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The task effect on Main Sequence

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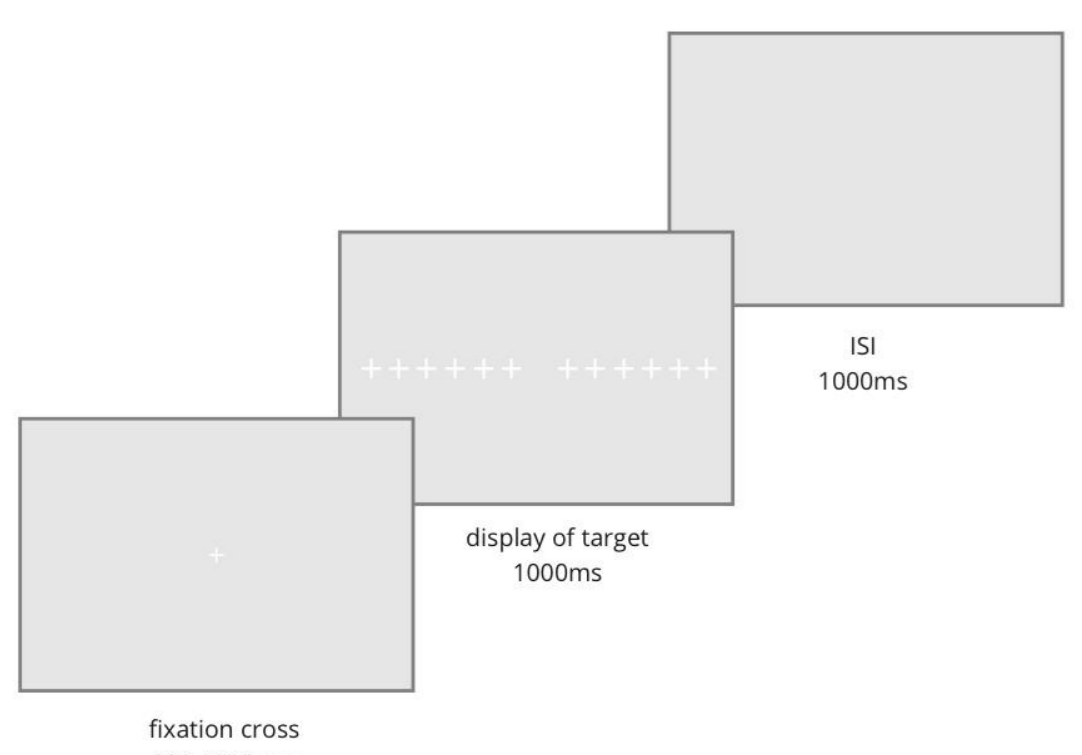
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Background

Saccades' kinematic is well defined through the Main Sequence that links saccade amplitude and peak velocity. While a study showed that the Main Sequence is repeatable under different experimental conditions (Gibaldi & Sabitini, 2021), another study found that it differs between voluntary and involuntary saccades (Kaminiaz et al., 2009). In the same way, deviations from the Main Sequence have been observed for saccades recorded during scene exploration which might be explained by interactions with the visual scene content (Costela & Woods, 2019). Our aim is to compare the Main Sequence variability in a large group of participants for two tasks : sequential saccade testing (visually-guided saccades) (Gibaldi & Sabatini, 2021) and free exploration of natural scene images (free-viewing saccades).

Methods

Sequential saccade testing (SST)

