Eye-Tracking in Practice: An Application to Human Postures

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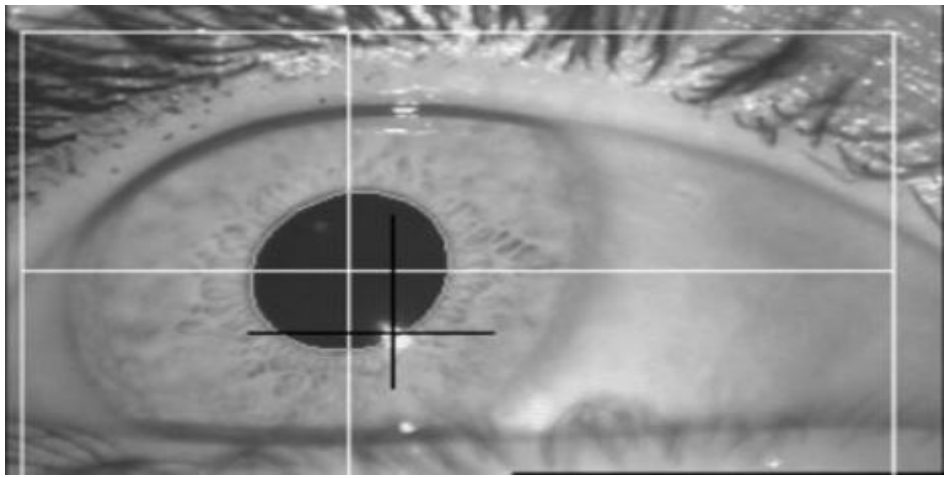
Outline

Development

- Eye trackers first built in the late 1800s.
- Eye tracking techniques developed rapidly during the past century.
- Video-based pupil and corneal reflection tracking method are the dominating eye tracking method since early 1990s.



The identified pupil (white cross-hair) and corneal reflection (black cross-hair). (Previously published in Holmqvist et al. 2011).

