Working memory in action: directional differences in transsaccadic working memory?

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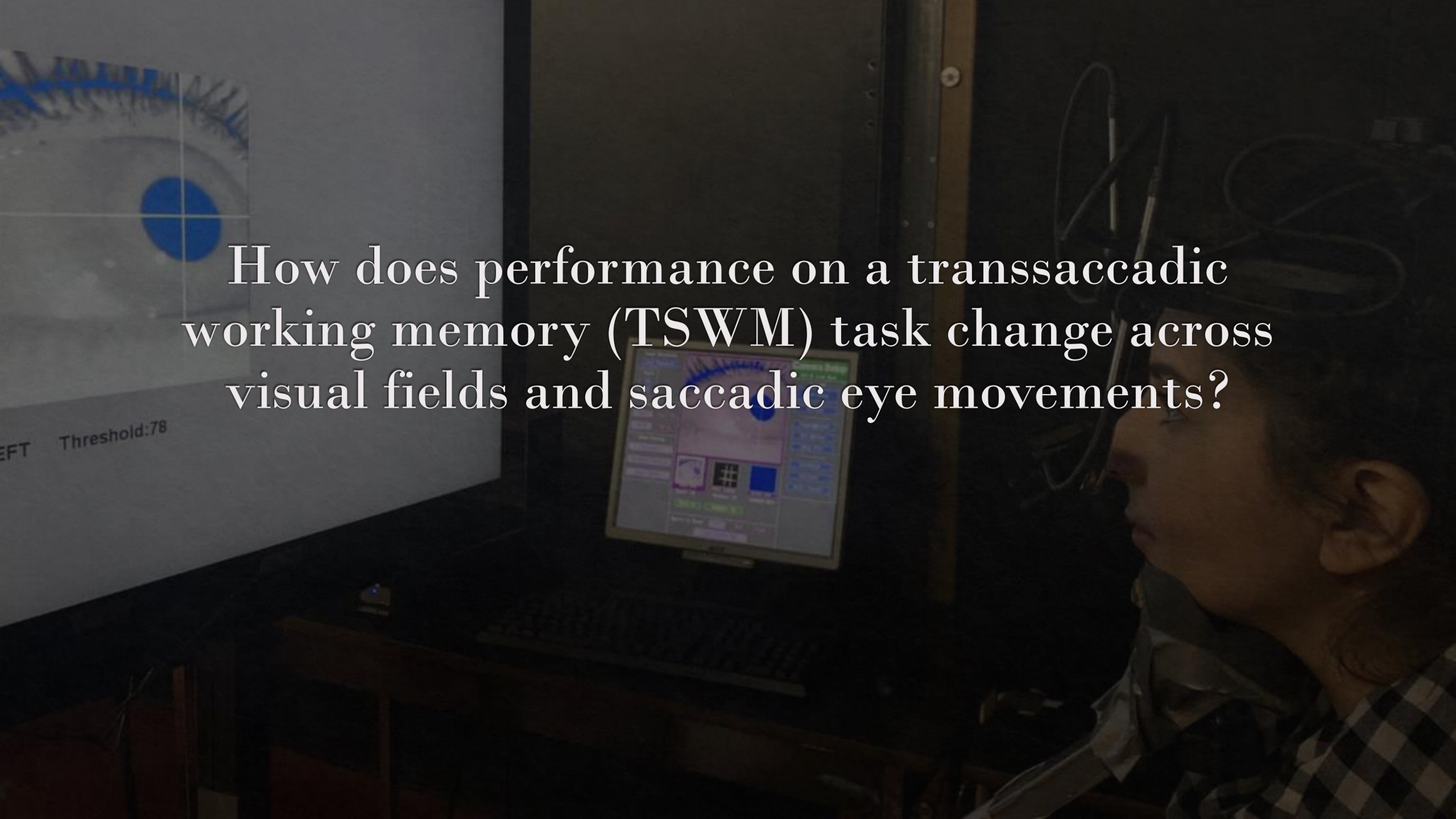
Background information

- Individuals make saccades to fully perceive and scan their surroundings.
- This results in a buildup of images in their percept which then is unified by **transsaccadic integration**.
- The integration of information into a unified percept results in **transsaccadic perception.**

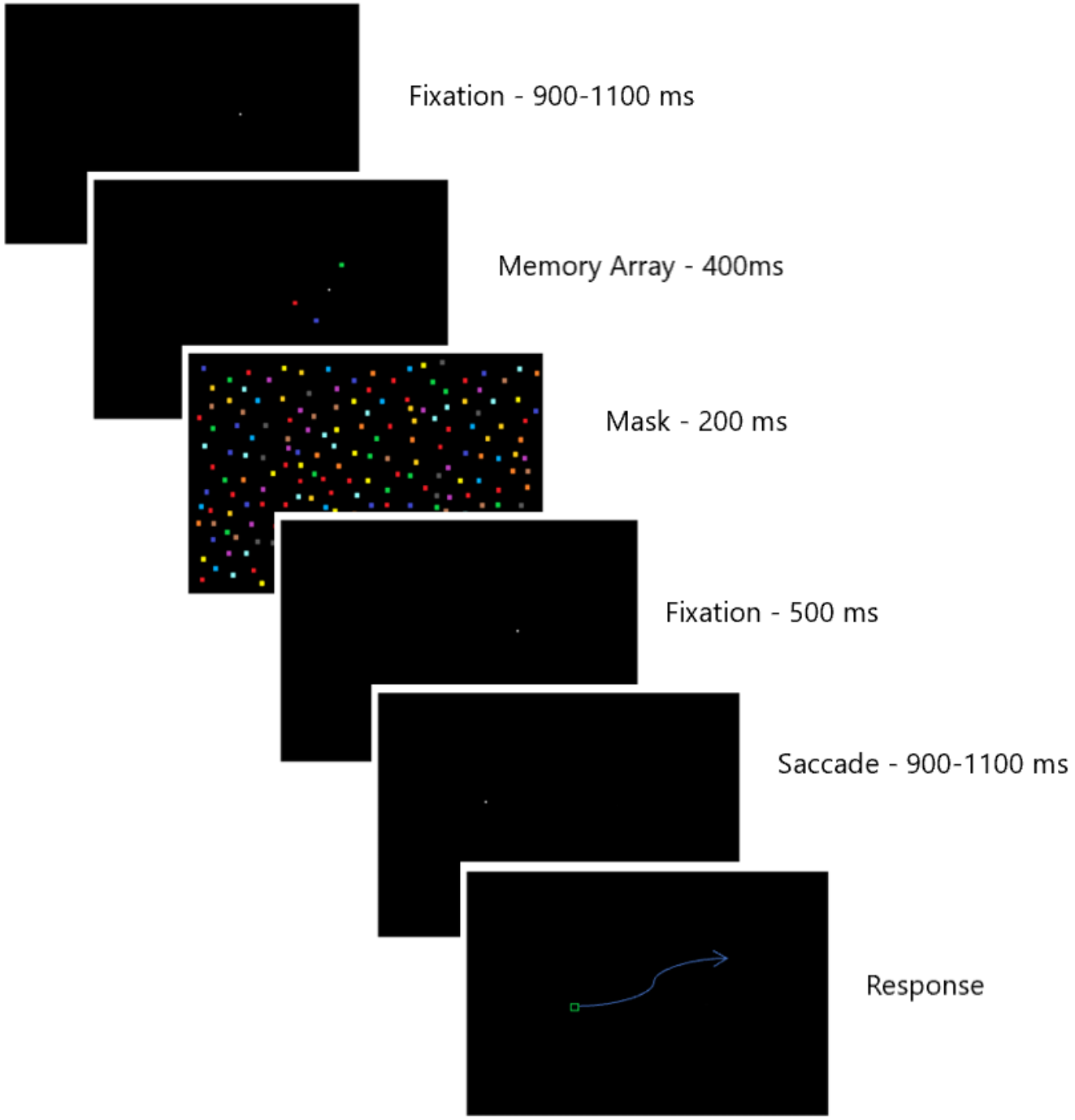
Possible limitations in TSWM?

- Perception of a displaced target is **distorted** and **suppressed** during a saccadic eye movement
  - change blindness or suppression of displacement
- …visual representations have still been shown to be **preserved** across saccades
- It is the attentional shift that allows for the encoding of information near the saccade time and location

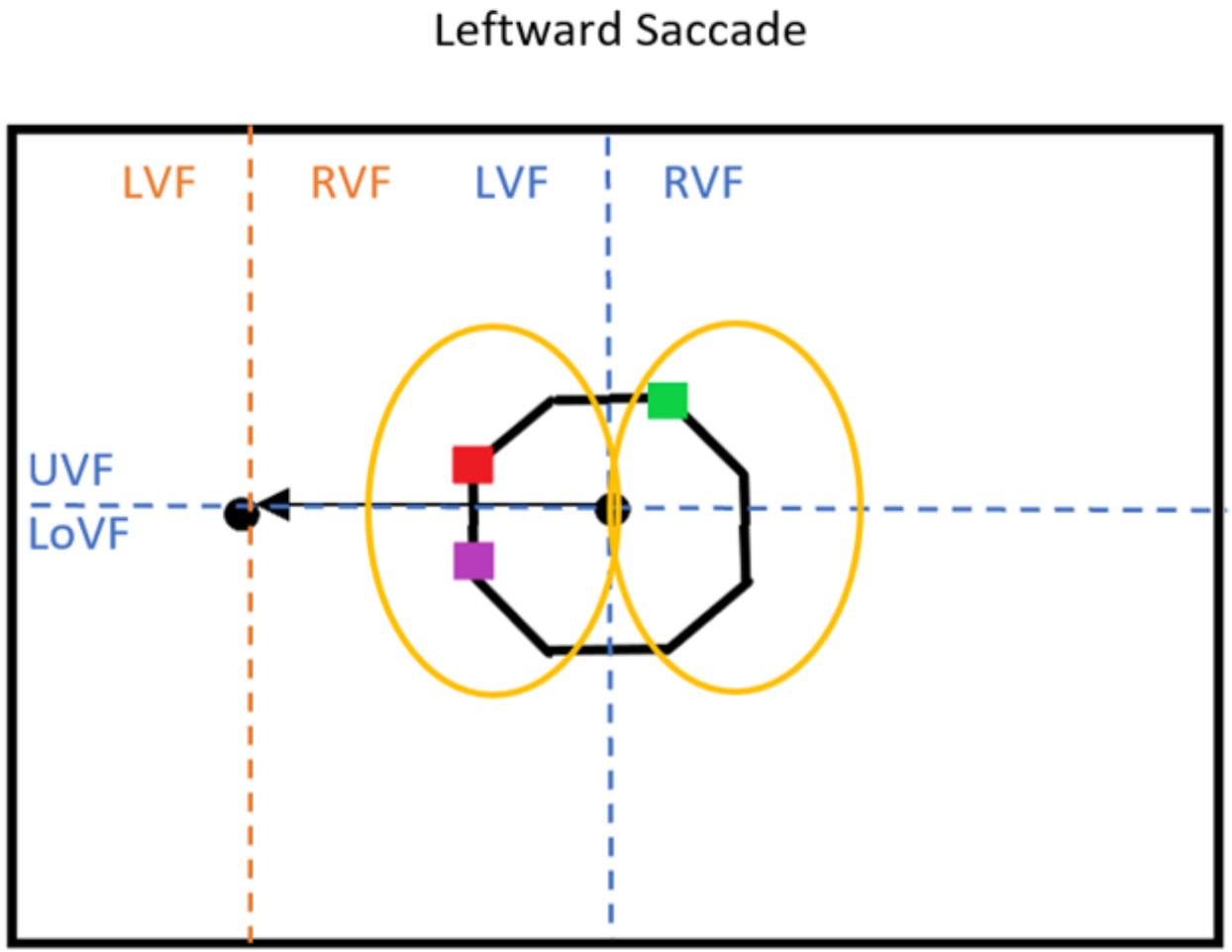


How does performance on a transsaccadic working memory (TSWM) task change across visual fields and saccadic eye movements?