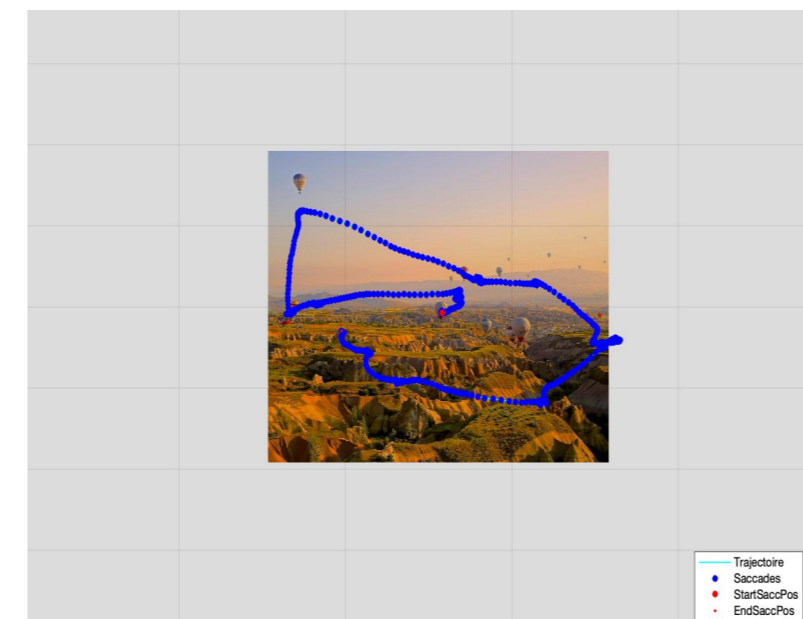
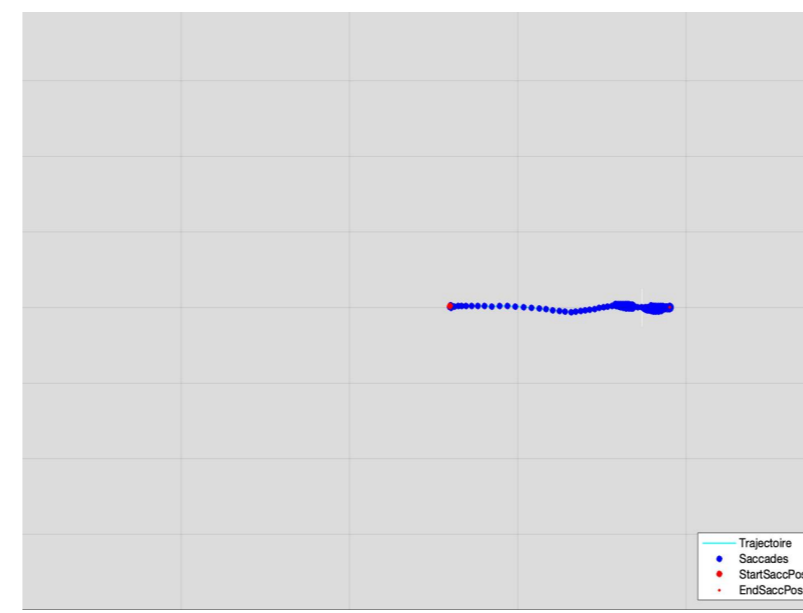


Time course of SST

- Target : white crosses
- Size : 1° x 1° (49 x 49 pixels)
- Duration : 1000 ms
- Trials : 120
- Eccentricities : ±2°, ±4°, ±6°, ±8°, ±10° or ±12°
- Saccade type : visually-guided saccades

Participants

- 58 undergraduate students majoring in psychology from Université Grenoble Alpes