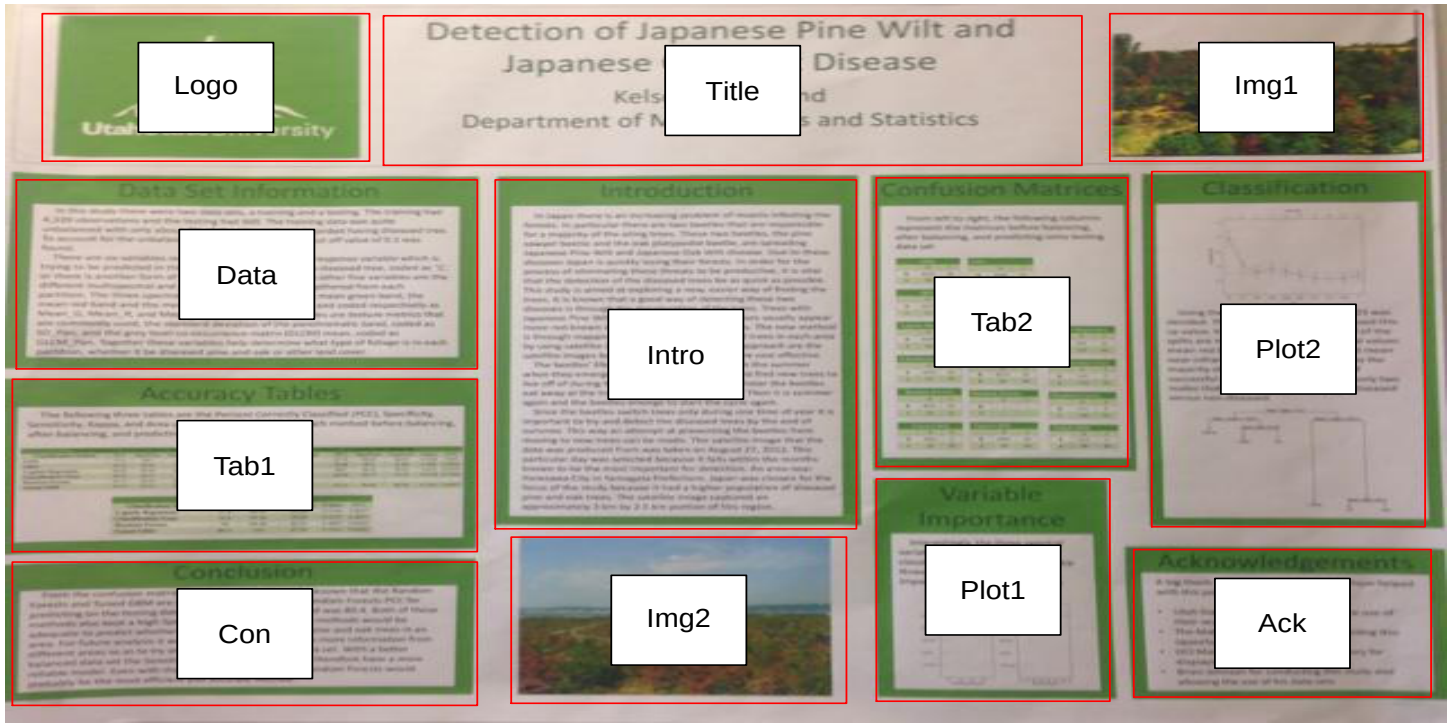
Applications

- **Education:** Solving problems, classroom presentations, reading, and looking at graphics.
- **Usability Research:** Reading behaviors online, searching, scanning online information, and web page design.
- **Sports:** Studying basic technical mistakes in hand-eye coordination and how to optimize performance in soccer, table tennis, shooting, hockey, and baseball.
- **Psychology:** Understanding how people gather information visually and how information is processed, e.g., research in autism.
- **Marketing:** Understanding of consumers' willingness to purchase goods or services.