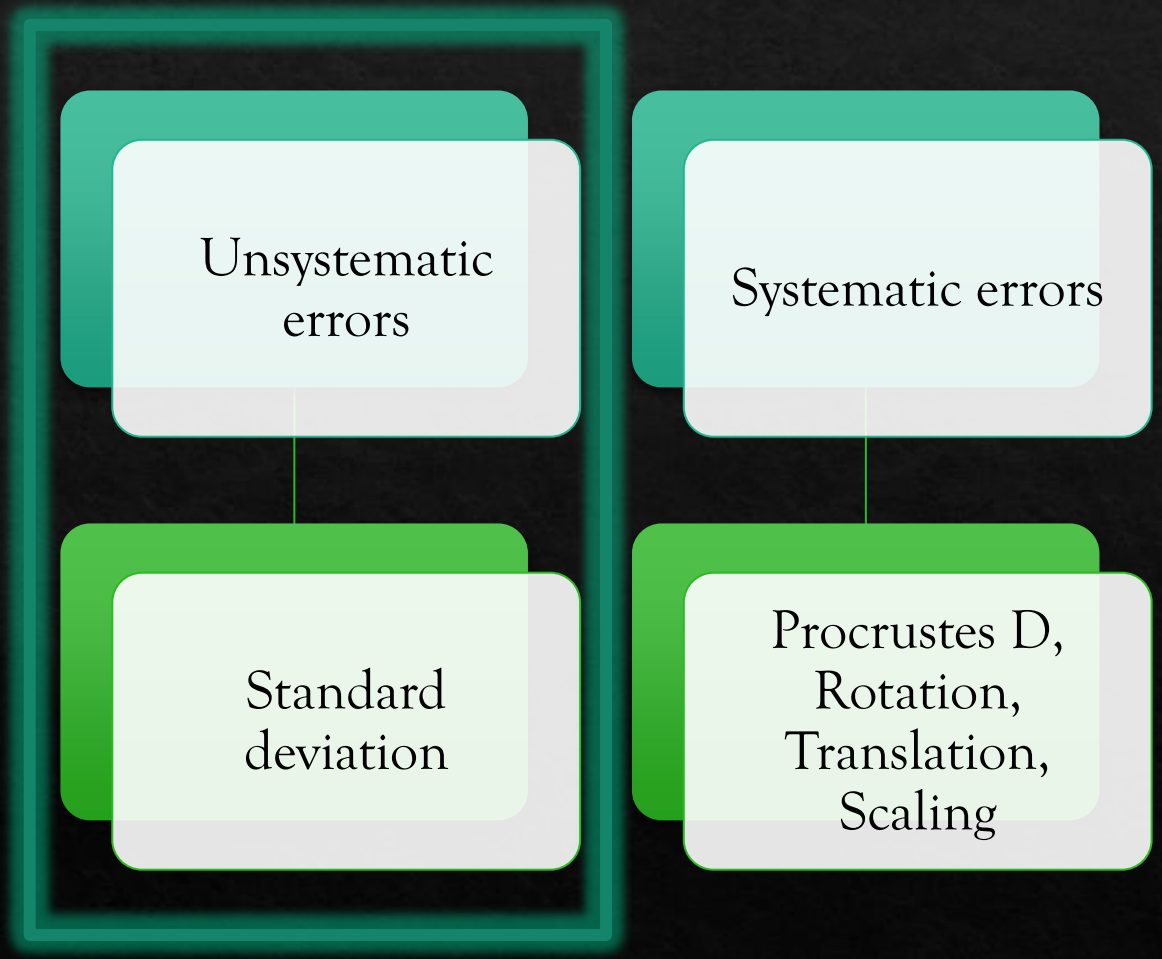
Experimental Design

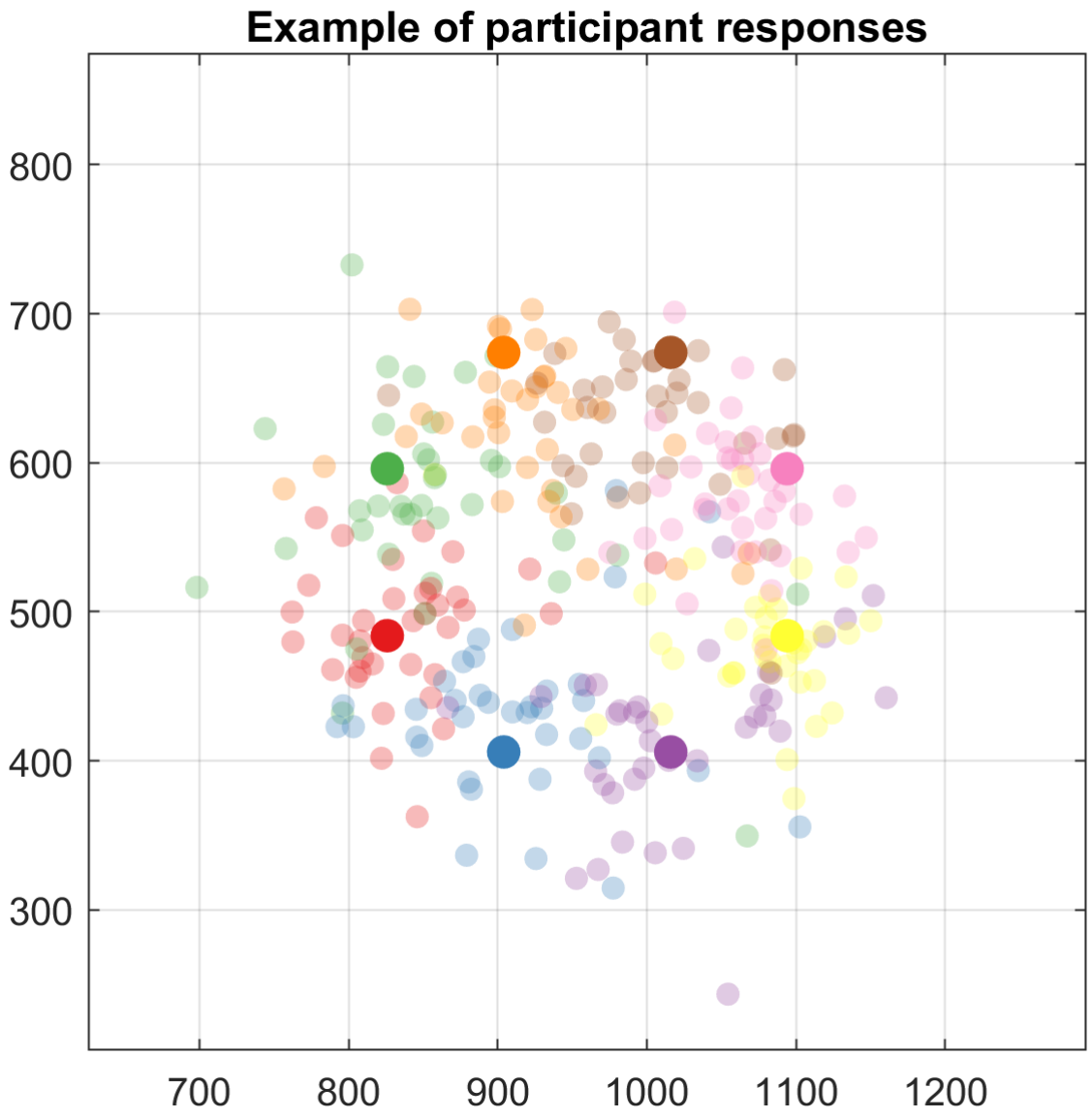


- Left saccade and Left Visual Field
  - Crosses LVF → RVF
- Left saccade and Right Visual Field
  - Stays in RVF
- Right saccade and Left Visual Field
  - Stays in LVF
- Right saccade and Right Visual Field
  - Crosses RVF → LVF
- Up saccade and Left Visual Field
  - Stays in LVF
- Up saccade and Right Visual Field
  - Stays in RVF
- Down saccade and Left Visual Field
  - Stays in LVF
- Down saccade and Right Visual Field
  - Stays in RVF

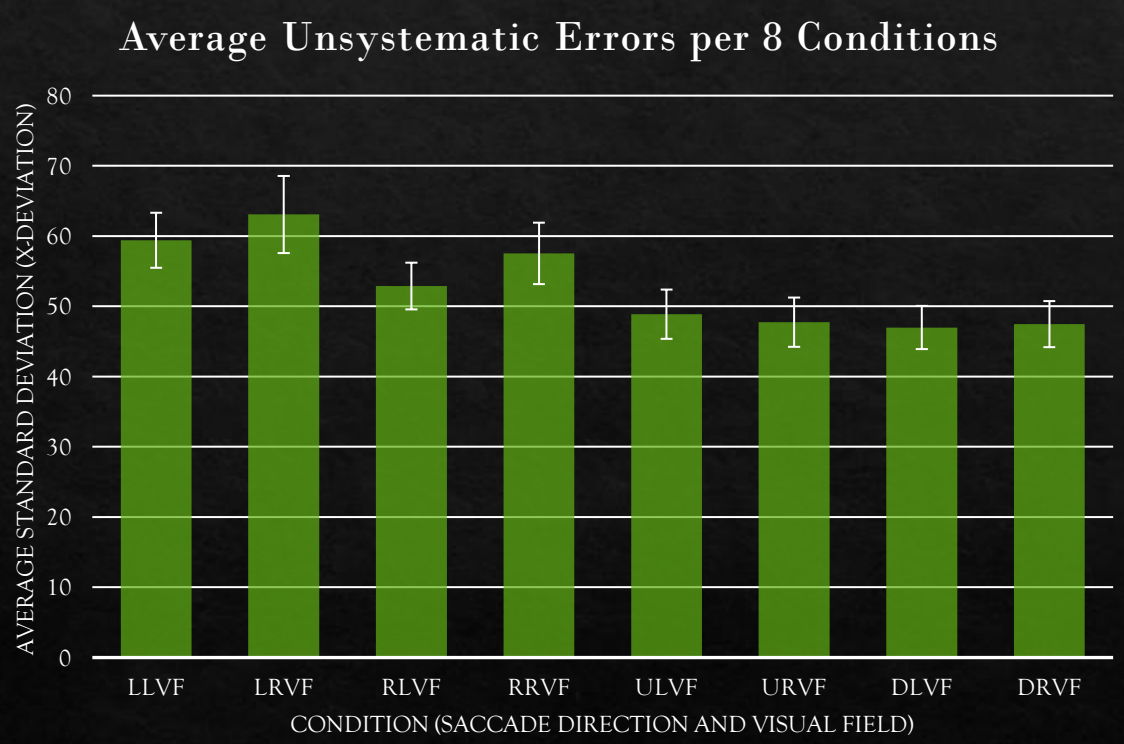


Measures of TSWM




Example of participant responses
800
700
600
500
400
300
700
800
900
1000
1100
1200

Unsystematic Errors – Standard Deviation



3-way Repeated Measures ANOVA

- **Level 1: Visual Field (LVF or RVF)**
- **Level 2: Saccade Plane (Horizontal or Vertical)**
- **Level 3: Saccade Direction (Left/Up or Right/Down)**
- Saccade Plane Significant
- Saccade Direction Significant

2-way Repeated Measures ANOVA Horizontal saccades

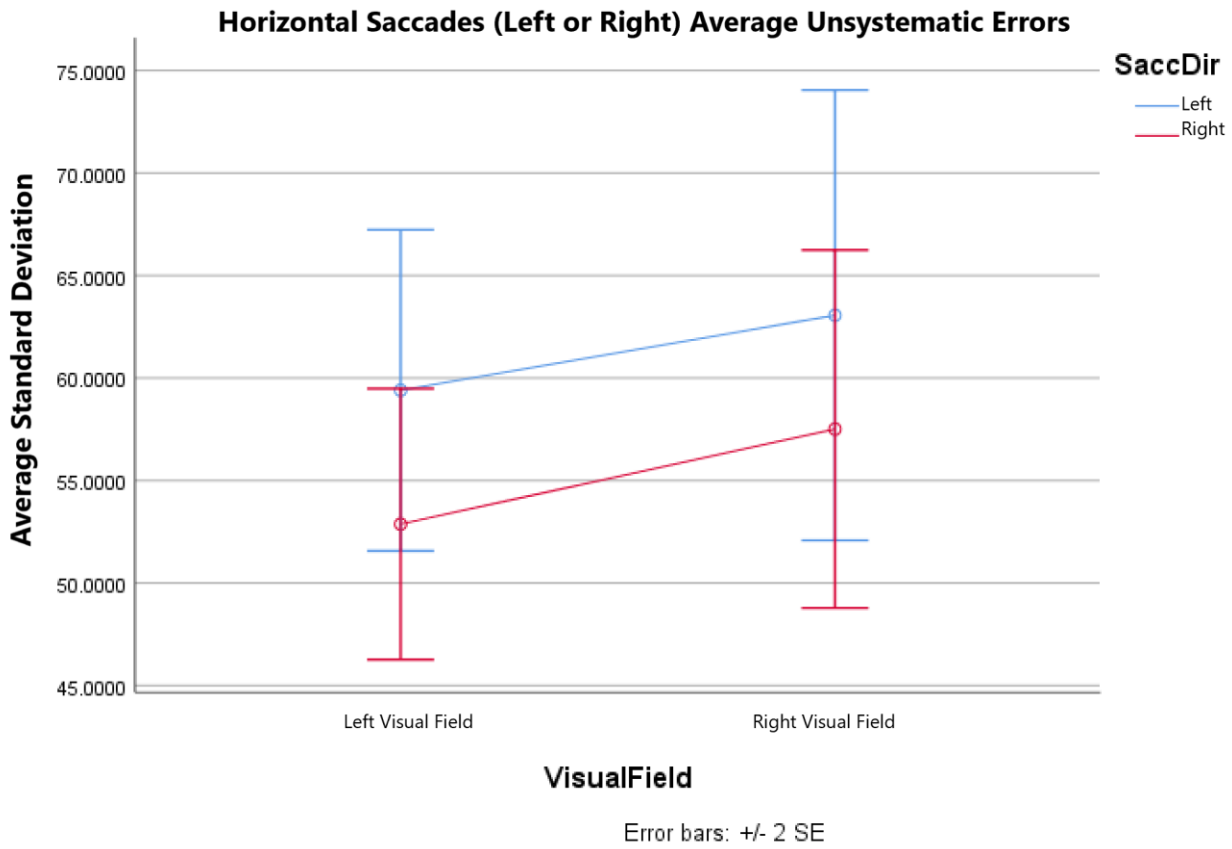
- Saccade Direction was significantly different
- Trend for difference across VF

