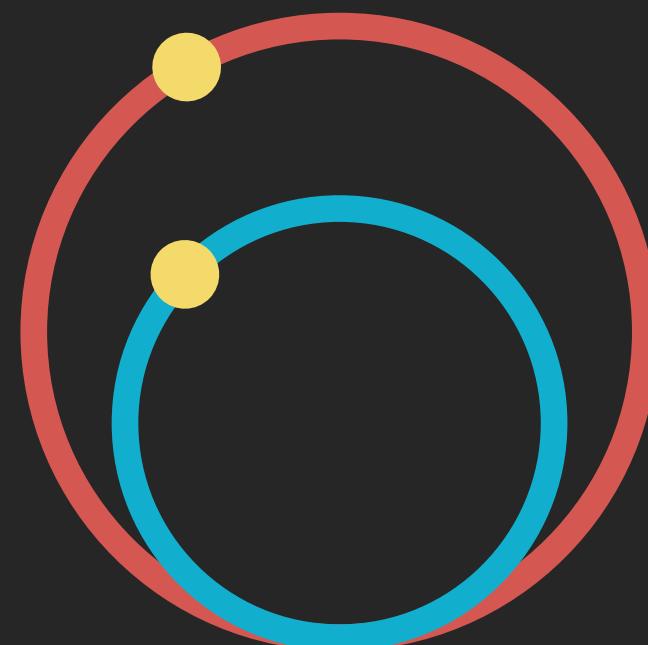
Literature Review:

User-Centred Design
Transport Planning

Historical Development
Visual Analytics

Extra | Literature – pbl. transp. planning

Te Brömmelstroet et.al. (2017) propose “bringing models closer to those who use their outputs” after having investigated experiences with transportation models among professionals in the field of transportation planning



- Explore how to best present data for the purpose of planning is essential
- The Metropolitan Region of Munich formed in 2007 to help facing the challenge of the city's growing population.
- The TUM Accessibility Atlas (Büttner, Kinigadner, Ji, Wright & Wulfhorst, 2018) was initiated in 2009: participatory development, up-to-date data and transparent indicators for effective decision making.

Literature Review:

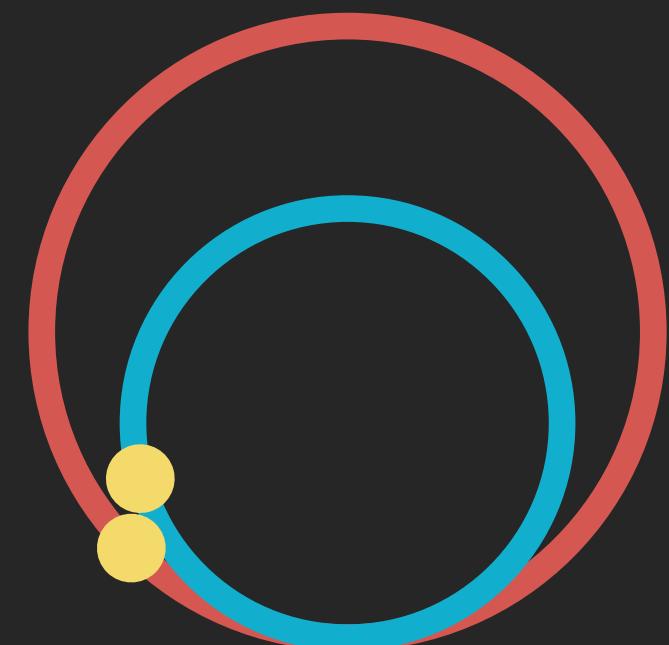
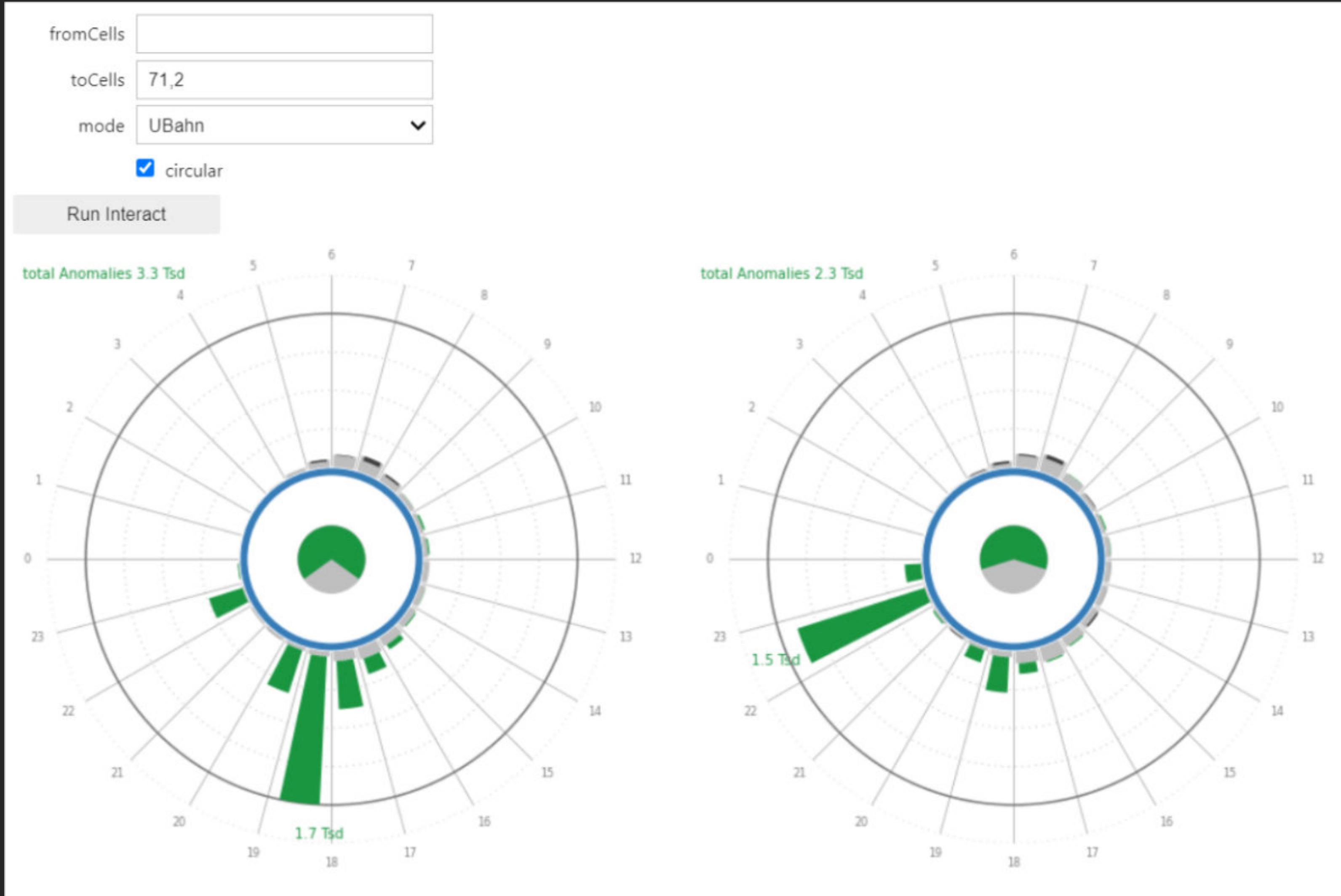
User-Centred Design
Transport Planning

Historical Development
Visual Analytics

BUT: Collaboration between visual analytics and transportation planning is still lacking.
(Andrienko, Andrienko, Chen et al., 2017)



Extra | Implementation of Changes



Evaluate User Test

Implement Changes
according to Results of Evaluation