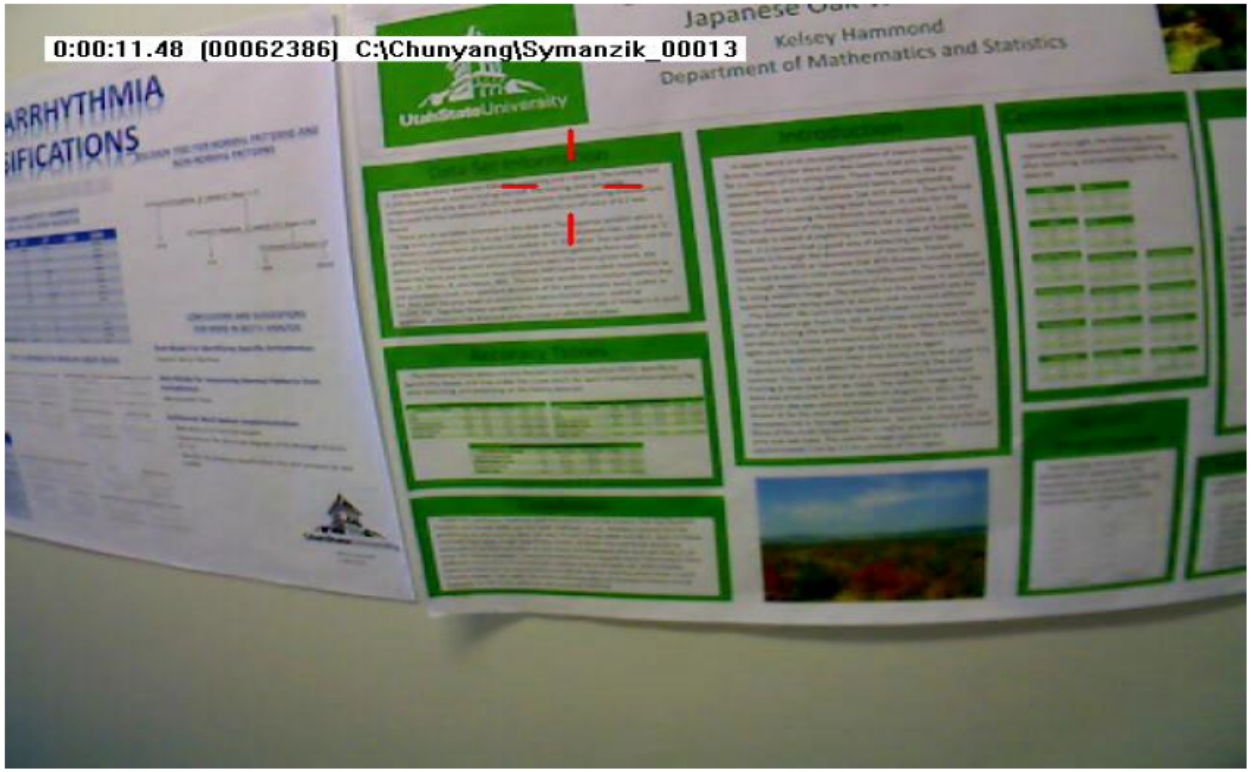
Mobile Eye Tracker

Recording Scene

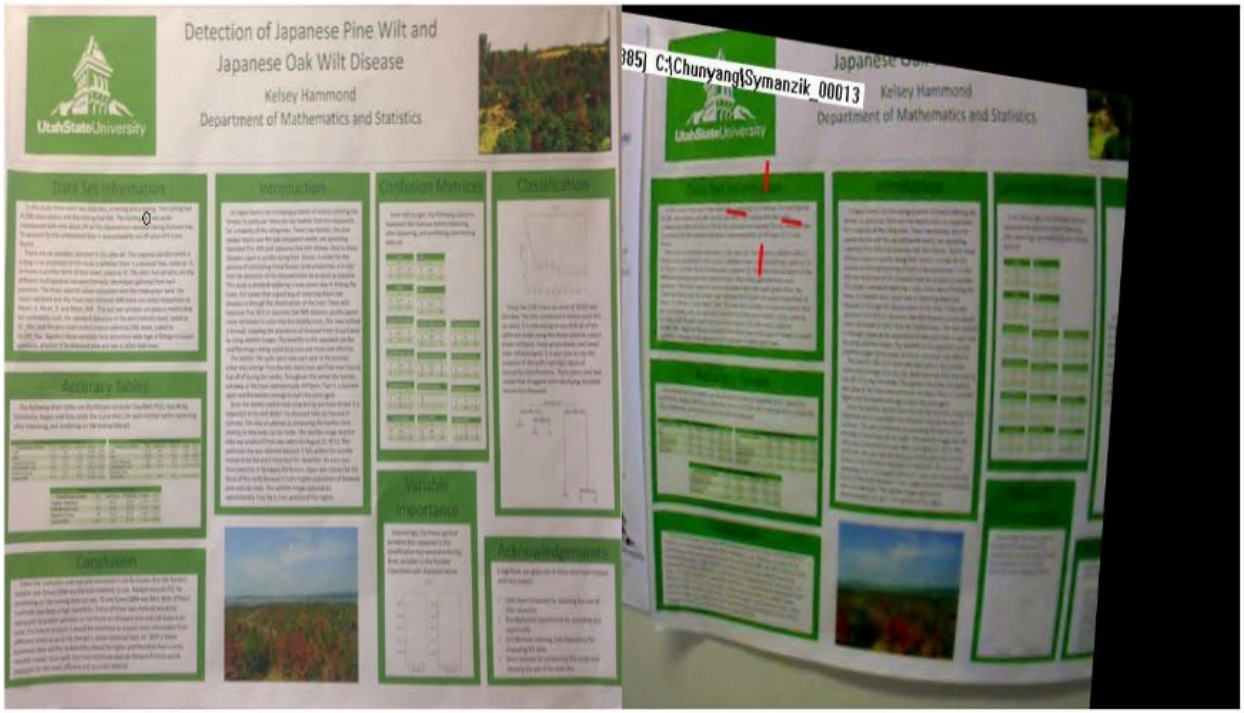
Areas of Interest (AOI)



Data Recording: Single Frame



Crosshair Matching: Single Frame



The Posture Study: Primary Research Questions

- Does judging the action capabilities of another person depend on one's own experiences?
- Background: Action anticipation must be present when interacting with others (e.g., to avoid collisions, pass something on to someone, etc.).
- Motivated by research in the Kinesiology and Health Science Department at Utah State University (USU).

Participants

- Group 1 (Control Group): 20 students with minimal experience with actions that require stability (e.g., yoga, gymnastics, . . .) from the undergraduate psychology student pool at USU.
- Group 2 (Treatment Group): 20 students with extensive yoga experience from advanced yoga classes at USU.
- Analysis still ongoing. Preliminary results presented here.
- See Symanzik et al. (2017 & 2018), for further details on this study.

