The Linked Microposter Plots Family as New Means for the Visualization of Eye Tracking Data

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Outline

Use of Eye Tracking Technology

- Eye tracking frequently used in education, usability research, sports, psychology, and marketing (Rayner 1998; Jacob and Karn 2003)
- Intent to measure eye positions and eye movement to analyze where people are looking
- Common devices: Desktop-based and mobile eye tracking devices

Mobile Eye Tracker

R Packages

- **saccadr** (Pastukhov 2023): Extracting saccades from eye tracking data
- **eyeTrackR** (on CRAN) (Godwin 2020): Organizing and analyzing eye tracking data
- **eyetrackingR** (Dink and Ferguson 2015; Forbes et al. 2023): Eye tracking data analysis
- **gazeR** (Geller et al. 2019, 2020): Analysis of gaze position and pupil size
- **popEye** (Schroeder 2024): Analysis of eye tracking data from reading experiments

Other Software

- Matlab toolboxes and functions:
  - **EyeMMV** (Krassanakis et al. 2014): Eye movement post-analysis tool
  - **GazeAlyze** (Berger et al. 2012): Analysis of eye tracking data
- Python packages:
  - **GazeParser** (Sogo 2013): Analysis of eye tracking data
  - **PyGaze** (Dalmaijer et al. 2014): Programming of eye tracking experiments

EyeTrackR Functionality

- Data processing
- Data summarization
- Common eye tracking visualization tools
- Linked microposter plots visualizations
- Main references: Li and Symanzik (2017); Li (2017)

- Accessible from
  `https://github.com/ChunyangCLi/EyeTrackR`

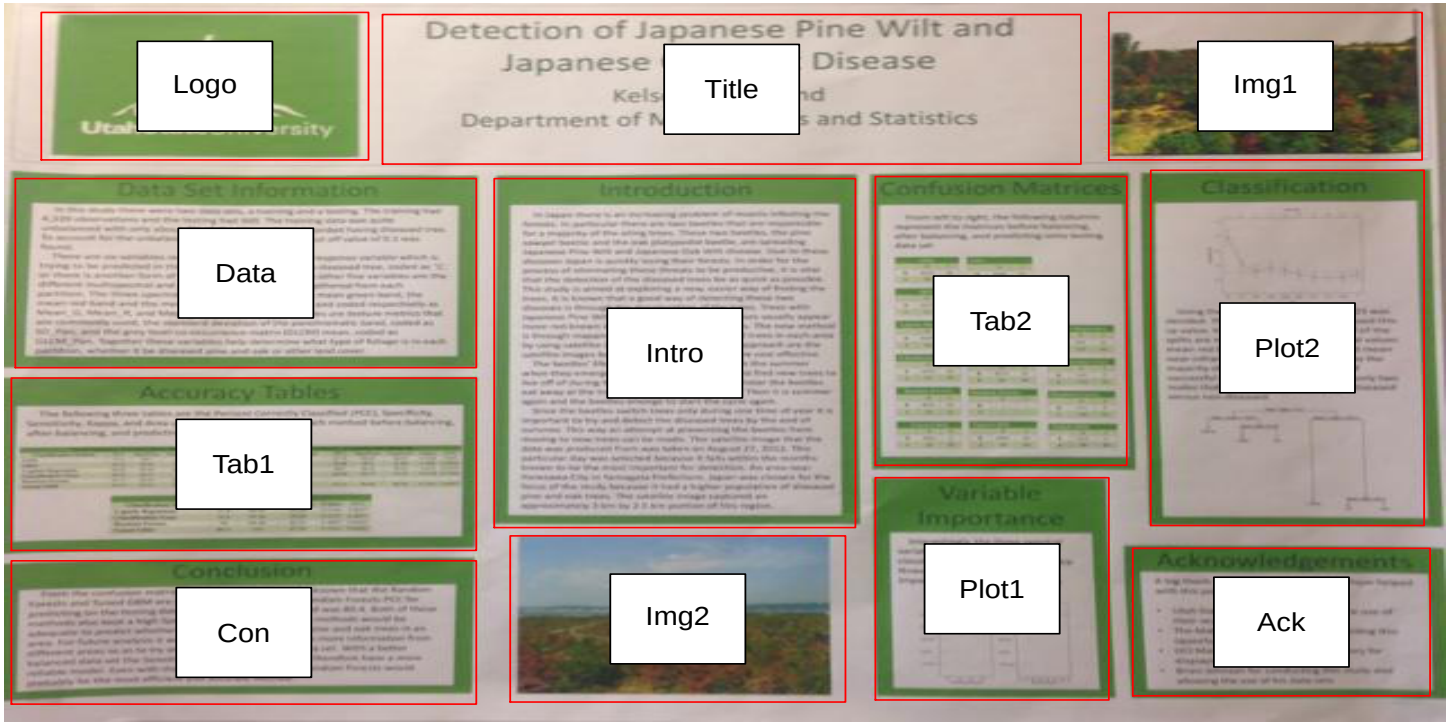
Data Processing

- Splitting eye tracking video recording into individual video frames
- Extracting eye coordinates (called gaze points or focus points) from each video frame

Data Extraction, Summarization, and Visualization

- Defining Areas of Interest (AOIs)
- Extracting fixations
- Determining scanpaths/saccades
- Common visualization of eye tracking data
- Advanced visualization

Defining Areas of Interest (AOIs)

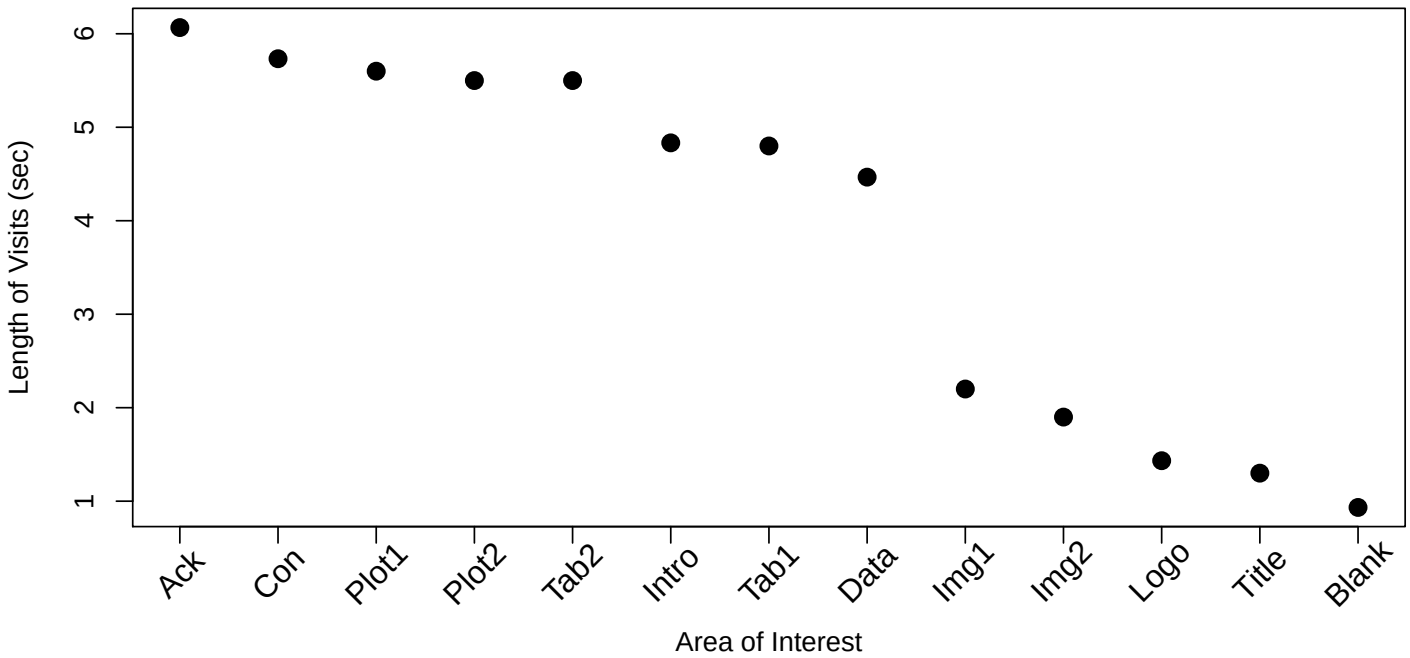


12 defined AOIs of a scientific poster (from Logo to Acknowledgement)