2-way Repeated Measures ANOVA Vertical saccades

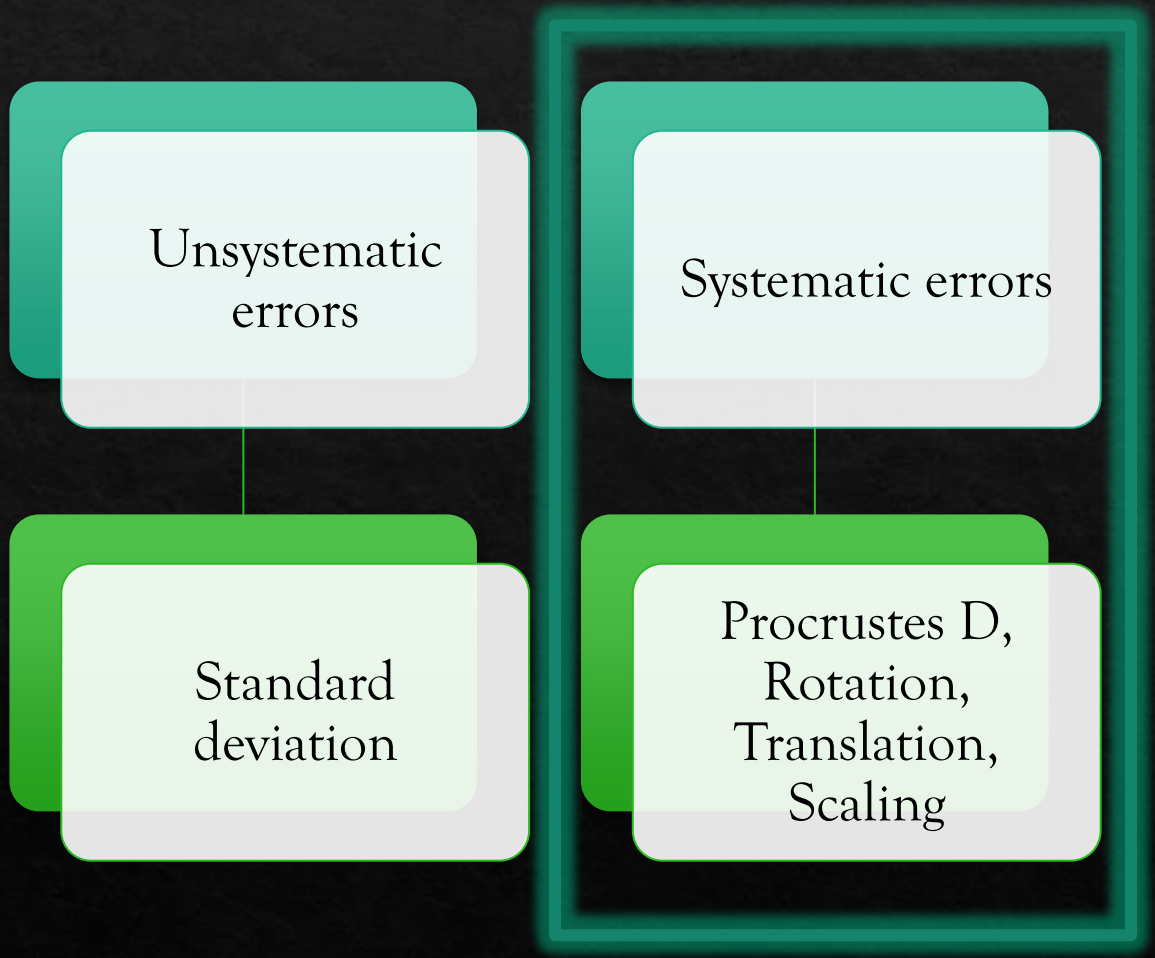
- Nothing is significant

2-way Repeated Measures ANOVA Horizontal saccades

- Saccade Direction was significantly different (p = 0.017)
- Trend for difference across VF

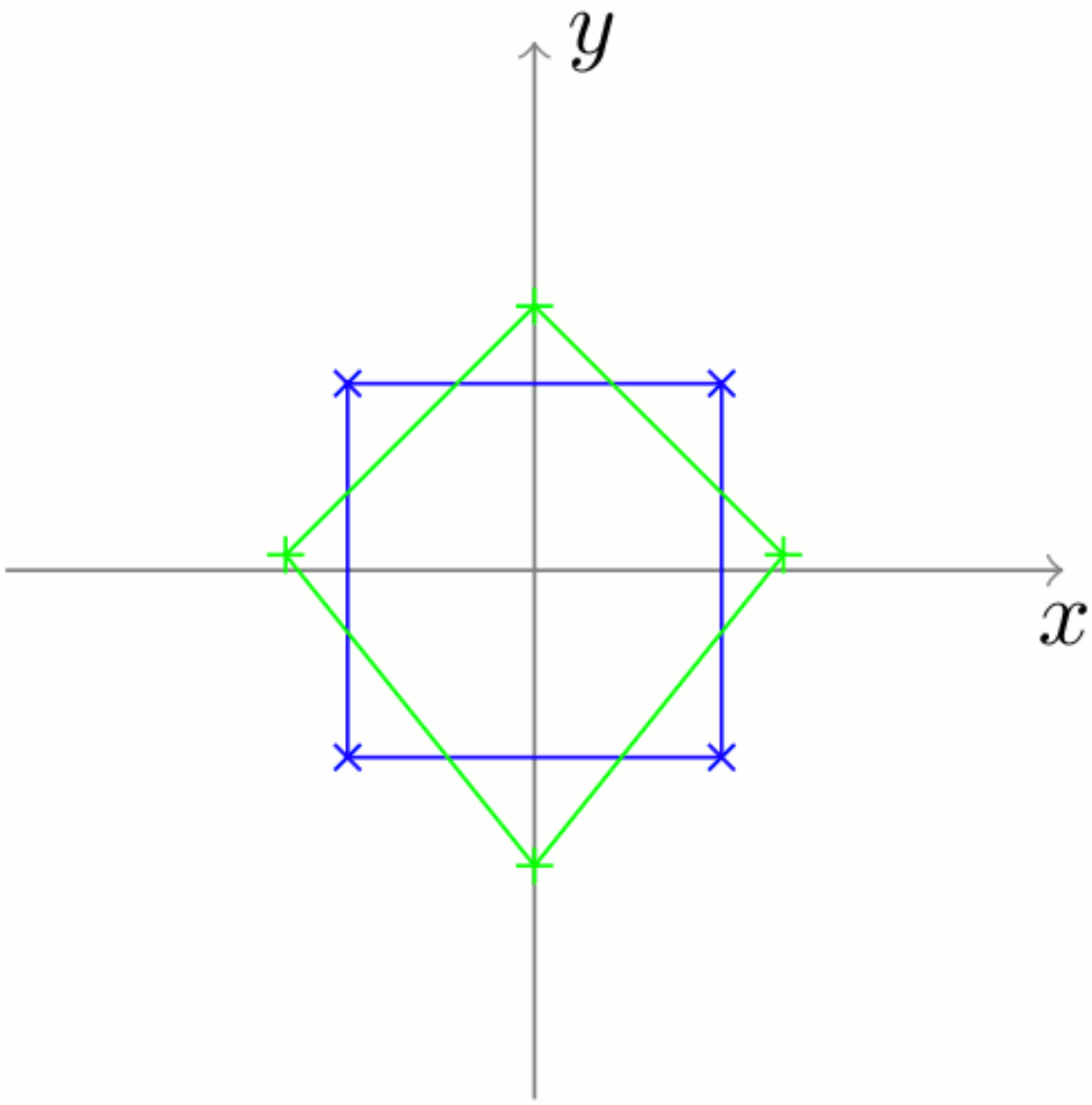


Measures of TSWM

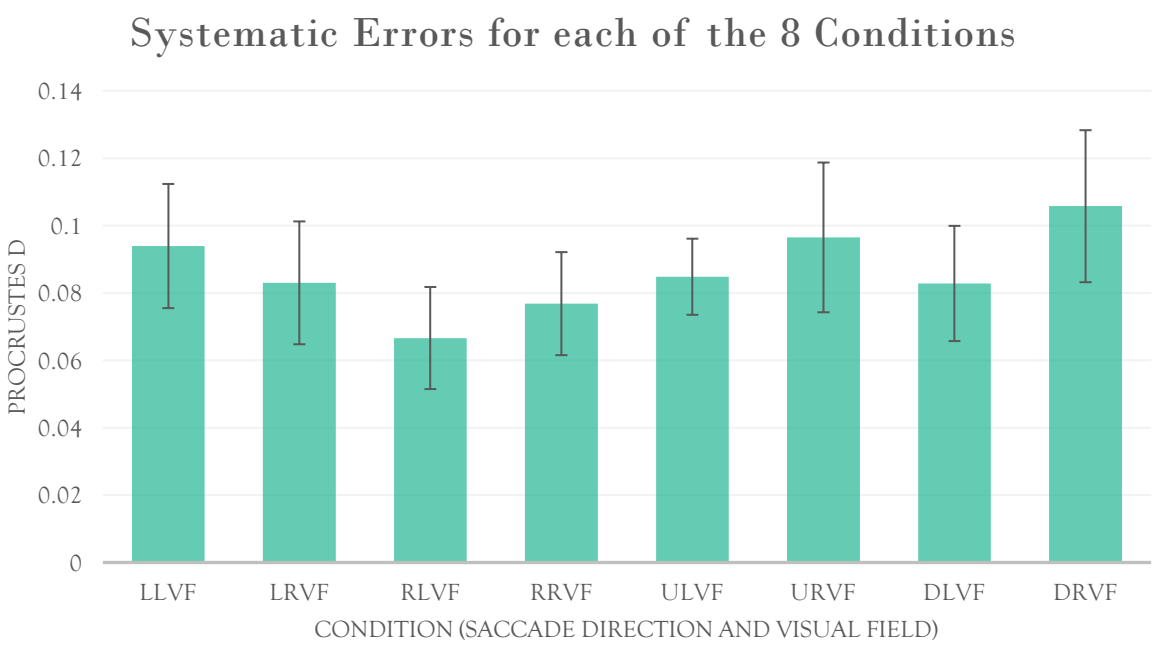


Procrustes D – D, Rotation, Scaling and Translation (x and y)

- Procrustes analysis is a form of statistical shape analysis used to analyse the distribution of a set of shapes.
- Linear transformation required of points in matrix Y (responses) to best conform to points in matrix X (Actual location of stimuli).



Systematic Errors



3-way Repeated Measures ANOVA

- Level 1: Visual Field (LVF or RVF)
- Level 2: Saccade Plane (Horizontal or Vertical)
- Level 3: Saccade Direction (Left/Up or Right/Down)
- Significance for Saccade Plane $p < 0.05$ (0.046

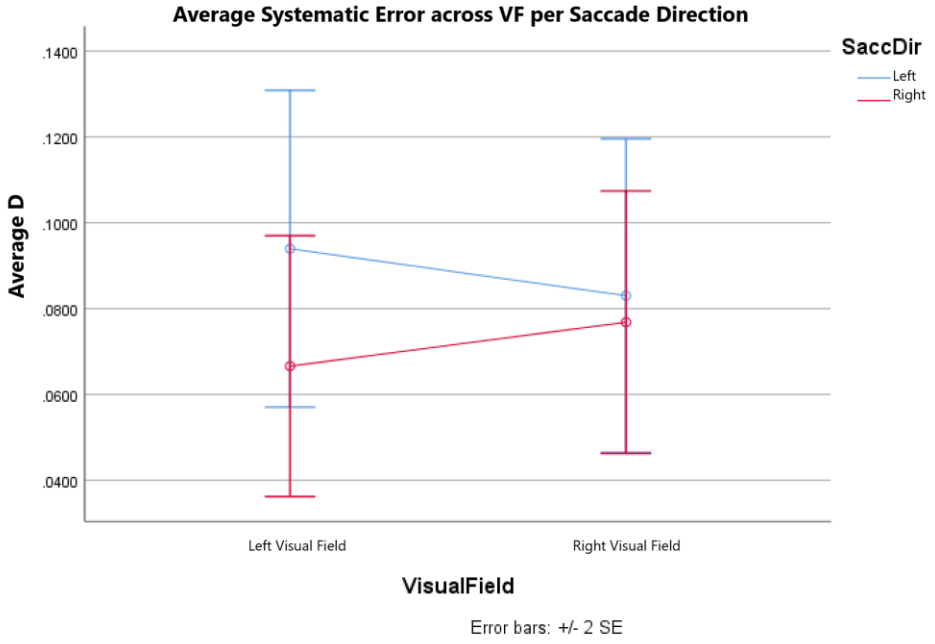
2-way Repeated Measures ANOVA

- No Significant difference for both Vertical and Horizontal Saccades

2-way Repeated Measures ANOVA

2-way Repeated Measures ANOVA

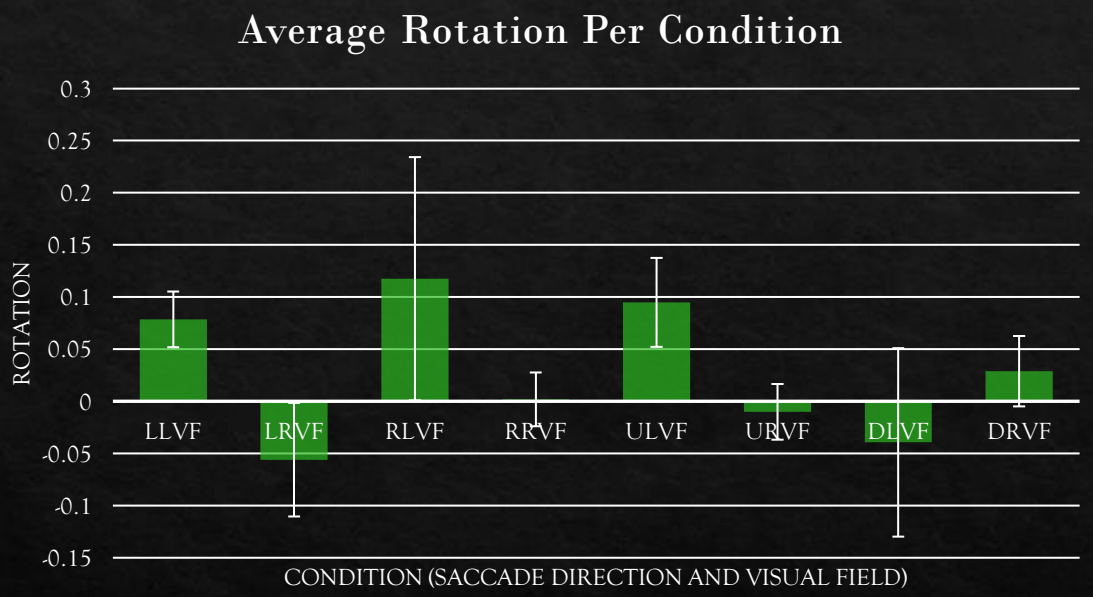
- No Significant difference for both Vertical and Horizontal Saccades
- Trend for less Systematic errors in LVF compared to the RVF for Vertical Saccades