Anticipated Outcomes

- Those with extensive yoga experience will judge an actor to be more stable than those without stability-specific experience.
- **The visual information (i.e., viewing patterns) used to judge stability will differ between different groups of individuals with unique action experiences.**

Apparatus and Tasks

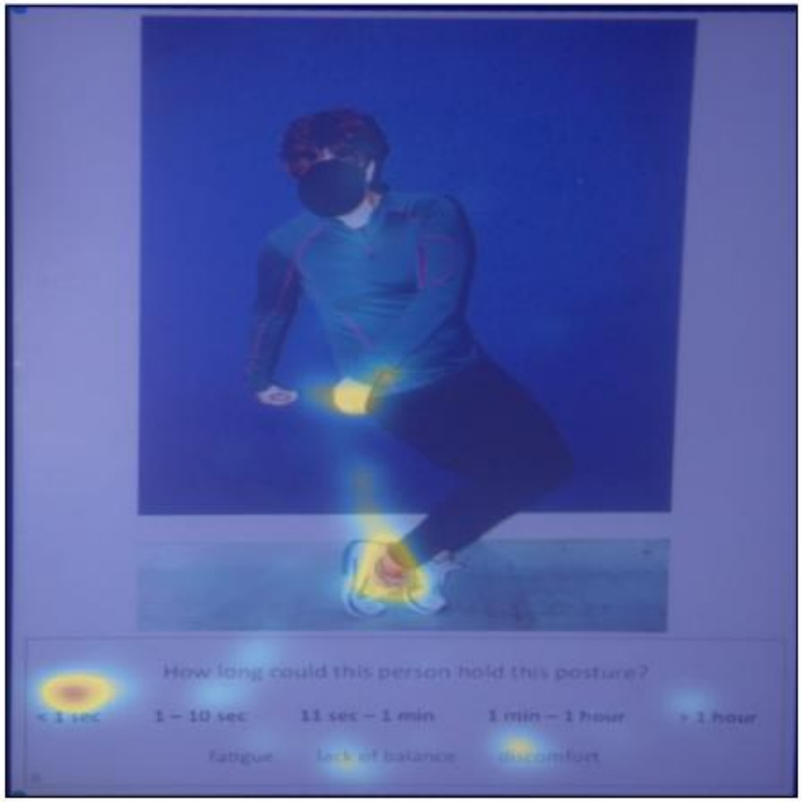
- 22 pictures of a single actor holding a posture.
- All postures shown to each participant in random order.
- Participants have to judge the stability of each posture, i.e., how long the person could hold the posture.
- Participants wear an ASL portable eye-tracking device that records the viewing patterns.
- Extract information from the eye-tracking videos via the *EyeTrackR* R package (Li, 2017; Li & Symanzik, 2016, 2017).

Postures 1 to 6 (out of 22)

Statistical Analysis

- What are **within groups** similarities /differences (if any) of the viewing patterns for each posture / for all postures?
- What are **between groups** similarities / differences (if any) of the viewing patterns for each posture / for all postures?

Posture 8: Similar Viewing Patterns (2 Participants) [Heatmaps]



Posture 17: Different Viewing Patterns (2 Participants) [Heatmaps]