Visualization Functions in the EyeTrackR R Package

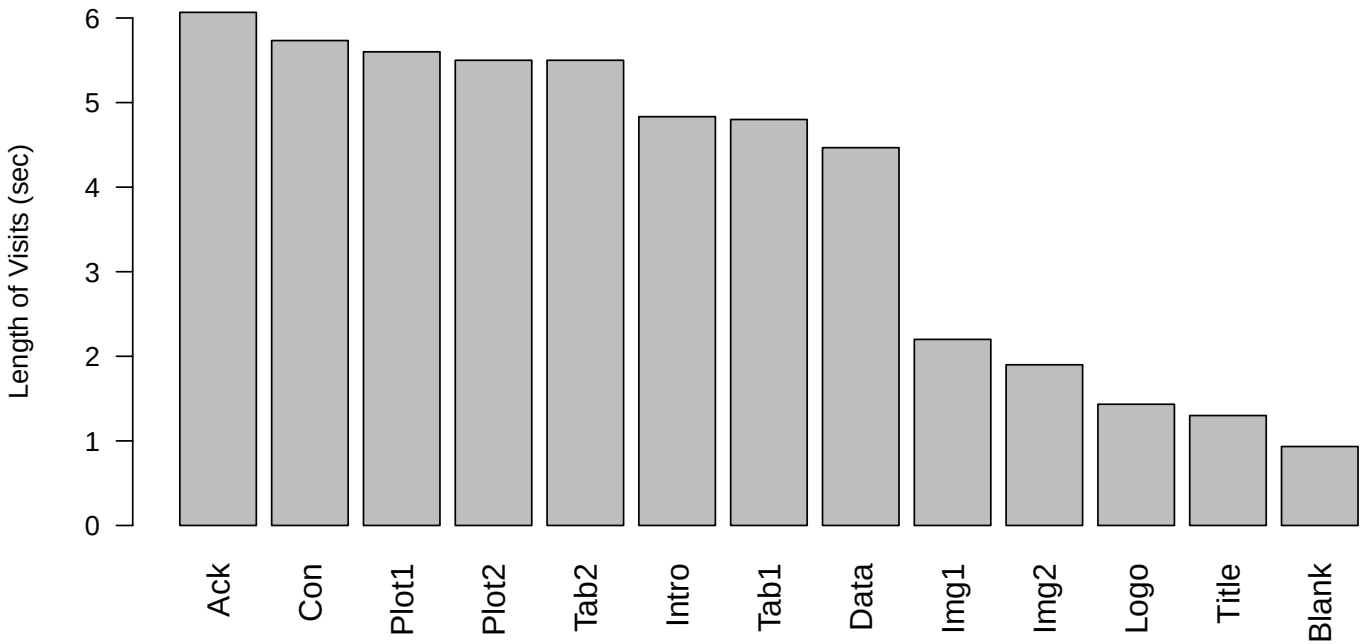
Function Name	Visualization Functionality Group
	(i) Common Eye Tracking Visualization Tools
DrawEyeDotplot	Create a dot plot indicating the time spent on each AOI.
DrawEyeBoxplot	Create a box plot showing the participant's pupil radiuses in each AOI.
DrawEyeBarplot	Create a bar plot indicating the time spent on each AOI.
DrawEyeScatterplot	Create a scatter plot showing the participant's focus points.
DrawEyeHeatmap	Create a heat map or hot spot map with Gaussian kernel.
DrawEyeAOITimelines	Create an AOI timeline plot.
DrawEyeScanpathMap	Create a scanpath map.
	(ii) Linked Microposter Plots Visualizations
DrawEyeLMPlot	Create linked microposter plots.
DrawEyeLTMPlot	Create linked timeline microposter plots.
DrawEyeLSMPlot	Create linked scanpath microposter plots.

DrawEyeDotplot



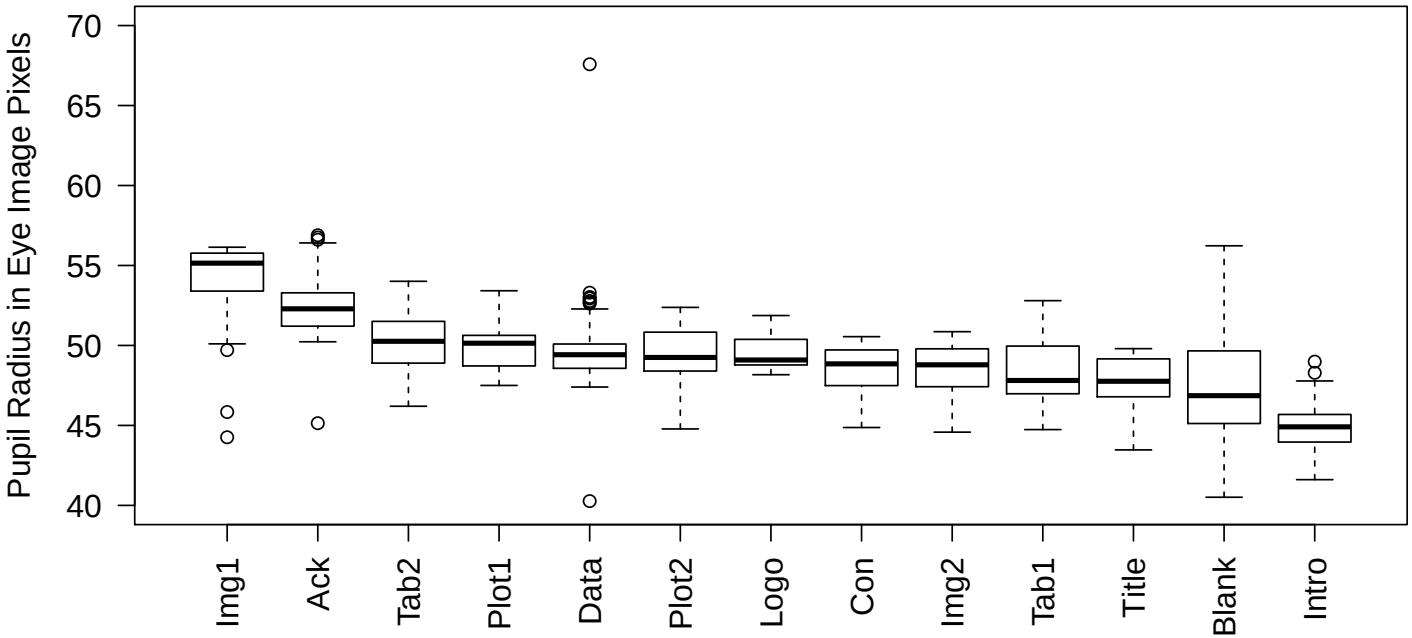
Dot plot showing the length of visits in each of the 12 defined AOIs (Blank = area between the AOIs)