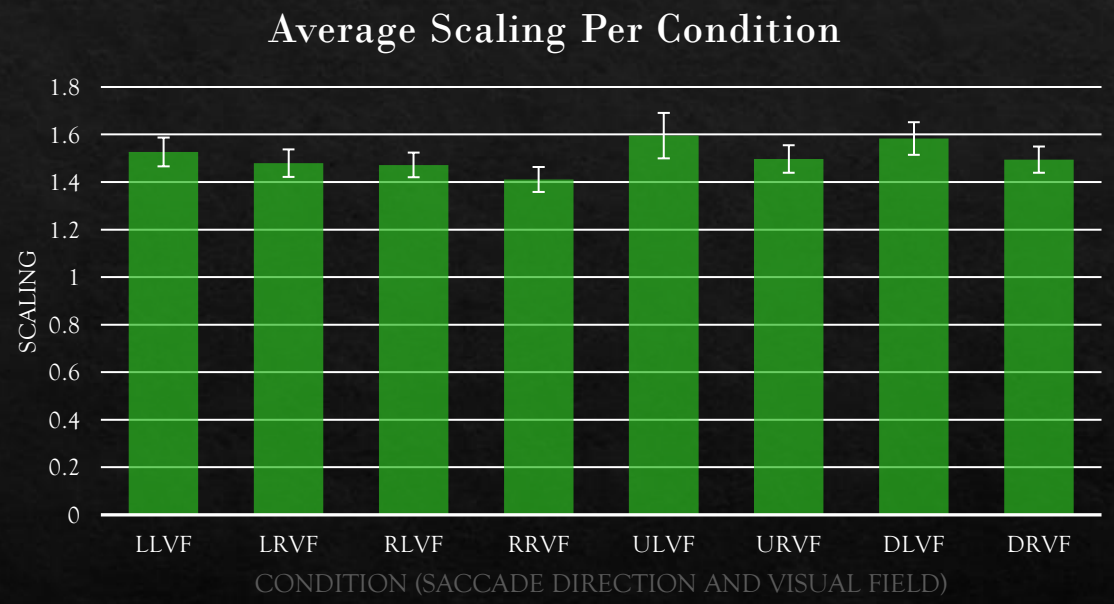


Next, I will be looking at the individual components of Procrustes D (Rotation, Scaling and Translation).

This is to further analyze changes across visual fields, saccade planes and saccade directions.

Rotation and Scaling

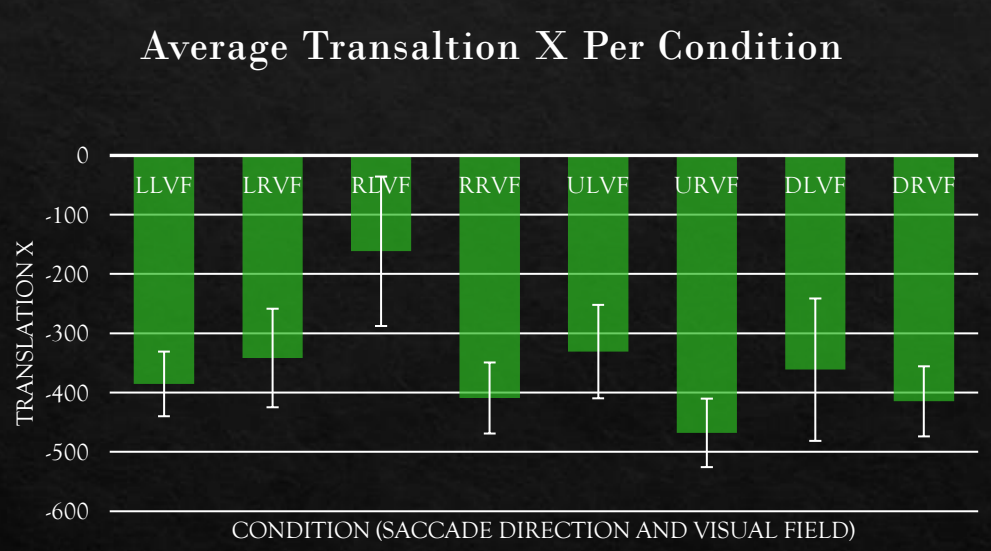


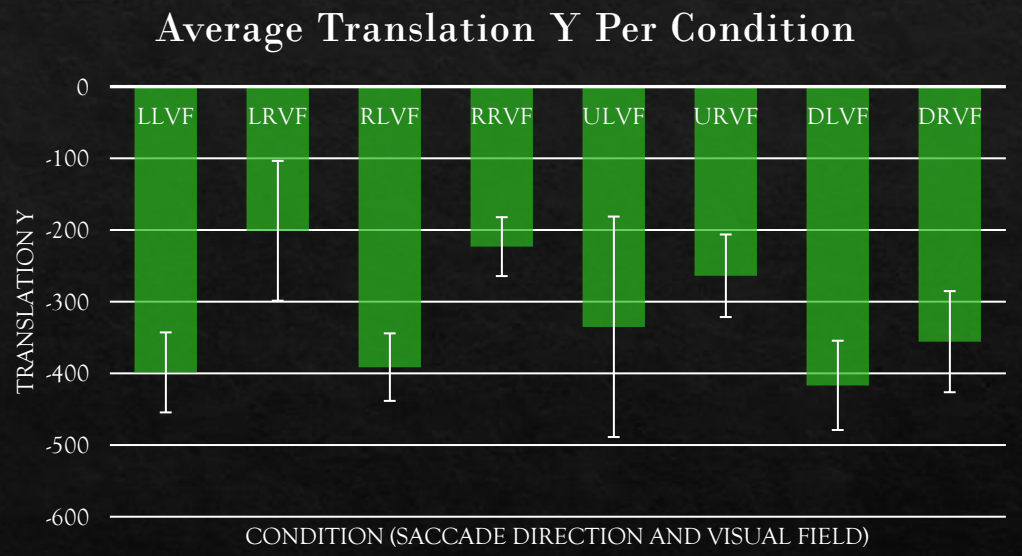


3-way RM ANOVA: Saccade Plane * Saccade Direction interaction effect p = 0.022.
2 way Horizontal: VF significant p = 0.009
2 way Vertical: VF*SaccDir interaction effect p = 0.013

3-way RM ANOVA: Saccade Plane p = 0.036 and Visual Field p = 0.022
2 way Horizontal: No significant differences
2 way Vertical: No significant differences

Translation x and y



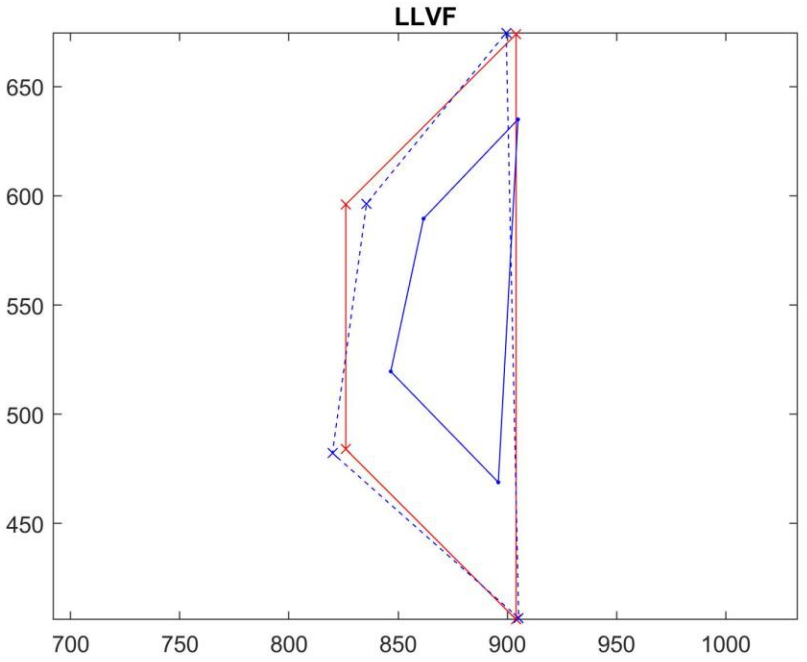


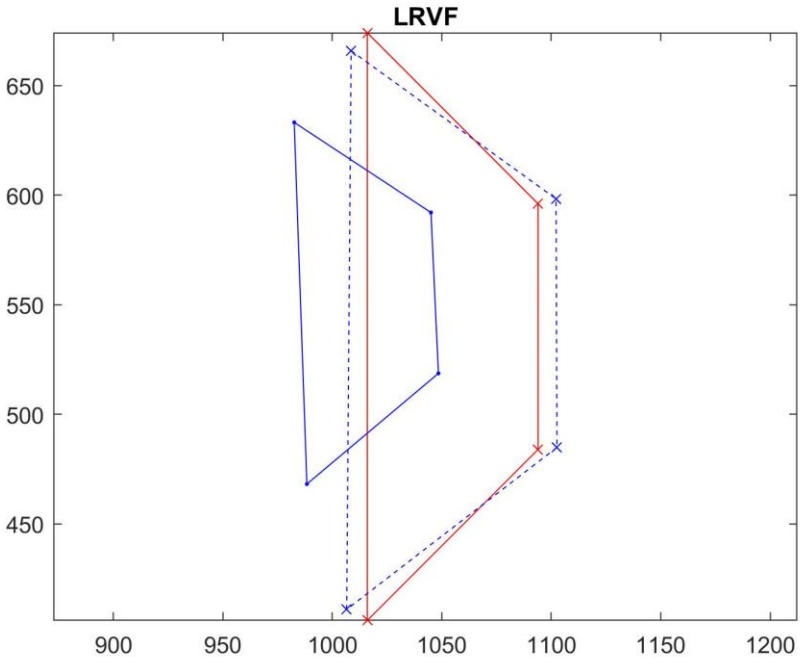
3-way RM ANOVA: Visual Field p = 0.043, Saccade Plane p = 0.021, 3 way interaction p = 0.034
2 way Horizontal: VF significant p = 0.018
2 way Vertical: NS

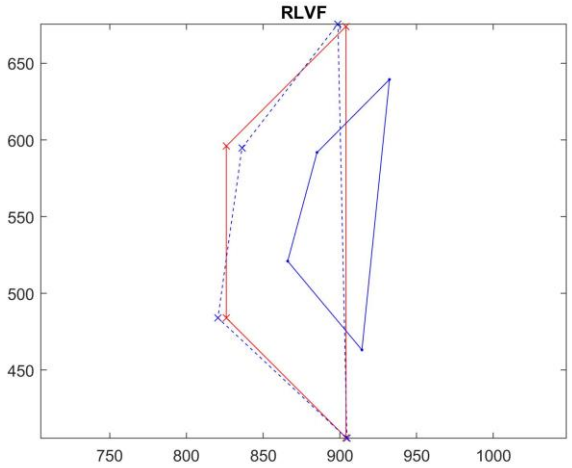
3-way RM ANOVA: Visual Field p = 0.027
2 way Horizontal: Visual Field p = 0.000...
2 way Vertical: NS