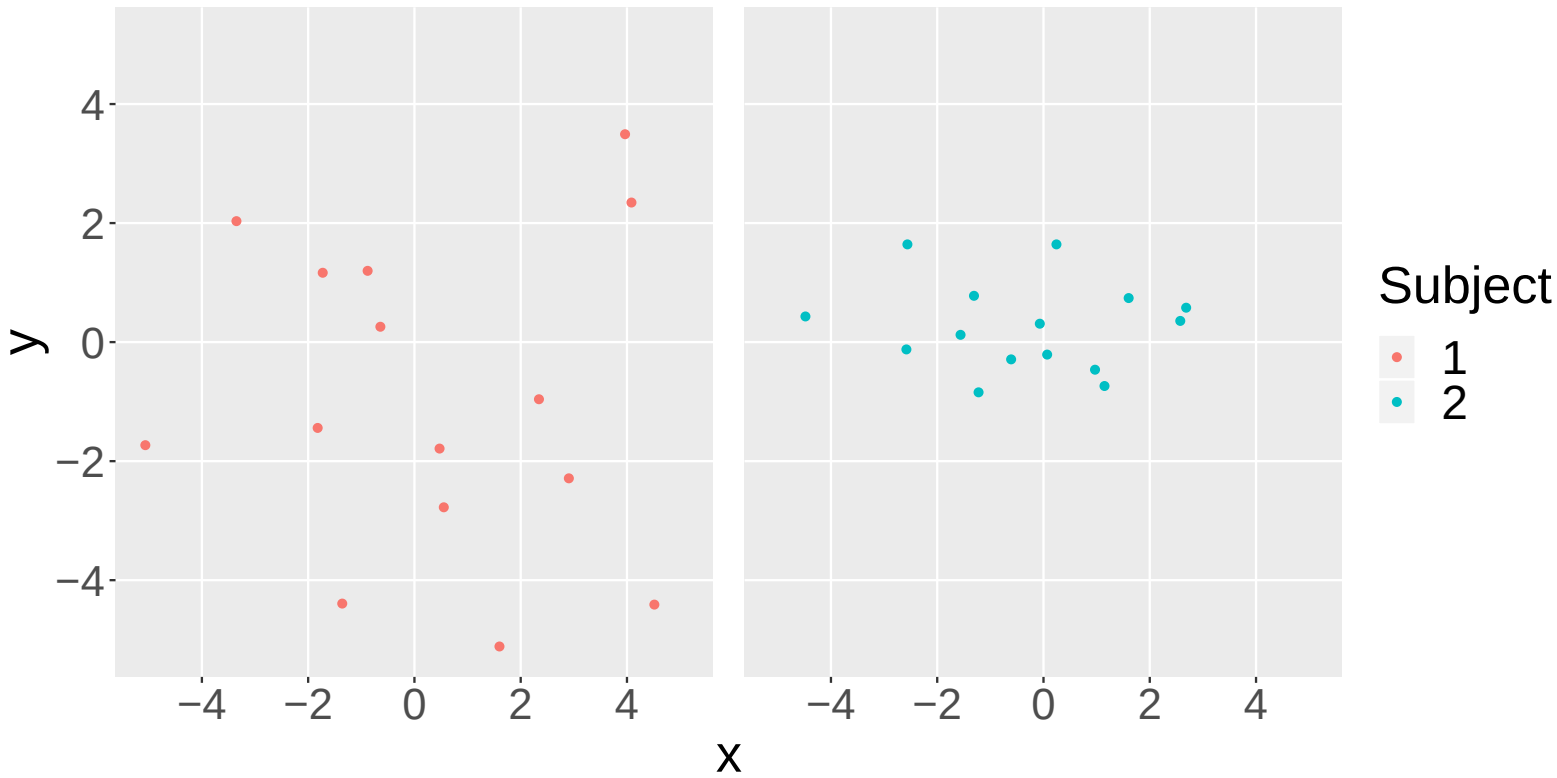
The Syrjala (1996) Test

- Tests for a difference between the spatial distributions of two populations.
- Sensitive to differences in the way the populations are distributed across the study area, but insensitive to differences in abundance between the two populations.
- Frequently used for wildlife sample surveys and epidemiology; rarely used for eye-tracking so far (e.g., Chetverikov et al., 2018).
- Here: Applied to the viewing patterns from pairs of participants using 5×5, 10×10, and 20×20 **grids** and 25, 100, and 400 **random point locations** obtained from a sequential spatial inhibition (SSI) process.
- Caveat: Results of Syrjala's test highly depend on type of data conversion (grid vs. random points) and number of grid cells or number of random cells, respectively (see McKinney and Symanzik, 2019).