DrawEyeBarplot



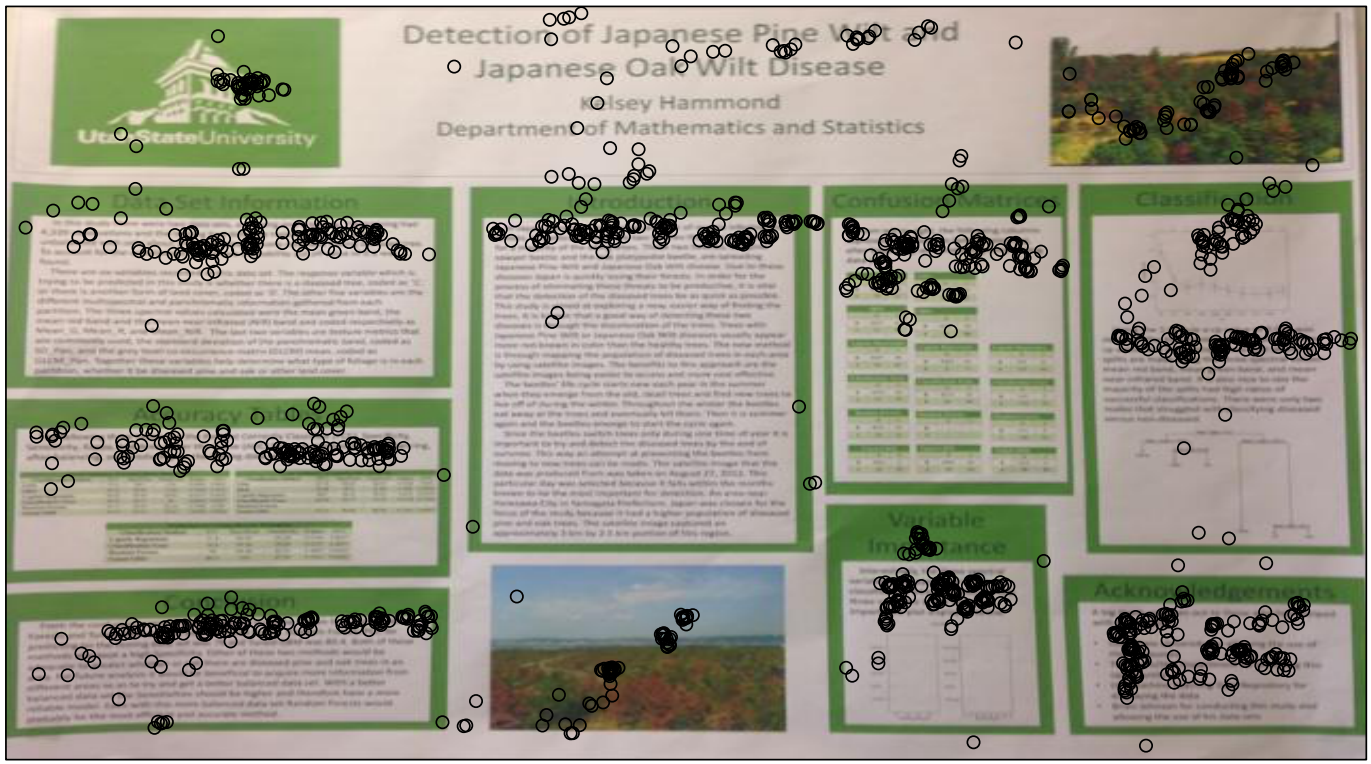
Bar plot showing the length of visits in each of the 12 defined AOIs (Blank = area between the AOIs)

DrawEyeBoxplot



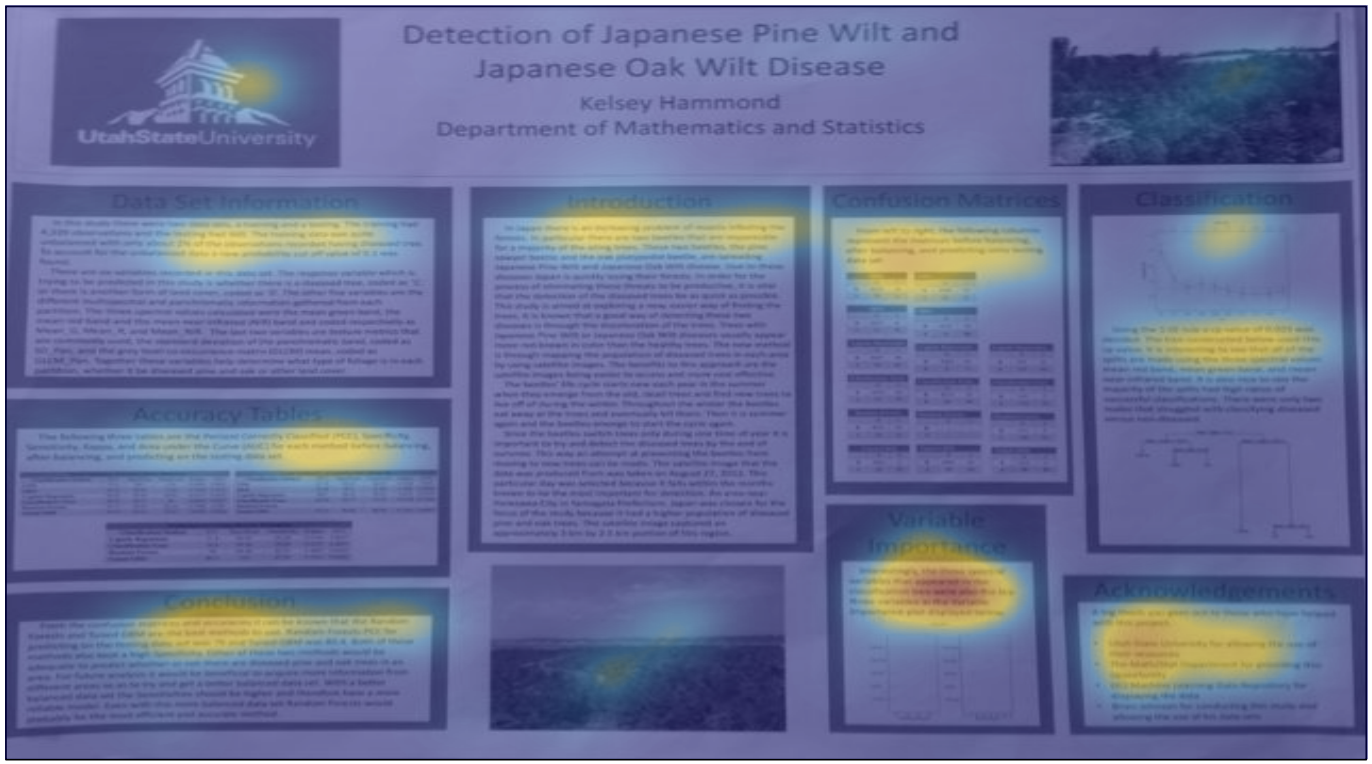
Box plot showing the pupil radius in each of the 12 defined AOIs (Blank = area between the AOIs)