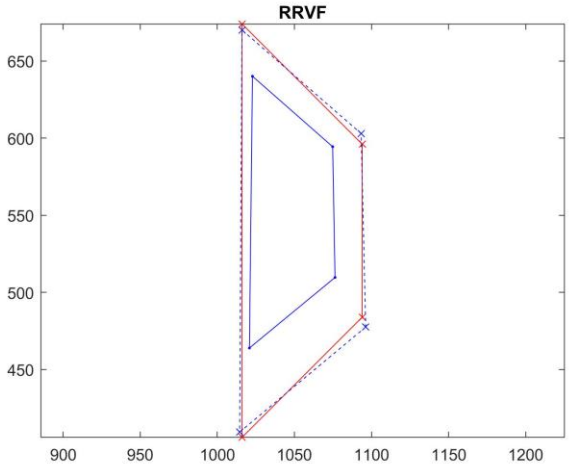
Systematic Errors – Left Saccade

- Amount of scaling look similar across VF
- Rotation amount similar but in opposite directions
- Differences in translation



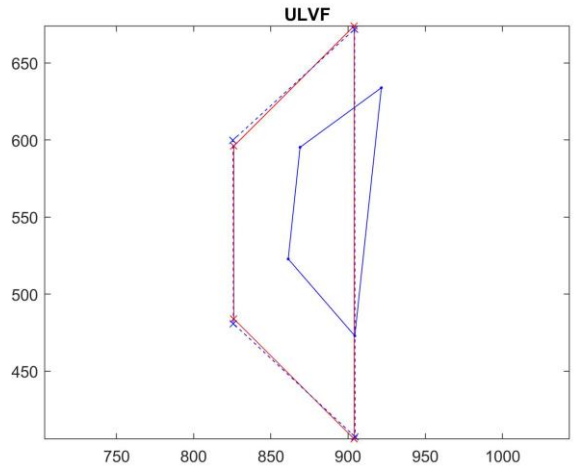


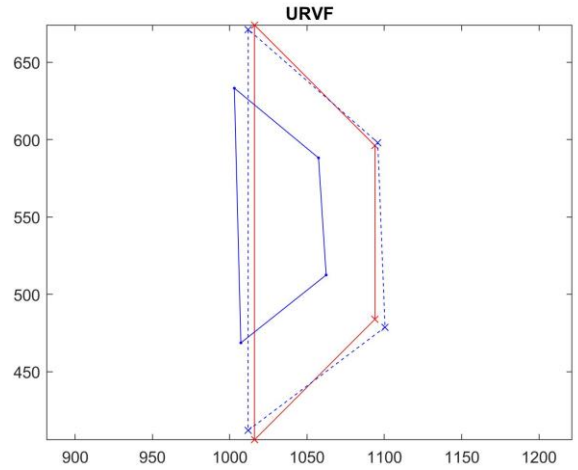




Systematic Errors – Right Saccade

- Require approximately same amount of scaling
- More translation required for LVF
- More rotation required for LVF



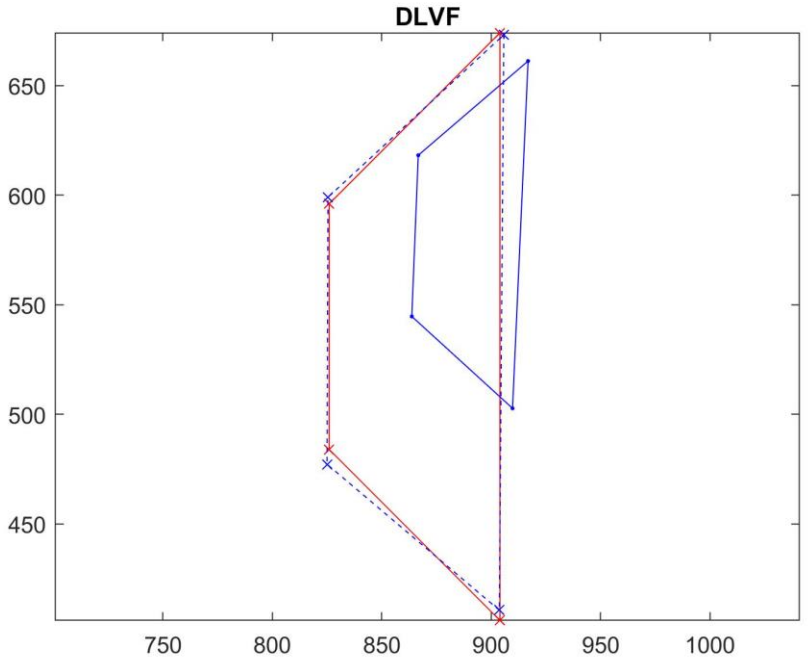


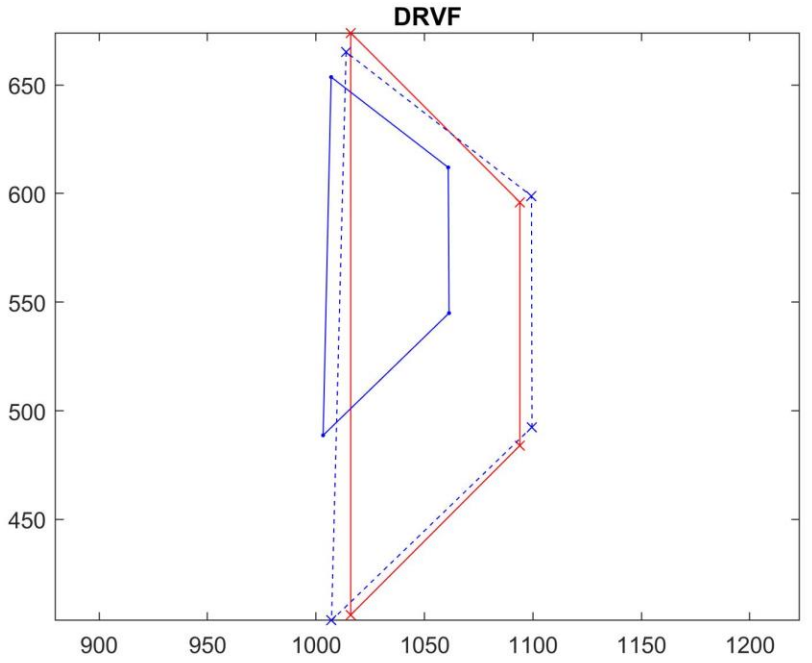
Systematic Errors – Up Saccade

- Similar amount of scaling required for both
- Slight rotation differences
- Similar in terms of amount of translation required

Systematic Errors – Down Saccade

- Amount of required scaling is very similar
- Amount of translation is very similar
- Amount of rotation is also very similar





Can we make some conclusions?

- Similar systematic deviations for vertical saccades
- Increased amount of deviation when starting off in the LVF for horizontal saccades
- Looking for overall differences in precision is hard to decipher when variables include positive and negative values, where high positive and low negative both mean poor performance

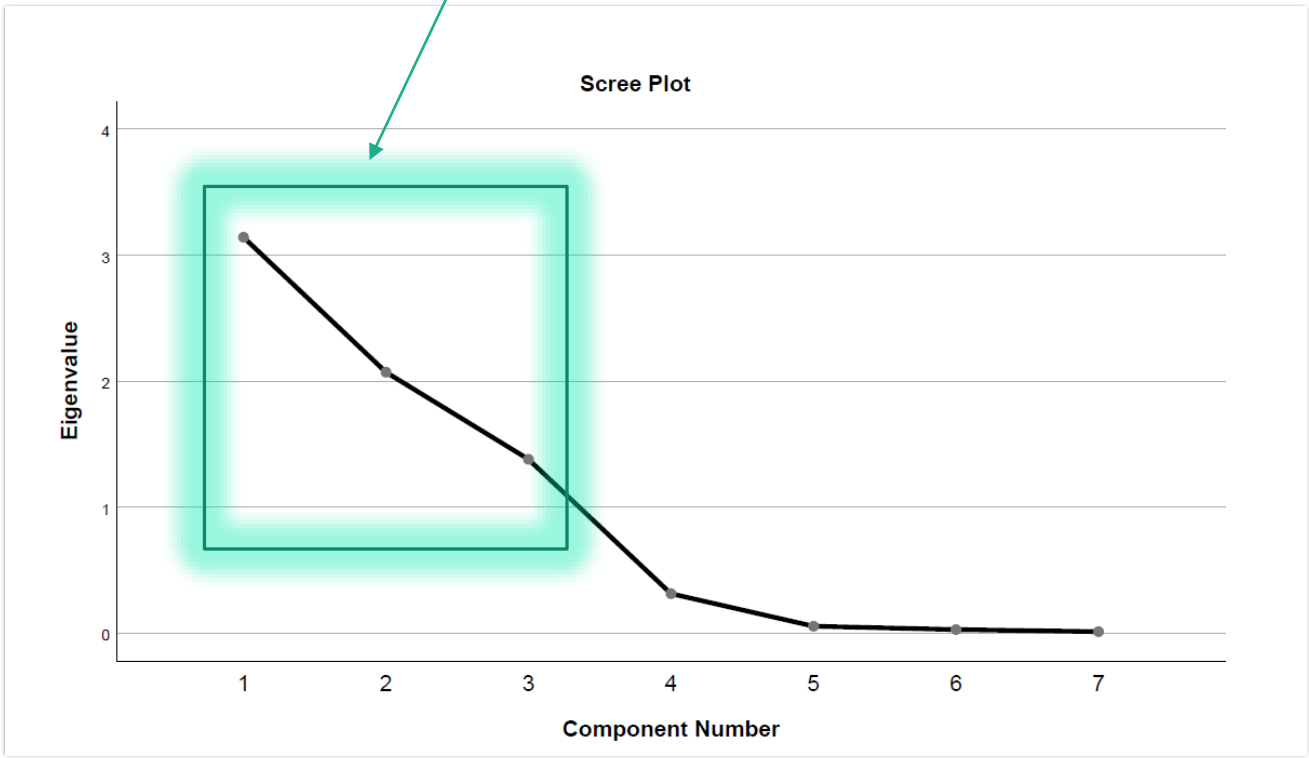
… what's next?

Principal Component Analysis

- How much does each condition relate to one another?
- Instead of 7 different components, can we reduce the components to 2 or 3?
  - 2 or 3 components that the 7 conditions vary along
- We want to find the components account for most of the variation in the data

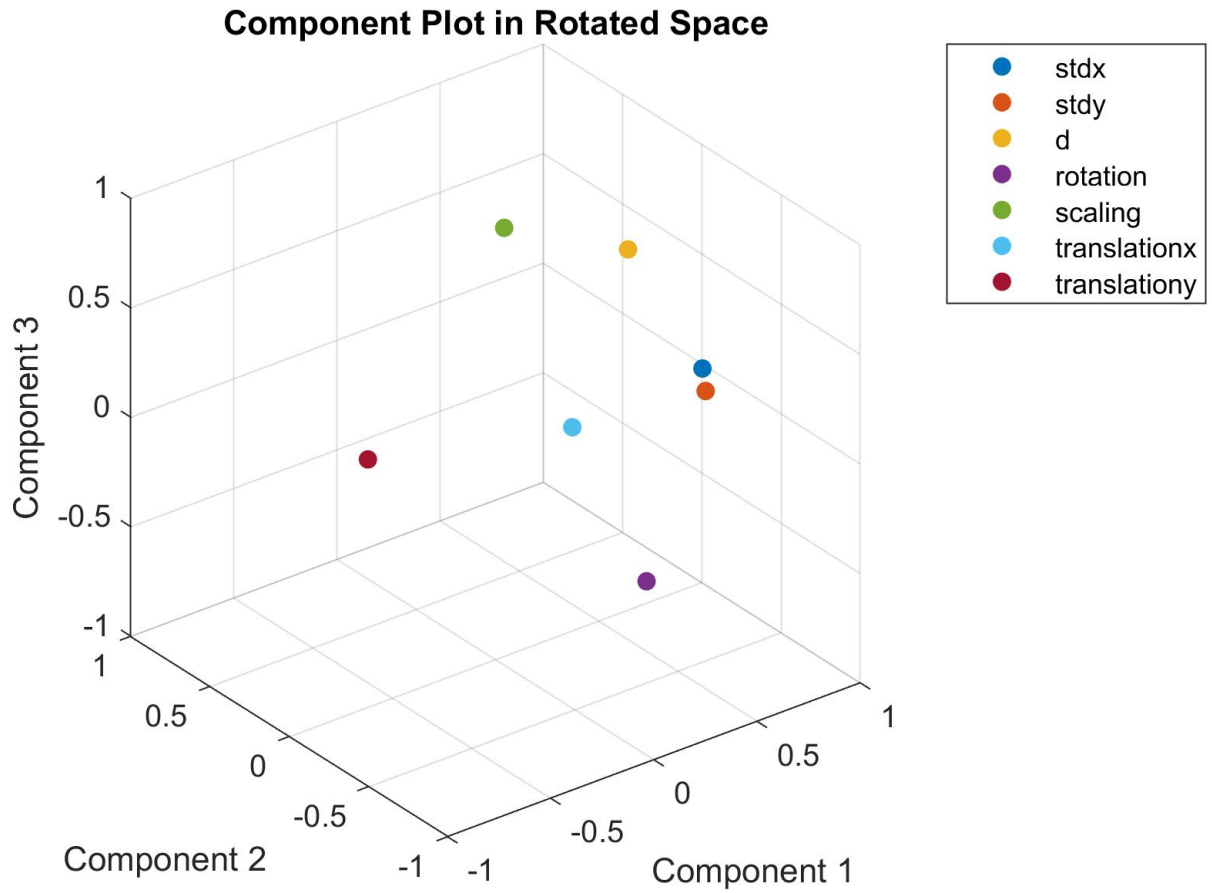
Principal Component Analysis – 3 Components