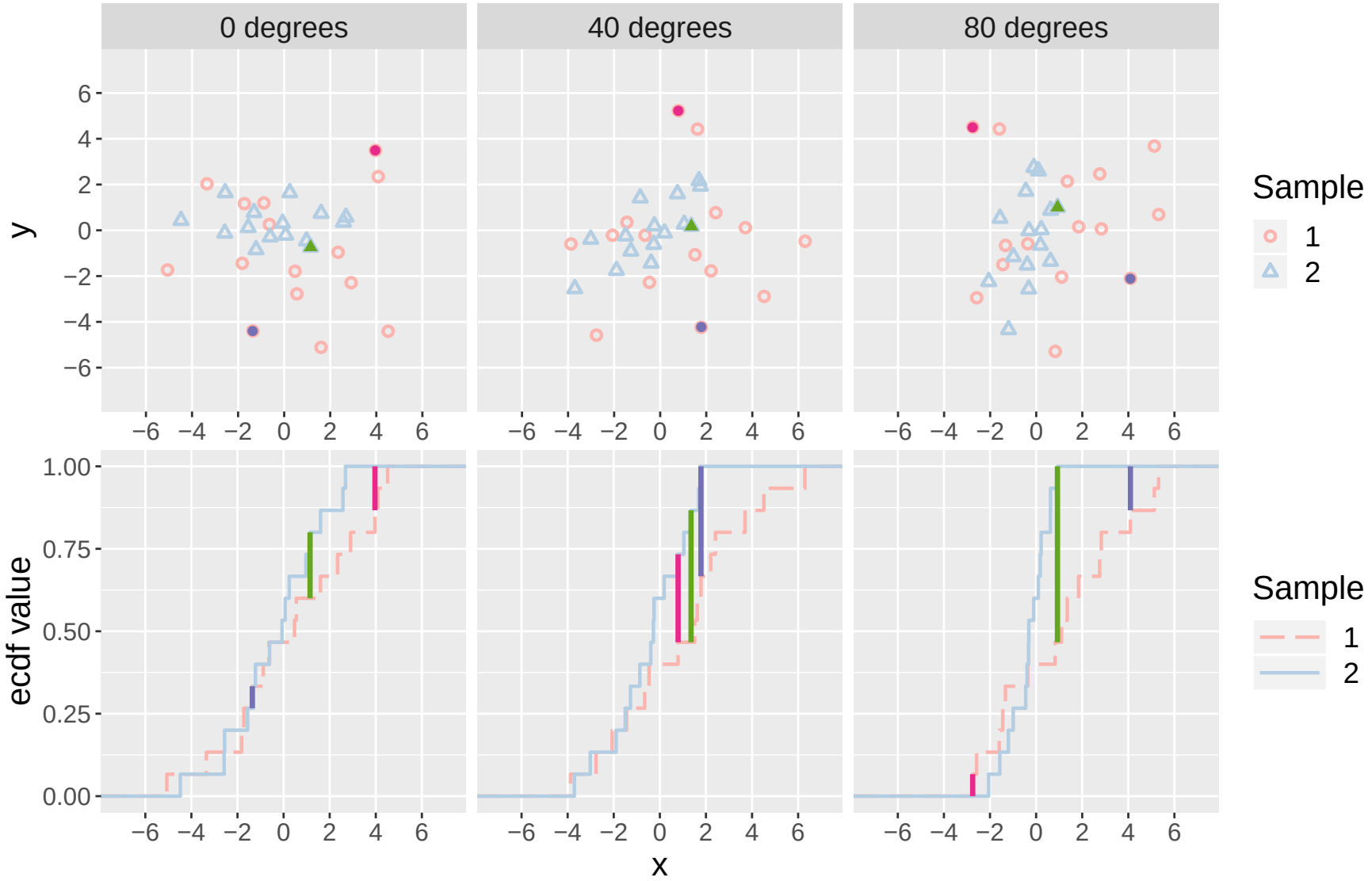
The Modified Syrjala Test (McKinney and Symanzik, 2019)

- Combine the labeled data.
- Center the data using a bivariate median.
- Calculate the weighted modified Syrjala statistic.
- Rotate the data about the bivariate median.
- Recalculate the weighted modified Syrjala statistic on the rotated data.
- Repeat through 360°.
- Permute the data and repeat calculations of the statistic across all of the rotated data.
- Compute the permutation test p-value.