DrawEyeScatterplot



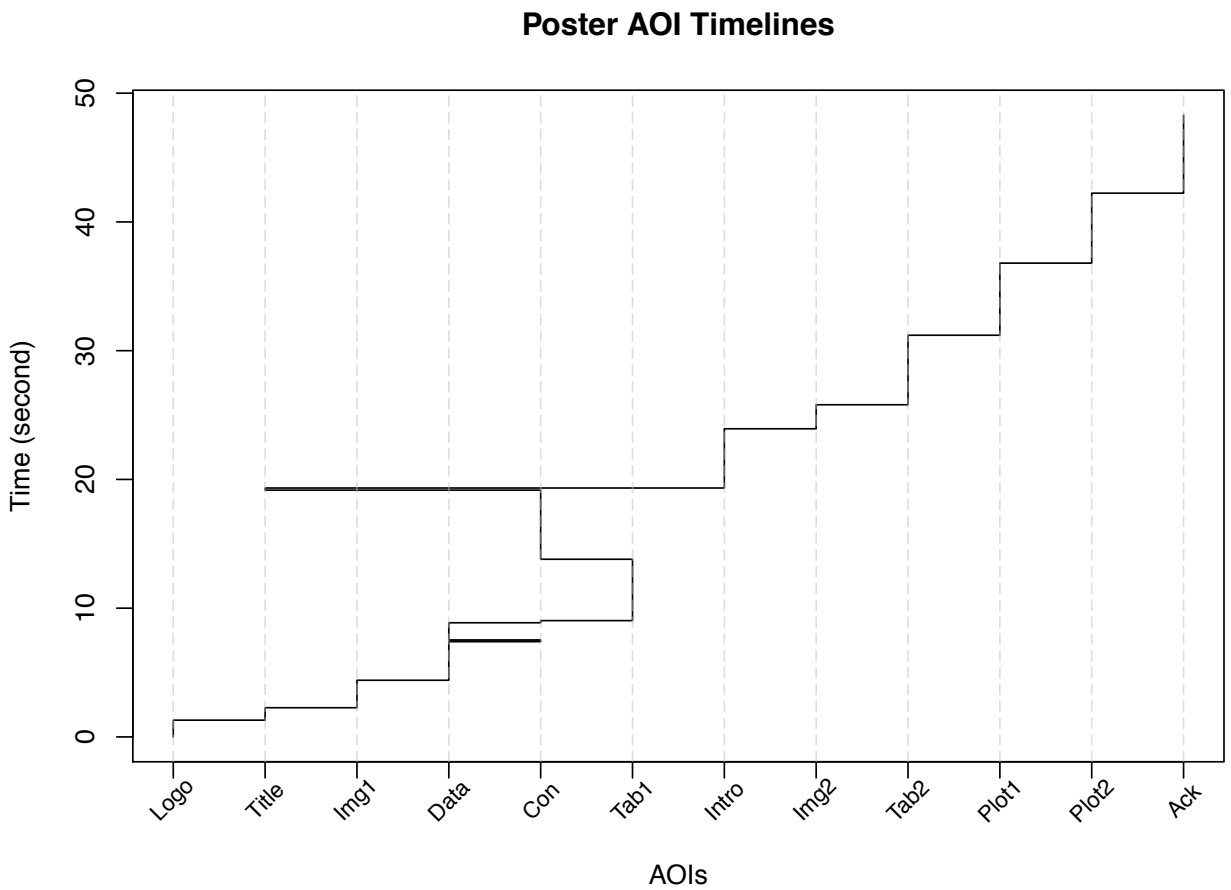
Scatterplot showing all extracted focus (gaze) points overlaid on poster

DrawEyeHeatmap



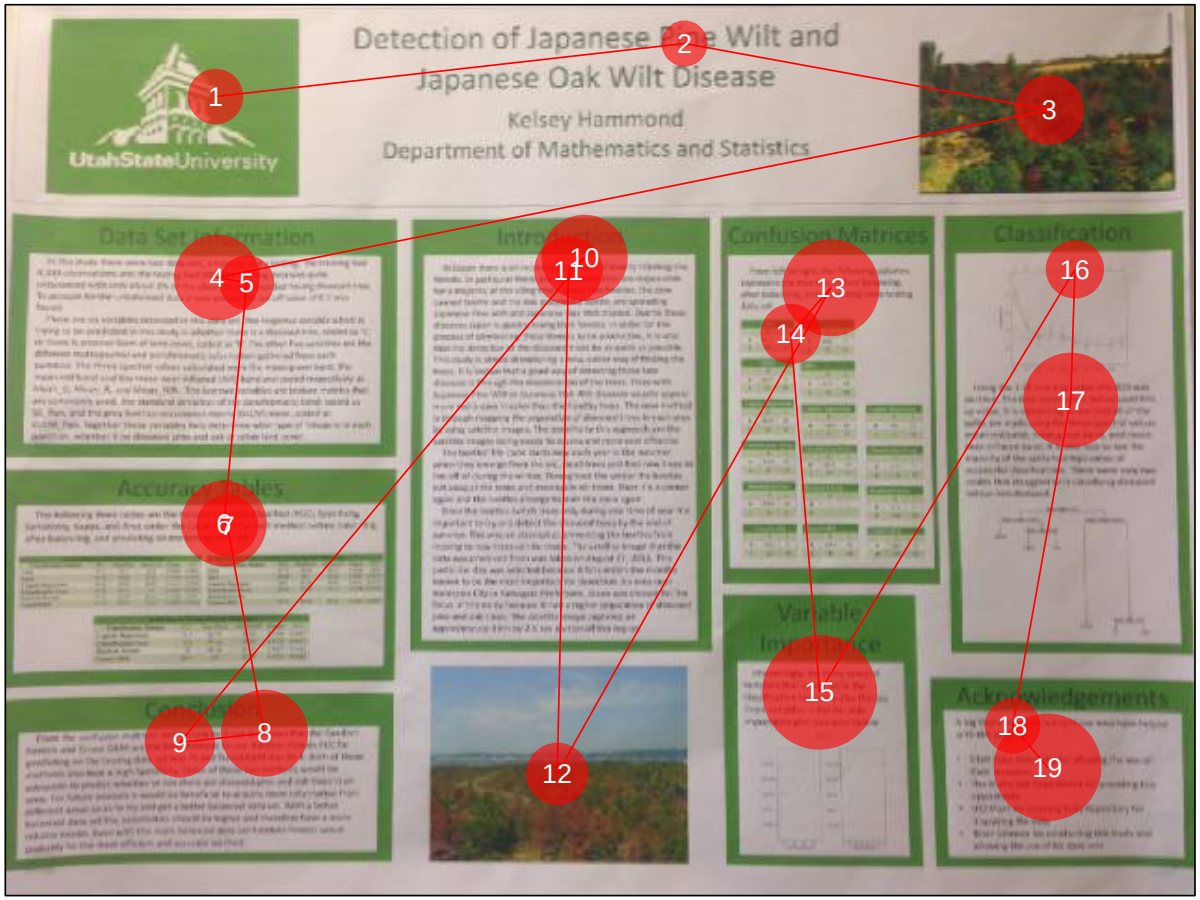
Heatmap, i.e., hot spots that attracted the participant's attention, overlaid on poster