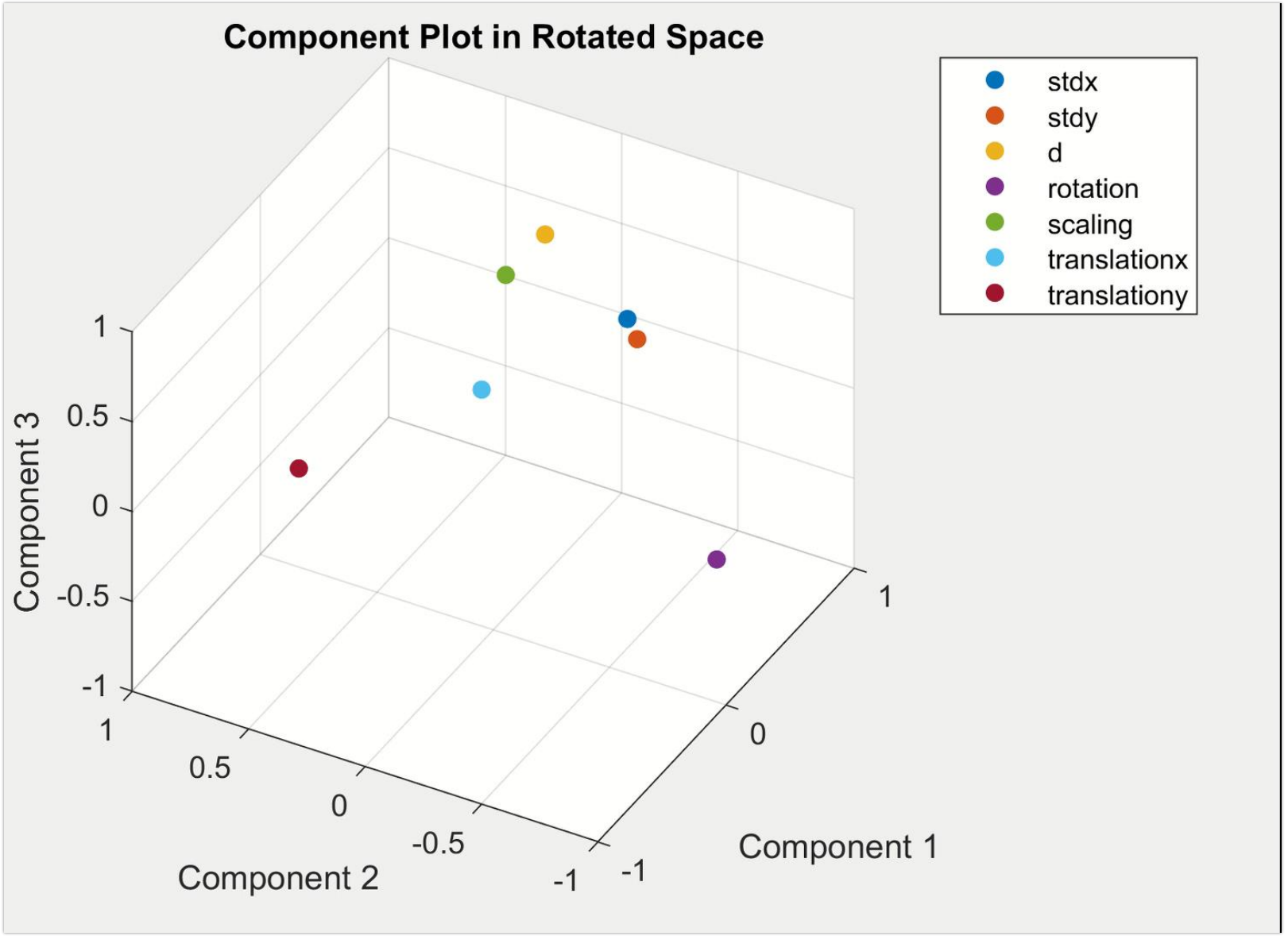
3 Components extracted



Principal Component Analysis – 3 Components

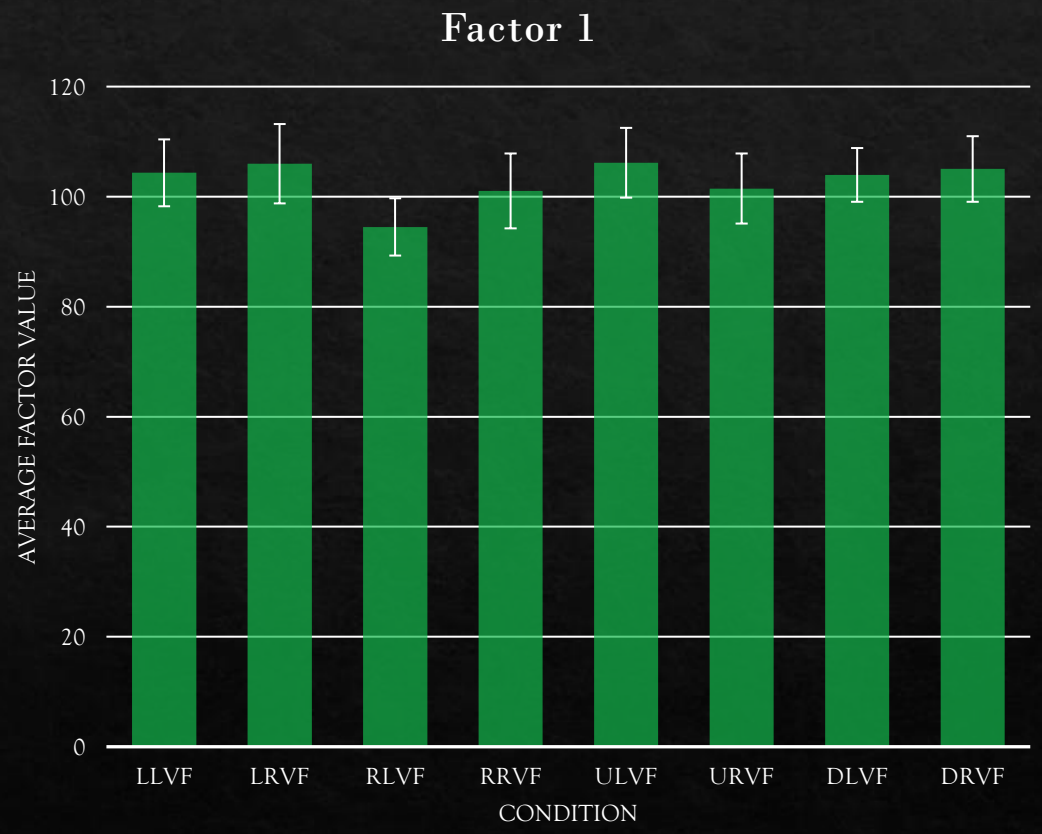
Rotated Component Matrix			
	Component		
	1	2	3
stdX	0.971	-0.041	0.007
stdY	0.942	-0.099	-0.059
d	0.816	0.227	0.483
rotation	-0.008	-0.964	-0.198
scaling	0.001	-0.053	0.996
translationX	0.711	0.442	-0.391
translationY	0.039	0.857	-0.492



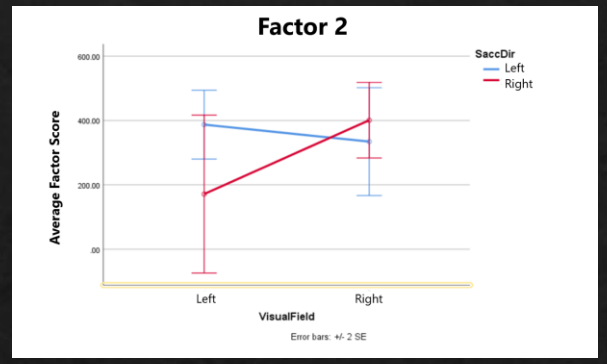

Component Plot in Rotated Space
stdx
stdy
d
rotation
scaling
translationx
translationy
Component 3
1
0.5
0
-0.5
-1
Component 2
1
0.5
0
-0.5
-1
Component 1
1
0
-1

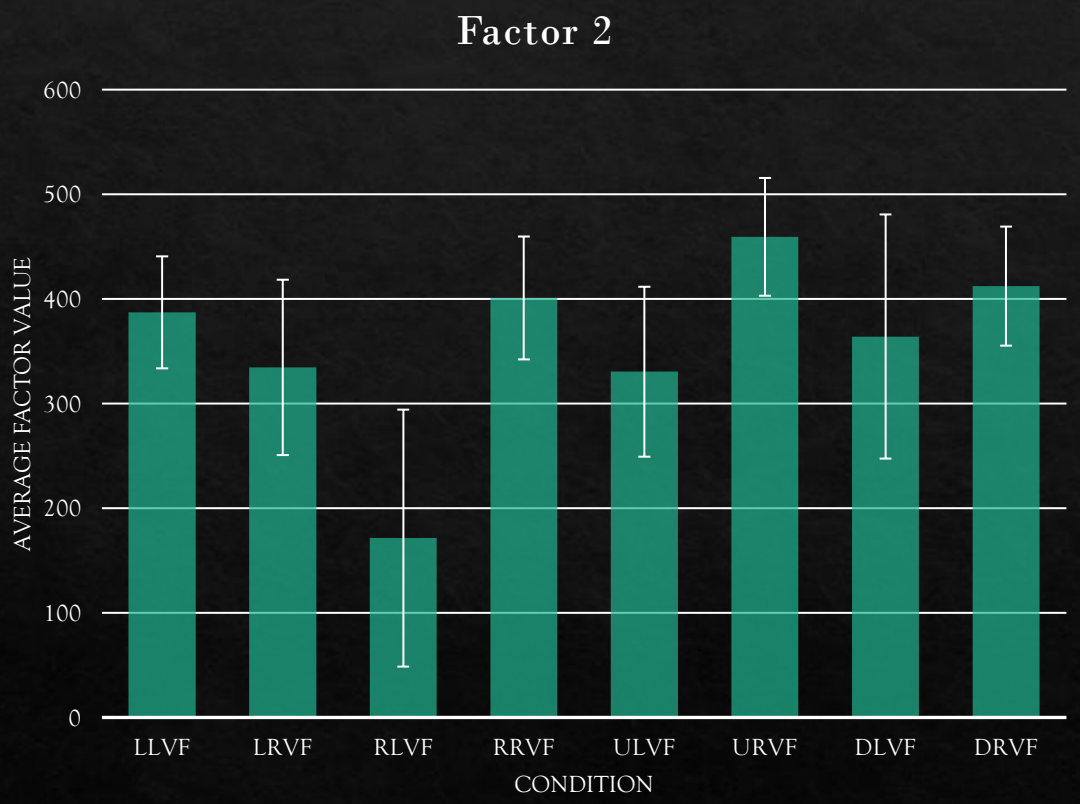
Factor 1

- 3-way Repeated Measures ANOVA
  - **Level 1: Visual Field**
  - **Level 2: Saccade Plane**
  - **Level 3: Saccade Direction**
  - No significance



Factor 2





3-way Repeated Measures ANOVA

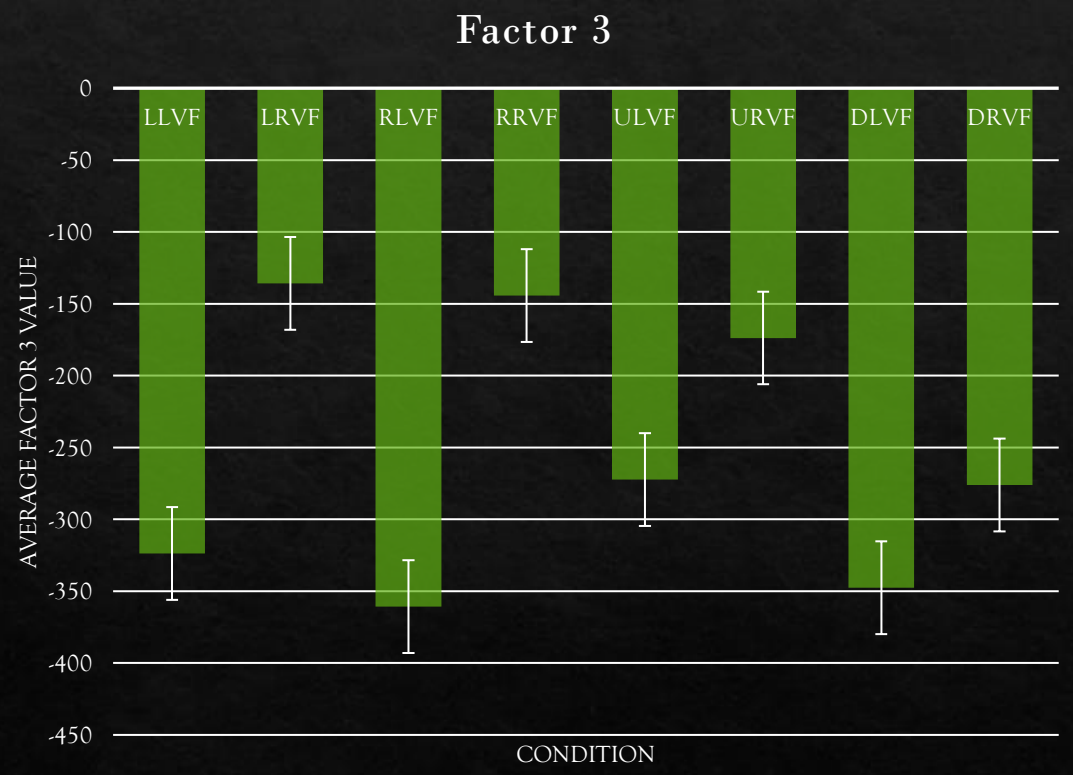
- Level 1: Visual Field
- Level 2: Saccade Plane
- Level 3: Saccade Direction
- Saccade Plane significant (p = 0.021)
- Visual Field*Saccade Plane (p = 0.05)
- Visual Field * Saccade Plane * Saccade Direction Significant (p = 0.044)

2-way Repeated Measures ANOVA

- Level 1: Visual Field
- Level 2: Left or right saccade

- Vertical saccades: No Significance
- Horizontal Saccade: Visual Field Significant (p = 0.032)

Factor 3



3-way Repeated Measures ANOVA

- Level 1: Visual Field
- Level 2: Saccade Plane
- Level 3: Saccade Direction
- Visual Field Significant ($p = 0.002$)

2-way Repeated Measures ANOVA

- Horizontal Saccades: VF significant ($p < 0.0005$)
- Vertical Saccades, No significance, but trend similar to Horizontal Saccades

What to do now?