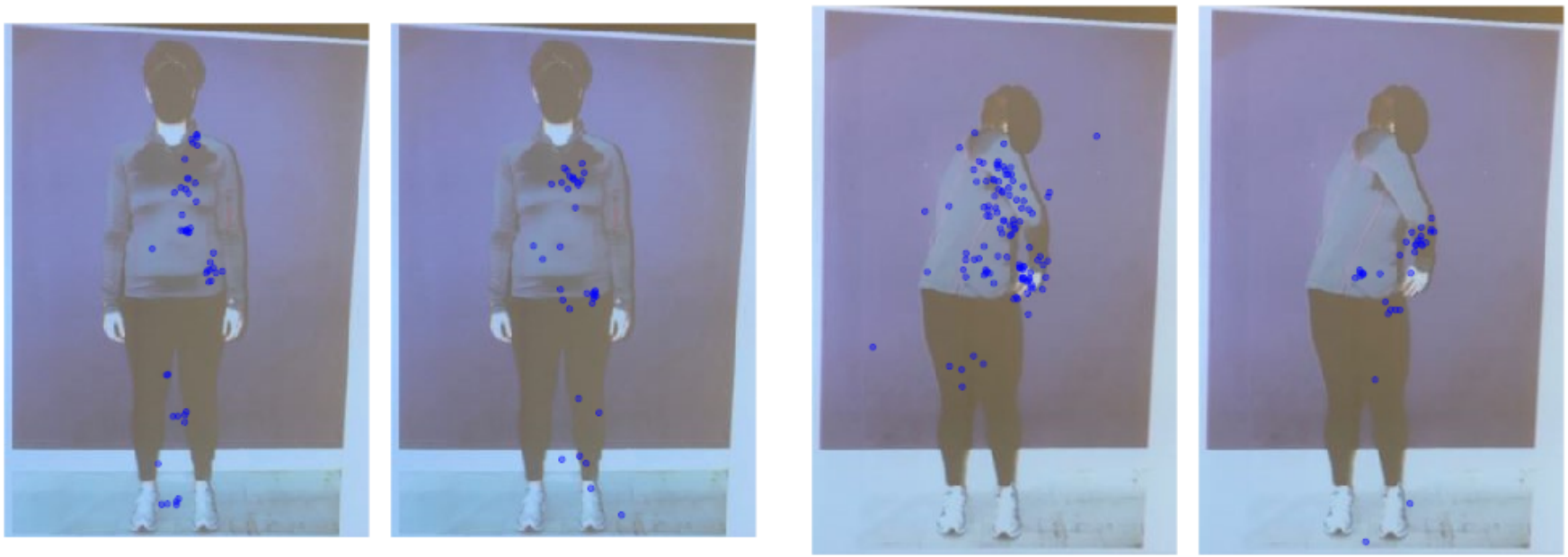
A Comparison of Two Bivariate Dot Plots



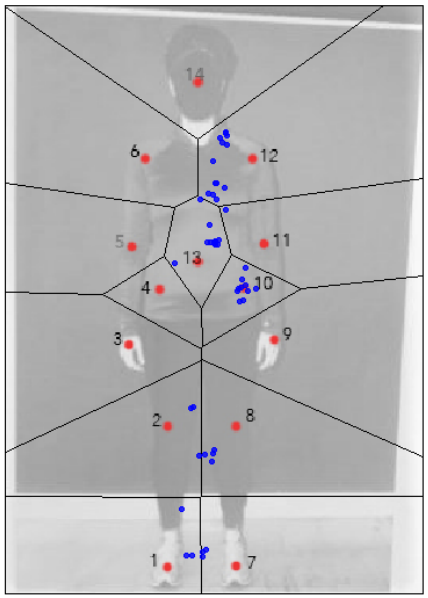
Visualization of Calculations within the Modified Syjrala Statistic

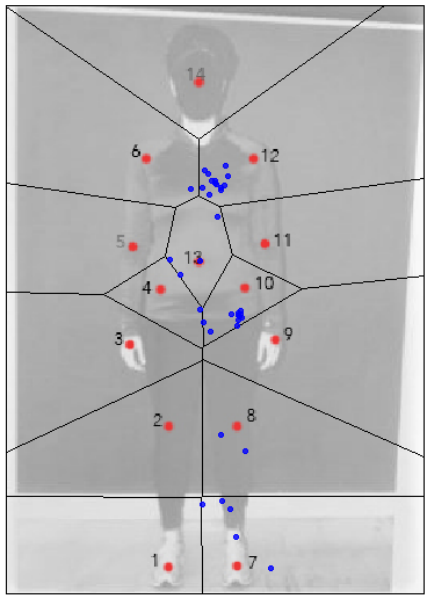


Postures 1 and 9: Scatterplots of Viewing Patterns (2 Participants)