DrawEyeAOITimelines



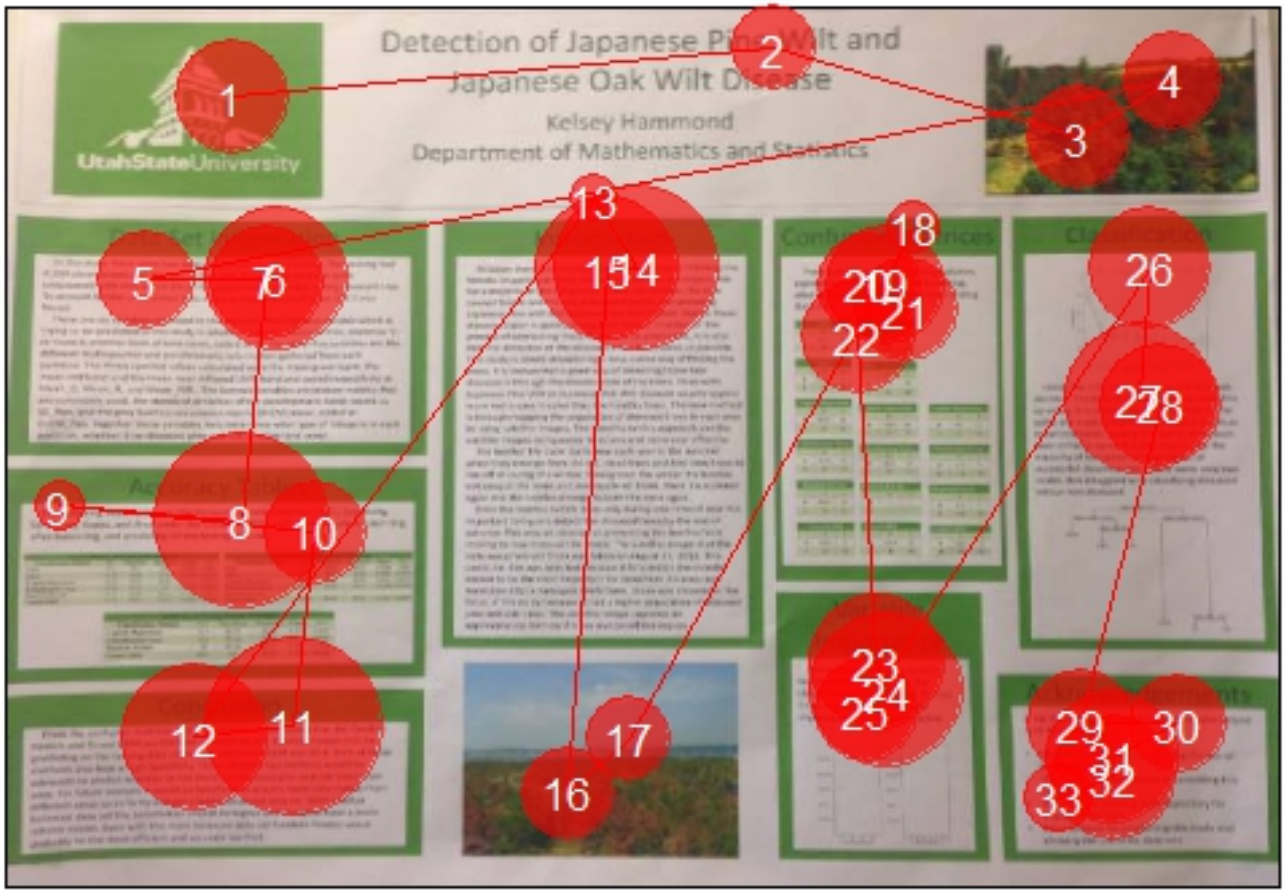
Temporal sequence of changes in viewing the 12 AOIs

DrawEyeScanpathMap (1)



Viewing sequence of the participant's 19 fixations

DrawEyeScanpathMap (2)



Viewing sequence of the participant's 33 fixations

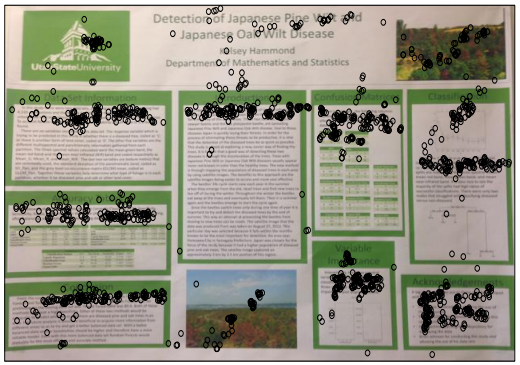
Background on Linked Microposter Plots

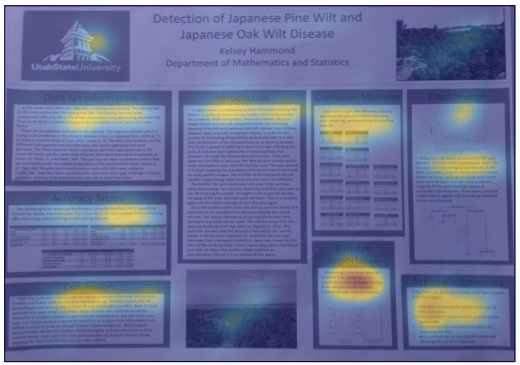
- Inspired by Linked Micromap Plots (Carr and Pierson 1996)
- Uses color to link maps (here: AOIs), identifiers, and statistical displays
- Allows to display several statistical variables to be shown simultaneously (and not just one as in traditional eye tracking visualizations)
- Examples of displays are dot plots (with and without confidence intervals), boxplots, and more
- Use of sorting capabilities to focus on most interesting spatial areas (here: AOIs)