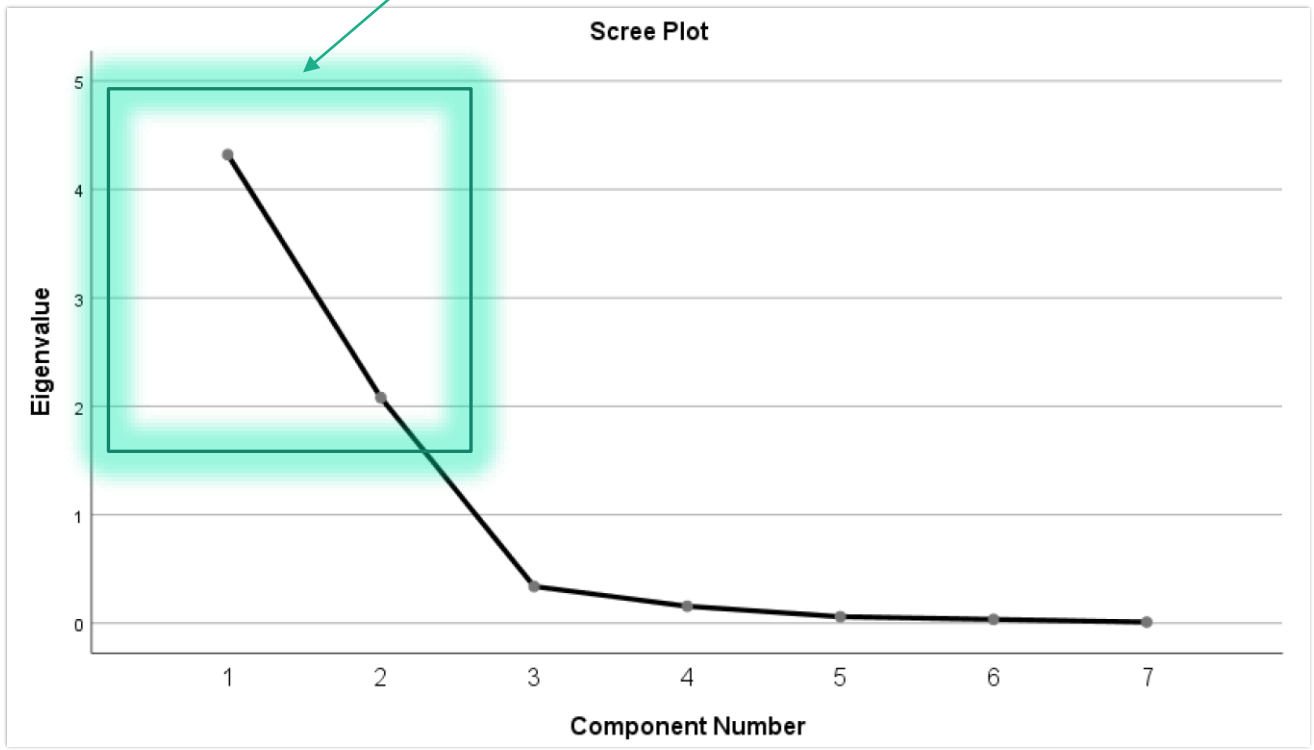
- Negative values = deviation away from perfect performance
- Take the absolute values of rotation, translation X and Y.
- Run a PCA on the rectified data, as well as on the rectified and unrectified data to see the relationship between all these variables.
- PCA with positive values might give us a better idea of whether working memory performance was good or bad.

Second PCA

- Rectified rotation, translation x and translation y data

Principal Component Analysis – Adjusted Data

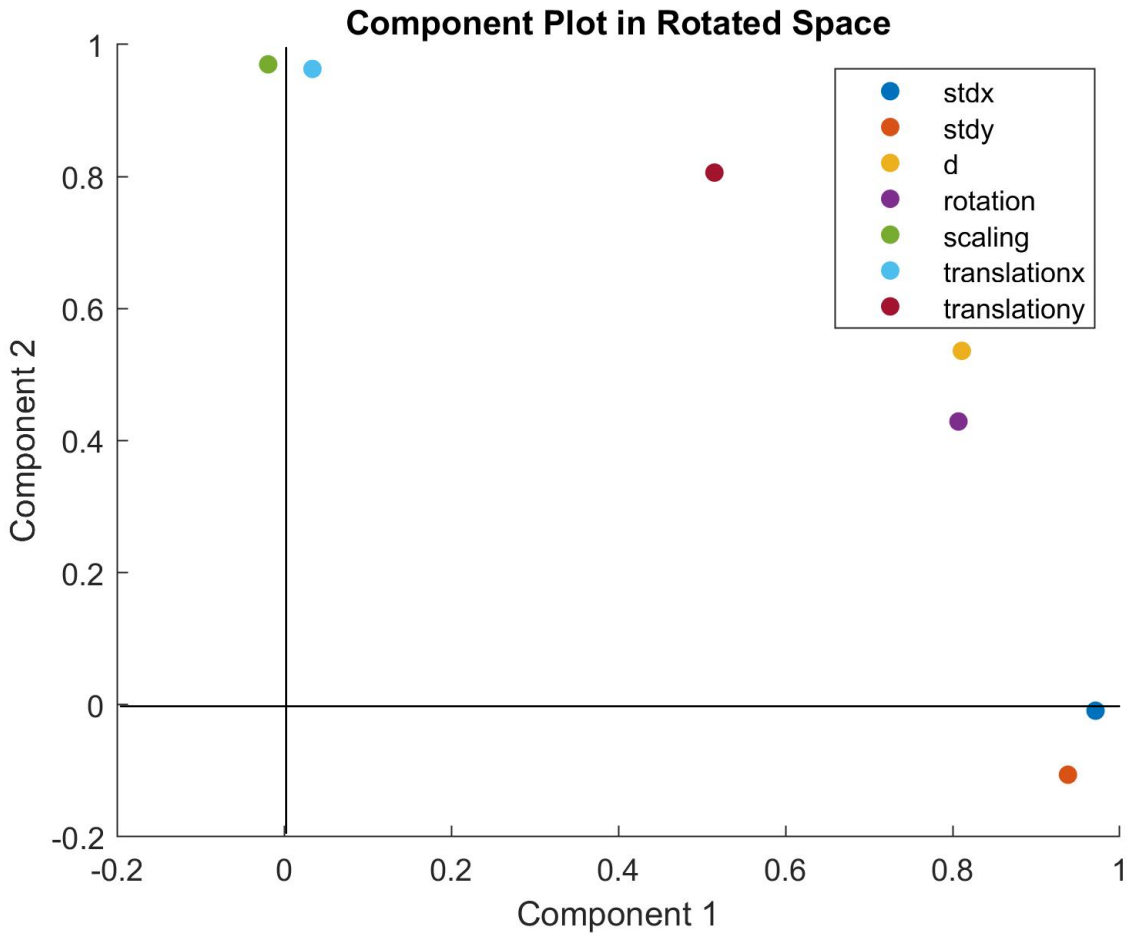
2 Components extracted



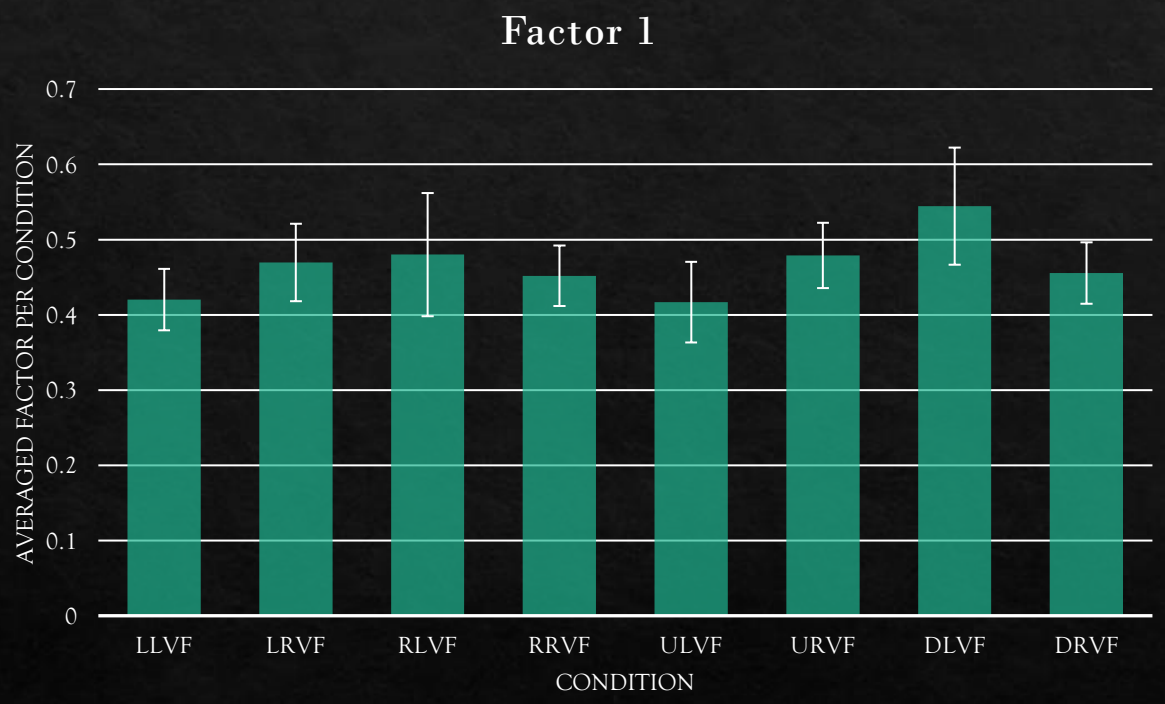
Principal Component Analysis – Adjusted Data

Rotated Component Matrix[a]

	Component	
	1	2
stdx	0.971	-0.009
stdy	0.938	-0.106
d	0.811	0.536
rotation	0.807	0.429
scaling	-0.019	0.970
translationx	0.034	0.963
translationy	0.515	0.806