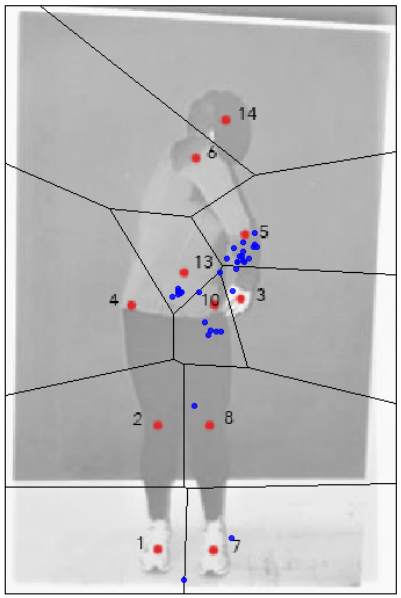
Posture 1: AOIs of Viewing Patterns (2 Participants)

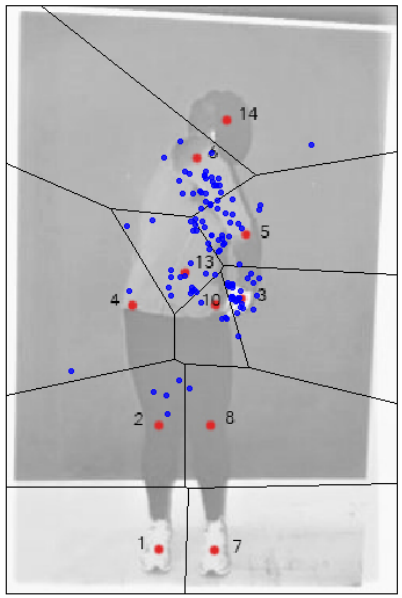




- Modified Syrjala-based p-value: 0.172 (based on 36 rotations and 999 permutations).
- AOI χ^2-based p-value: 0.3296.

Posture 9: AOIs of Viewing Patterns (2 Participants)





- Modified Syrjala-based p-value: 0.001 (based on 36 rotations and 999 permutations).
- AOI χ^2-based p-value: 0.2745.

Interpretation of Test Results

- Results of original Syrjala's test highly depend on type of data conversion (grid vs. random points) and number of grid cells or number of random cells, respectively.
- Our modified Syrjala test behaves more stable and provides similar results, even for different number of rotations.
- Occasional noticeable differences between modified Syrjala-based p-value and AOI χ^2-based p-value — needs further investigation.
- Extend quantitative analysis to entire groups, comparing treatment group with control group for each of the 22 postures. Consider different forms of weighting for different viewing lengths.

References

- Chetverikov, A., et al. (2018). Implicit Processing During Change Blindness Revealed with Mouse-contingent and Gaze-contingent Displays. *Attention, Perception, & Psychophysics*, 80(4):844–859.
- Holmqvist, et al. (2011). *Eye Tracking: A Comprehensive Guide to Methods and Measures*, Oxford, New York: Oxford University Press.
- Li, C. (2017). *Extracting and Visualizing Data from Mobile and Static Eye Trackers in R and Matlab*. PhD Thesis, Utah State University.
- Li, C. and Symanzik, J. (2016). The Linked Microposter Plot as a New Means for the Visualization of Eye Tracking Data. In 2016 JSM Proceedings, Alexandria, VA: American Statistical Association. (CD).
- Li, C. and Symanzik, J. (2017). EyeTrackR: An R Package for Extracting and Visualizing Data from Mobile and Static Eye Trackers. In 2018 JSM Proceedings, Alexandria, VA: American Statistical Association. (CD).
- McKinney, E. and Symanzik, J. (2019). Modifications of the Syrjala Test for Testing Spatial Distribution Differences Between Two Populations. In 2019 JSM Proceedings, Alexandria, VA: American Statistical Association. (CD).
- Symanzik, J., et al. (2017). Eye-tracking in Practice: A First Analysis of a Study on Human Postures. In 2017 JSM Proceedings, Alexandria, VA: American Statistical Association. (CD).
- Symanzik, J., et al. (2018). Eye-tracking in Practice: Results from a Study on Human Postures. In 2018 JSM Proceedings, Alexandria, VA: American Statistical Association. (CD).
- Syrjala, S. E. (1996). A Statistical Test for a Difference Between the Spatial Distributions of Two Populations. *Ecology*, 77(1):75–80.

- **Questions ?!? —**

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