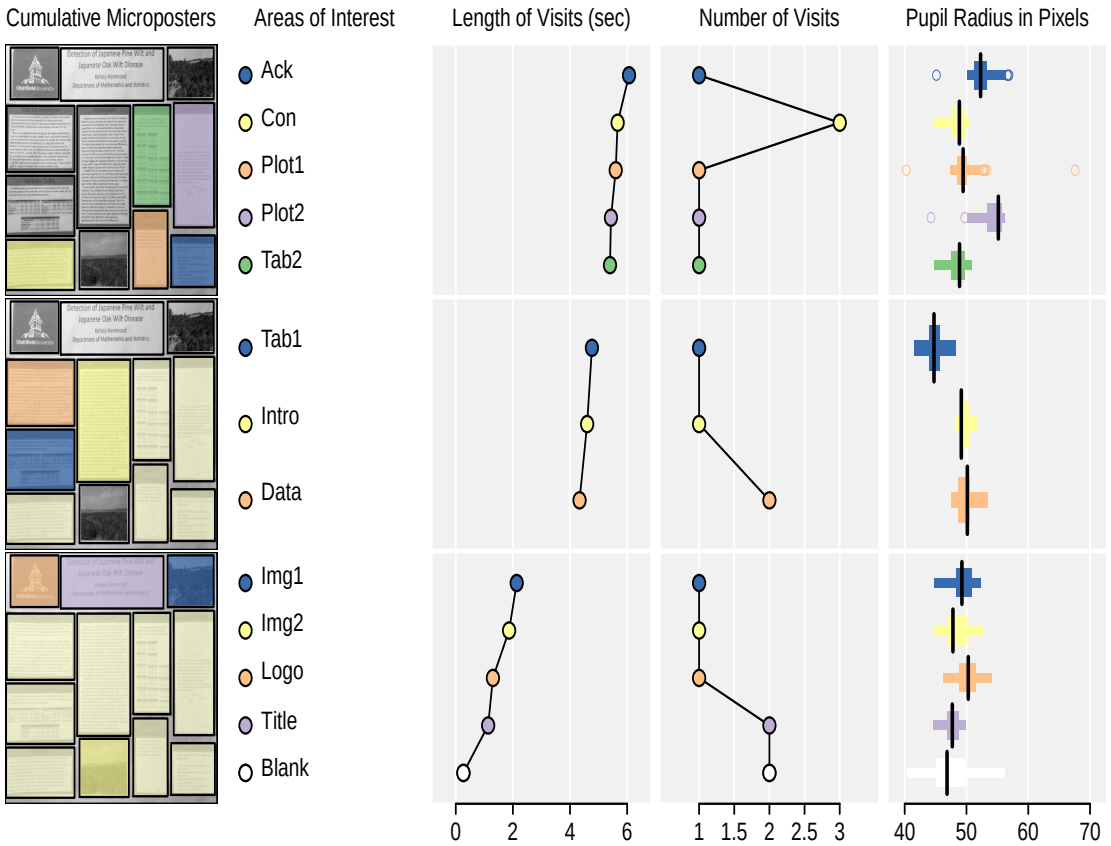
Linked Microposter Plots Variants

- Linked Microposter Plots (via *DrawEyeLMPlot*)
- Linked Timeline Microposter Plots (via *DrawEyeLTMPlot*)
- Linked Scanpath Microposter Plots (via *DrawEyeLSMPlot*)

Linked Microposter Plots (1)

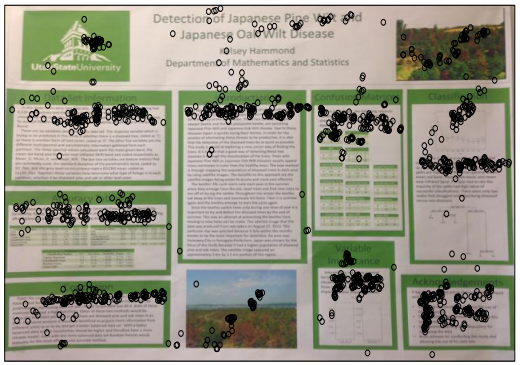


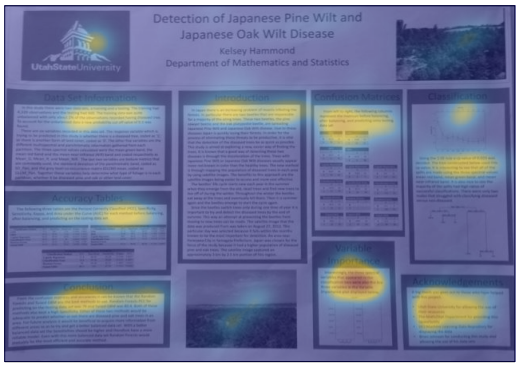


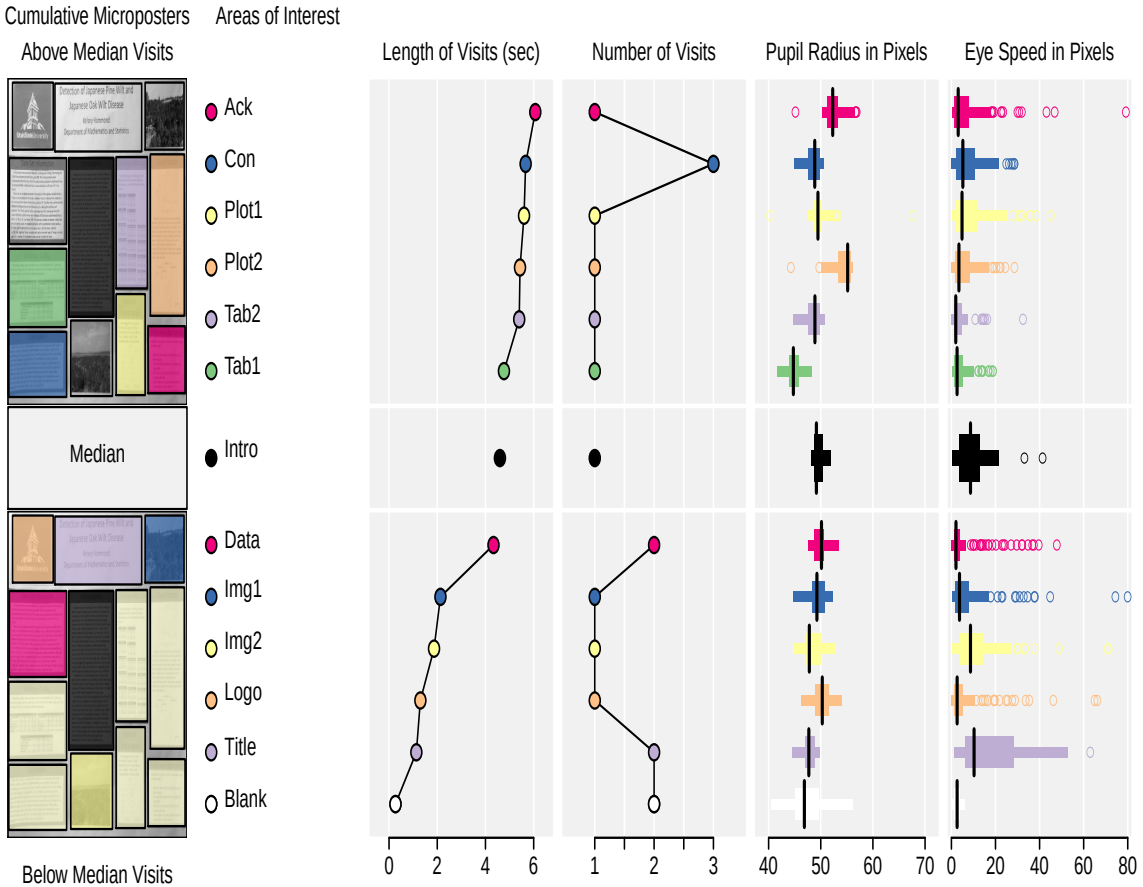


Linked microposter plots sorted by length of visits

Linked Microposter Plots (2)