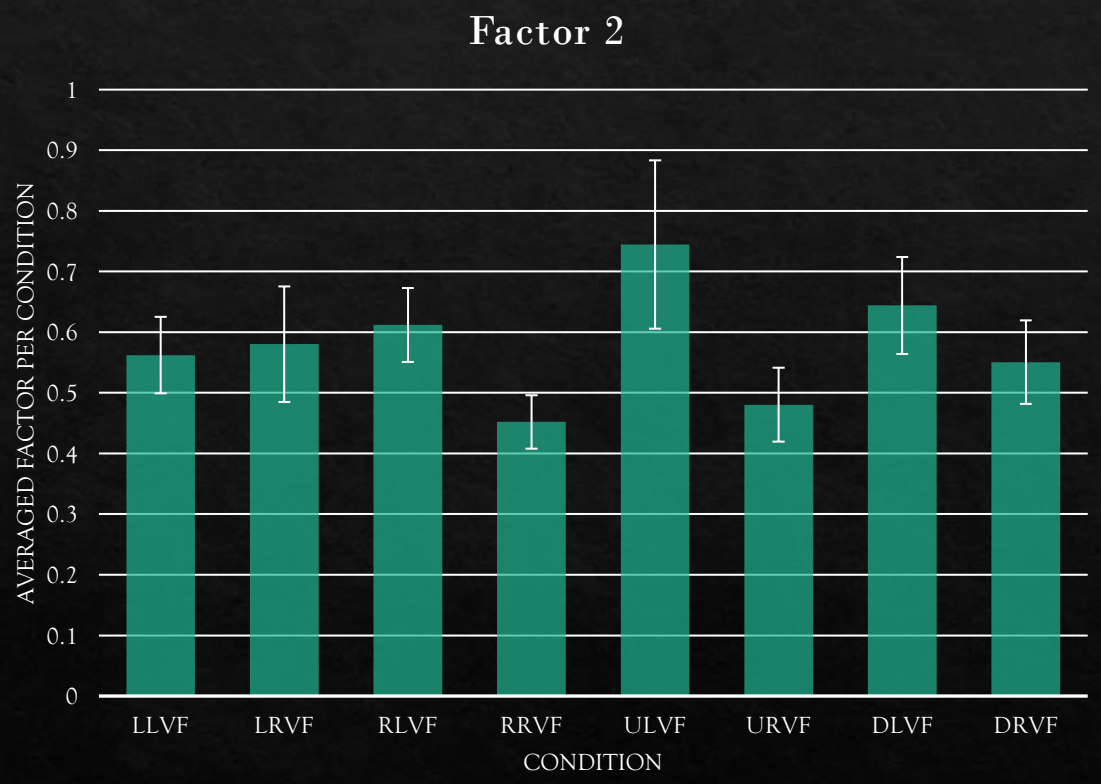
Factor 1



3-way Repeated Measures ANOVA

- 3 Levels (Visual Field, Saccade Direction, Saccade Plane)
- No significance

Factor 2



3 Way repeated Measures ANOVA

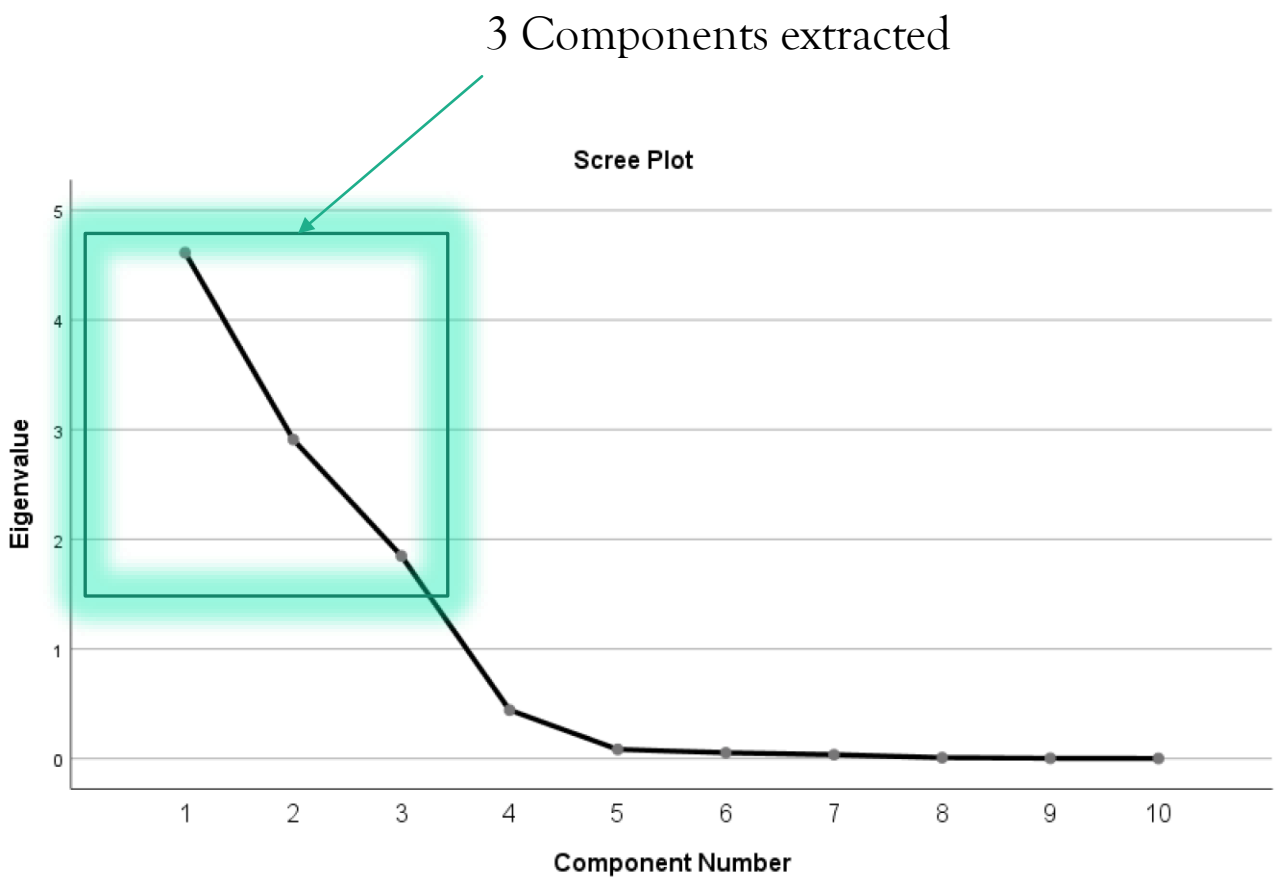
- 3 Levels (VF, SaccDir, SaccPlane)
- Visual Field Significant (p = 0.000...)

2 Way Repeated Measures ANOVA

- Horizontal Saccades: No Significance
- Vertical Saccades: Visual Field Significant at p = 0.008

3rd PCA: Rectified + Unrectified Data

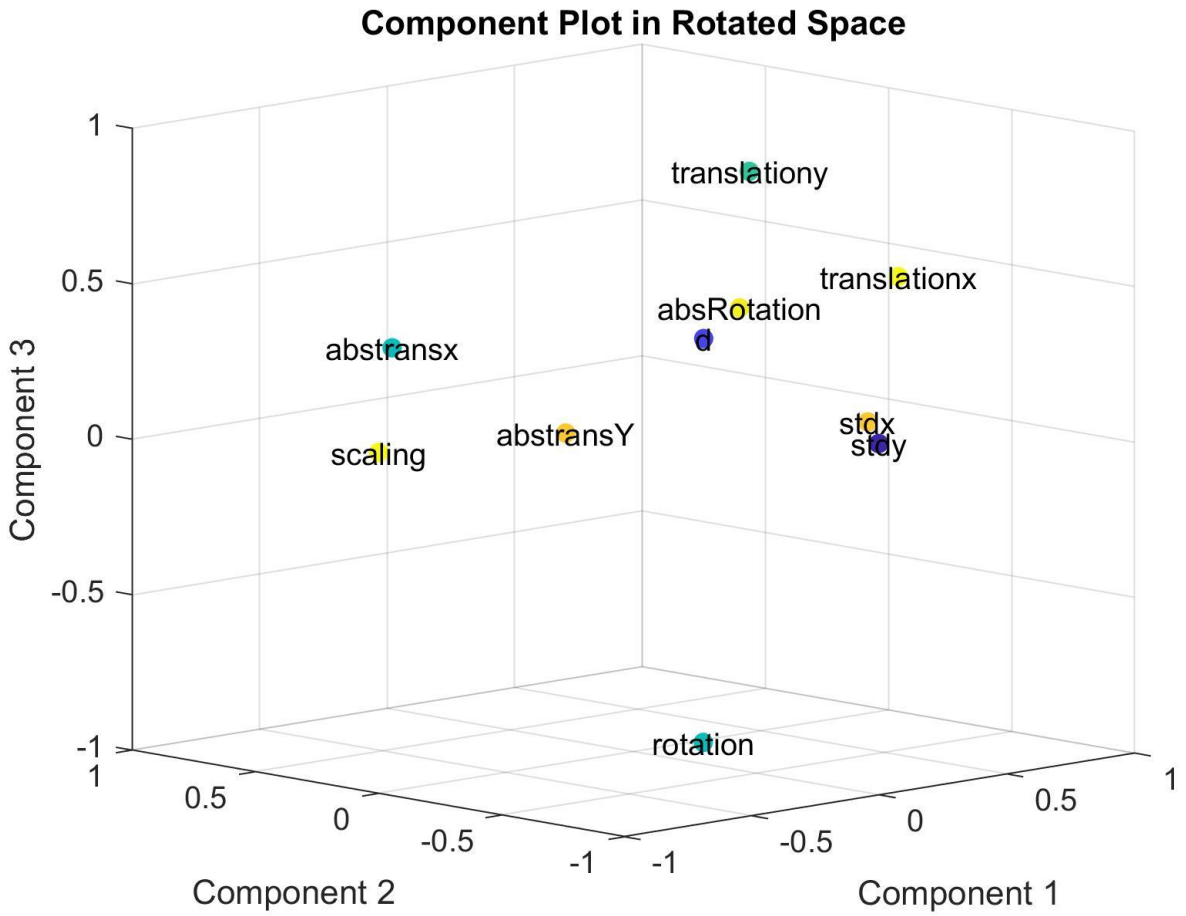
How the two PCAs relate to one another

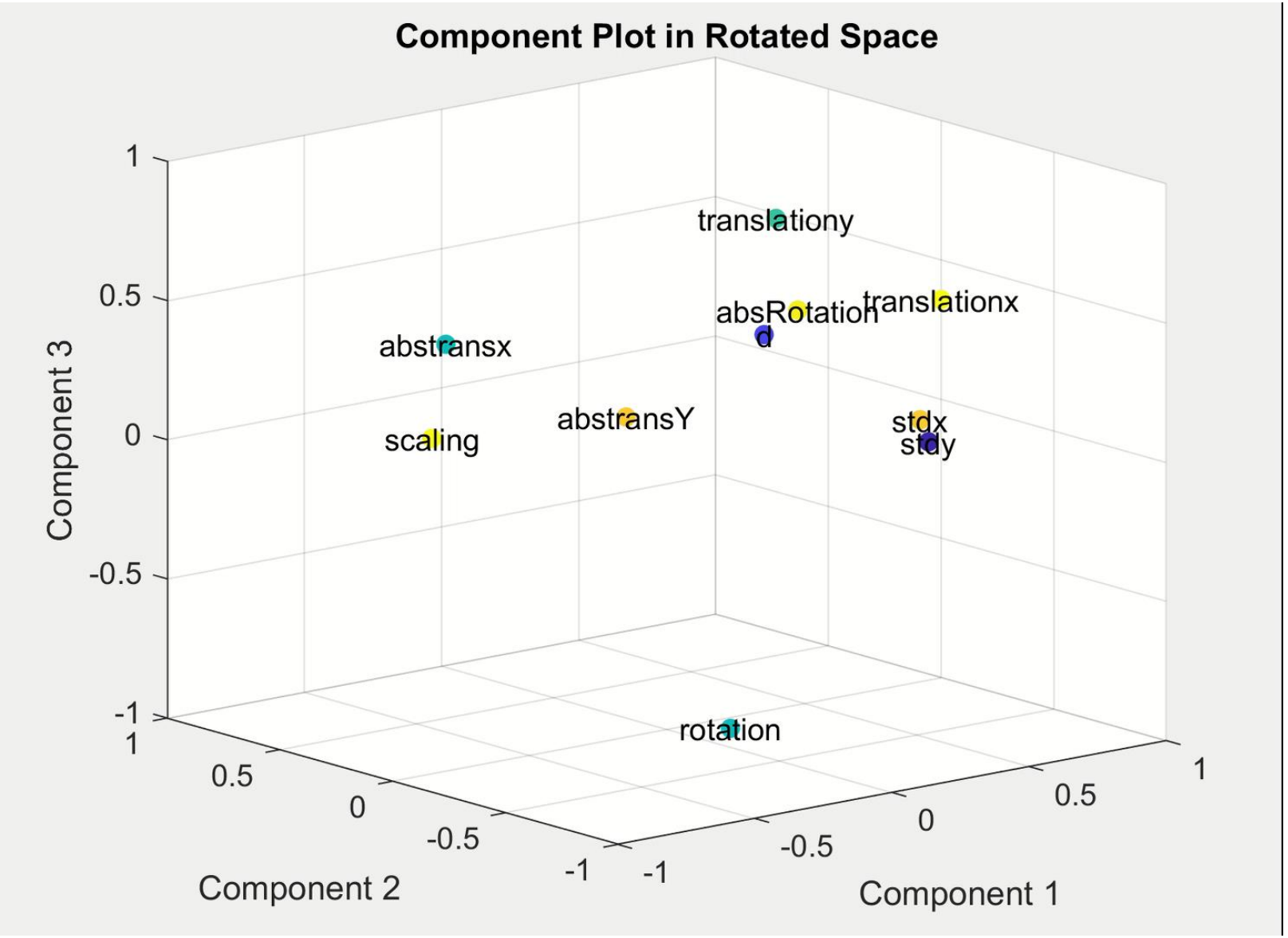


PCA: Rectified + Unrectified Data

Rotated Component Matrix[a]

	Component		
	1	2	3
stdx	0.950	0.032	-0.072
stdy	0.909	-0.055	-0.124
d	0.804	0.547	0.144
rotation	-0.007	-0.291	-0.929
scaling	-0.051	0.981	-0.168
translationx	0.776	-0.272	0.461
translationy	0.077	-0.391	0.910
rotationABS	0.822	0.419	0.258
transxABS	-0.007	0.972	0.164
transyABS	0.517	0.810	-0.158




Component Plot in Rotated Space
translationy
absRotation
translationx
d
abstransx
abstransY
scaling
stdx
stdy
rotation
Component 3
1
0.5
0
-0.5
-1
Component 2
Component 1