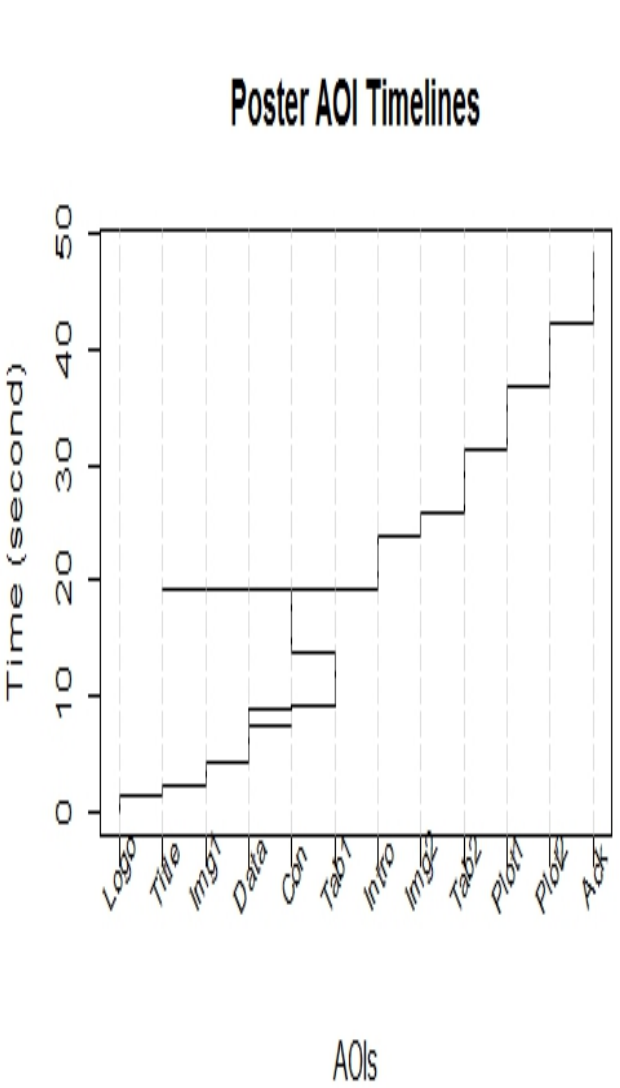


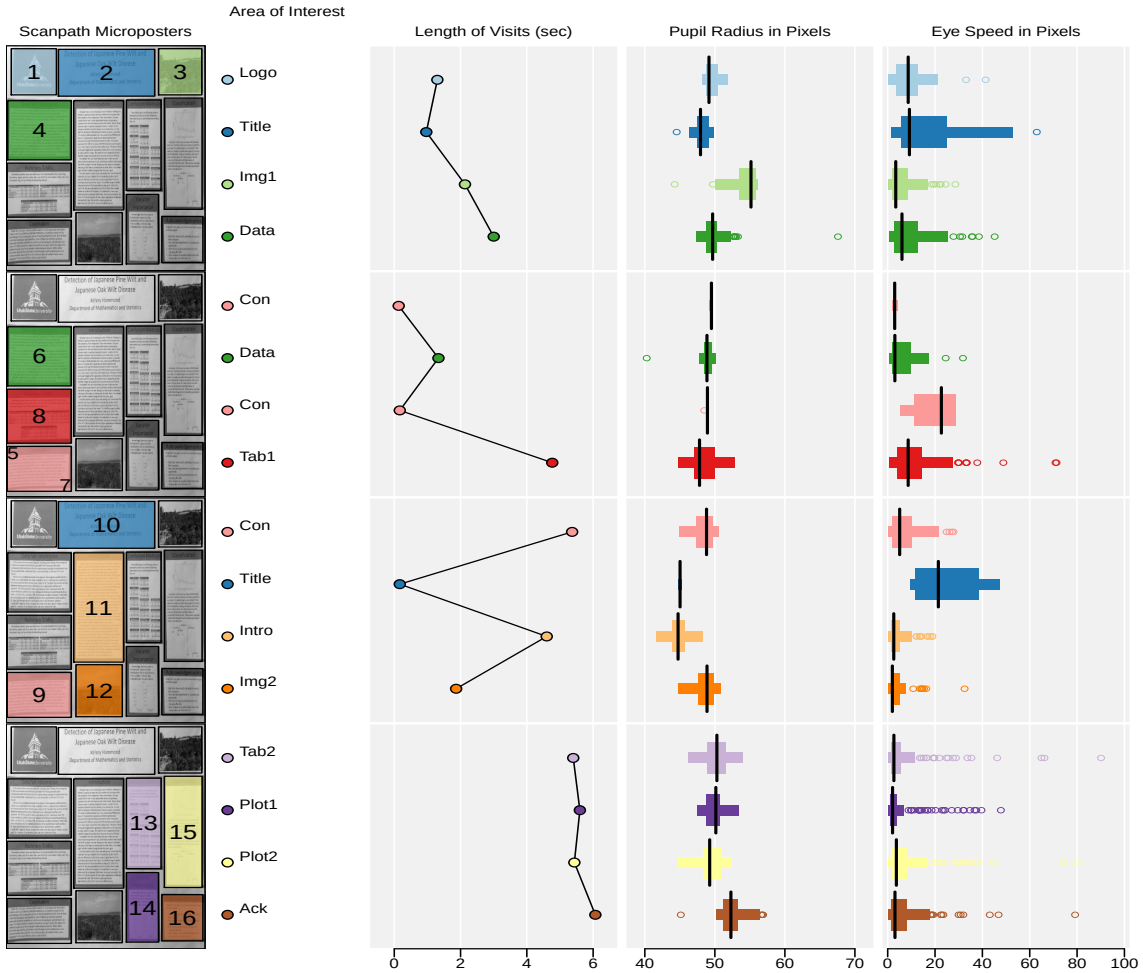




Linked microposter plots
with different layout and addtional statistical variable

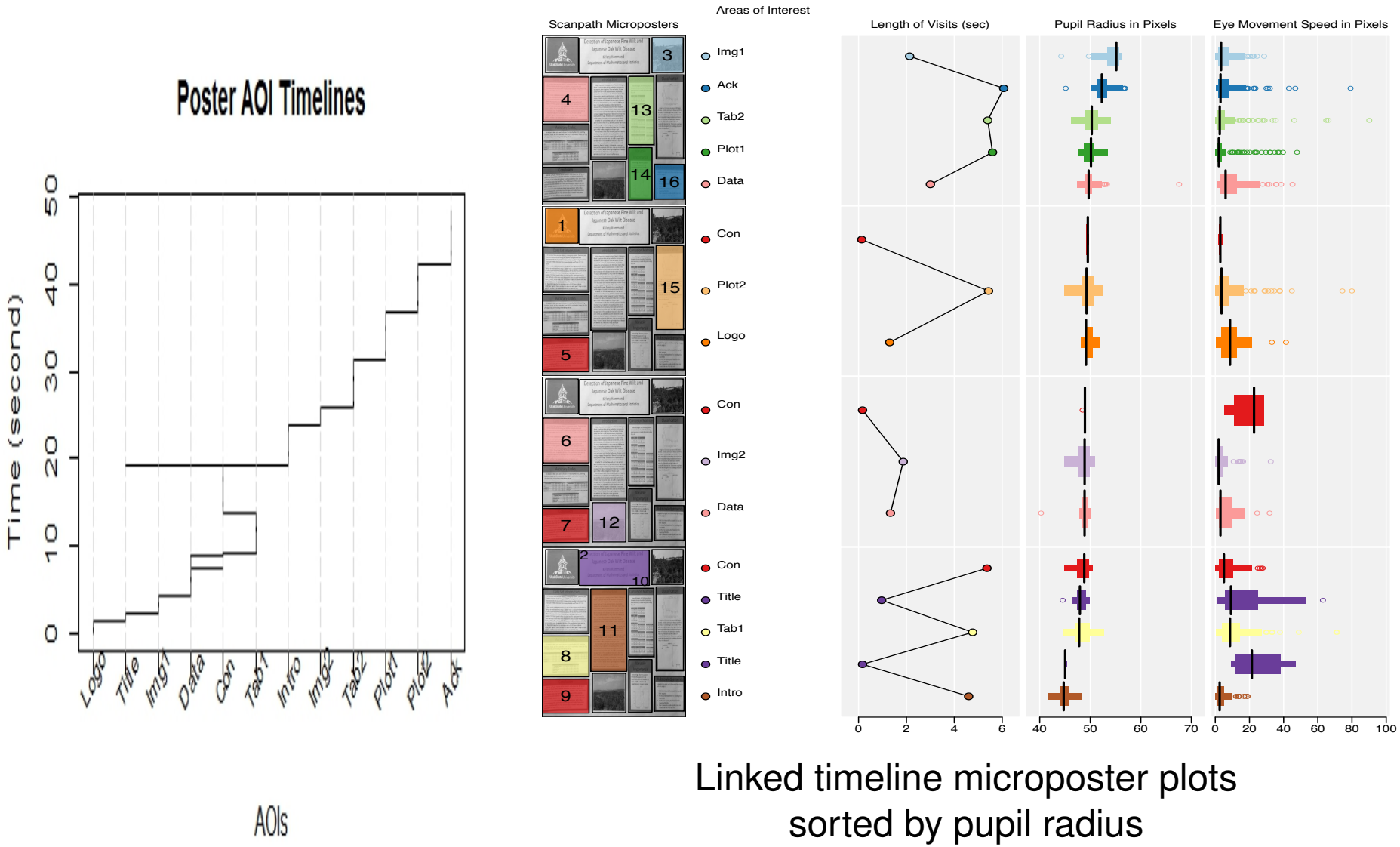
Linked Timeline Microposter Plots (1)





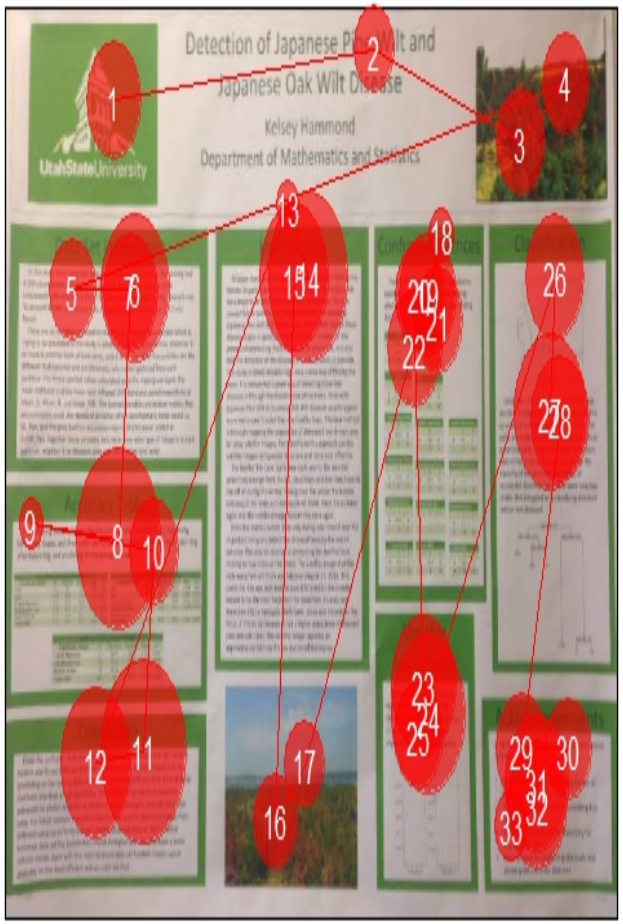
Linked timeline microposter plots sorted by viewing sequence

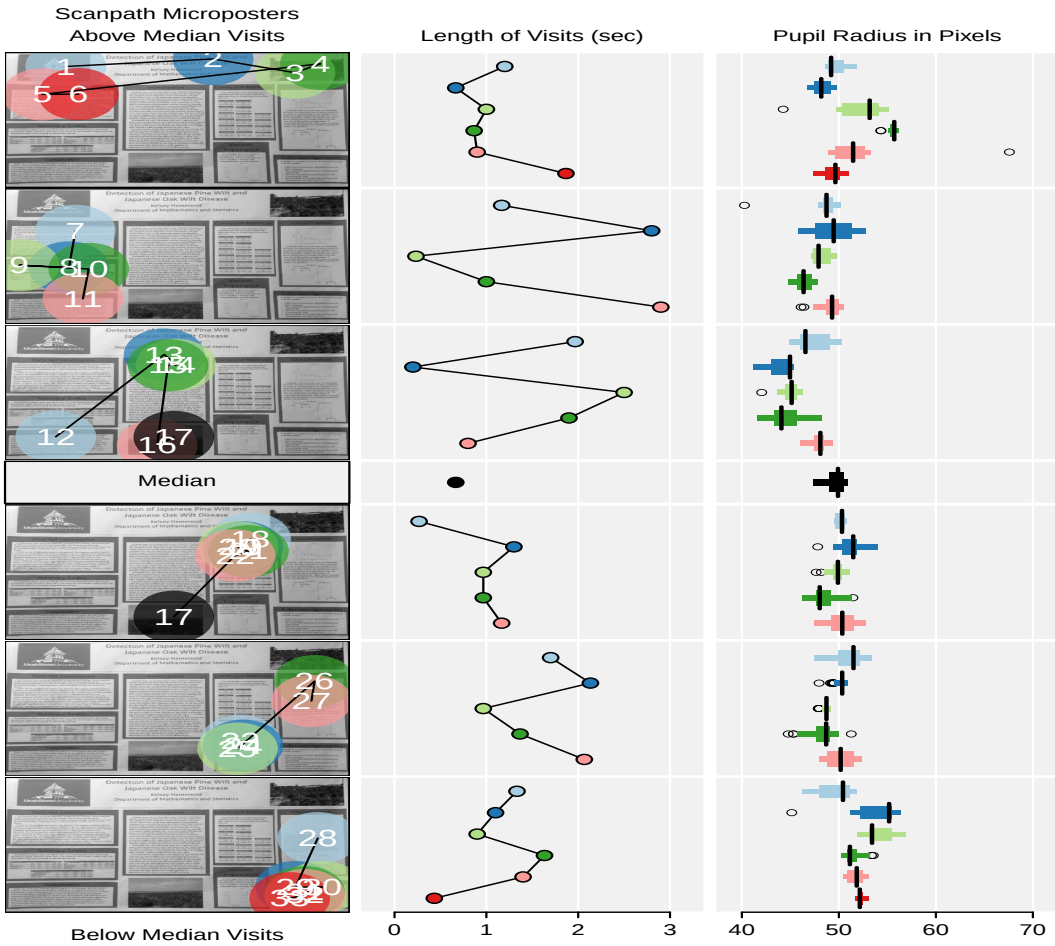
Linked Timeline Microposter Plots (2)



Linked timeline microposter plots sorted by pupil radius

Linked Scanpath Microposter Plots





Linked scanpath microposter plots sorted by sequence of 33 fixations

Conclusions and Outlook

- Linked microposter plots family allows for advanced visualization of eye tracking data
- **EyeTrackR** R package provides functionality for common (basic) and advanced eye tracking visualization via linked microposter plots
- In addition to scientific posters, future applications could be web pages, PowerPoint presentations, photos, etc.
- Data could be displayed simultaneously for multiple participants or groups of participants

- Full text of conference proceedings article available at `https://doi.org/10.1007/978-3-031-60114-9_6`

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- **Questions ?!? —**
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