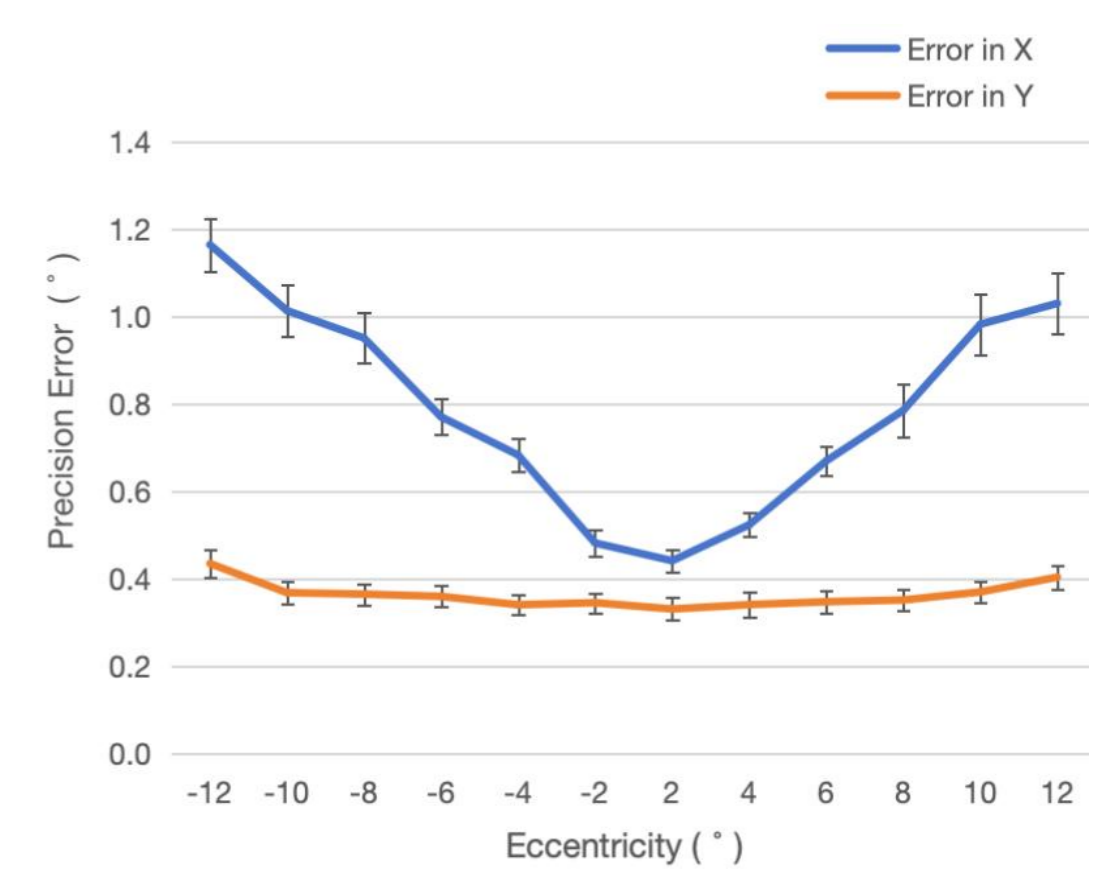


Examples of gaze samples for the two tasks

Precision errors (standard error) of SST

This error corresponds to the deviation between the target position and the saccade end position, calculated with all the first saccades of SST task for all subjects.

Saccade selection :
Only saccades falling within a square centered on the target (±1°) were taken into account for further analysis.



Free exploration of natural scene images (NAT)



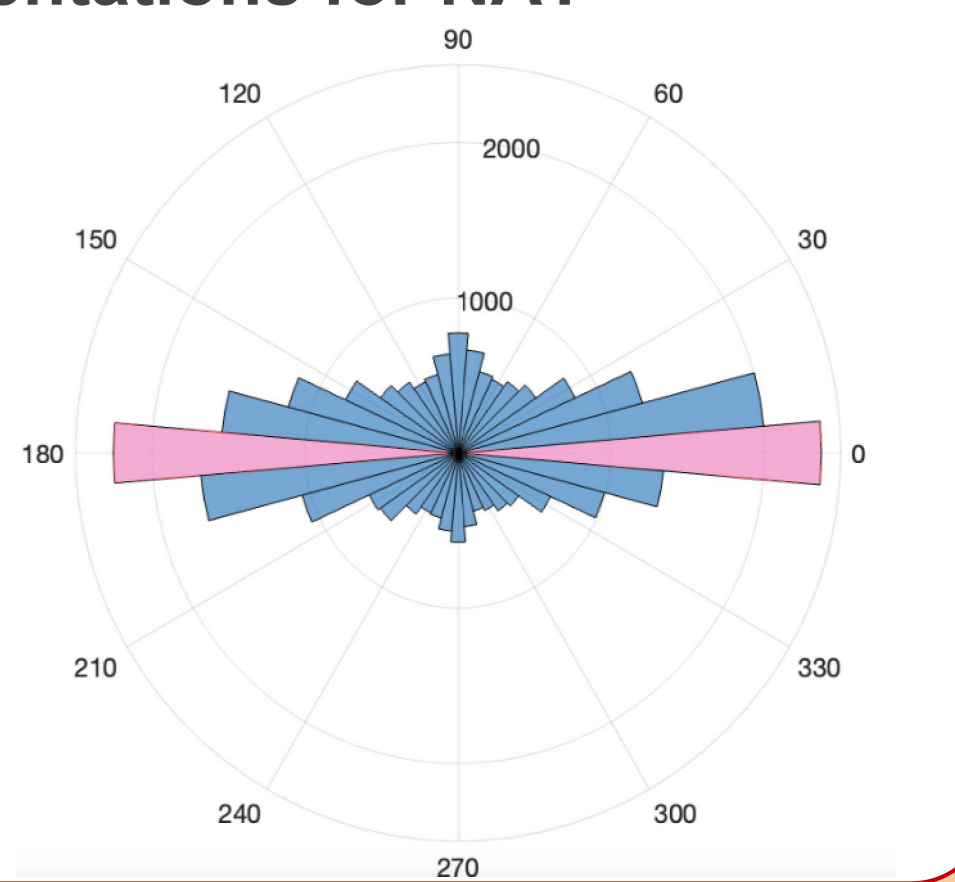
Time course of NAT

- Target : color images
- Size : 20.1 x 15.3° (1024 x 768 pixels)
- Duration : 3000 ms
- Trials : 60
- Saccade type : free-viewing saccades

Distribution of all saccade orientations for NAT

Among all saccades of all subjects, we counted the number that fell within each 10° interval according to their orientations.

Saccades selection :
Only horizontal saccades were selected and analyzed (with a tolerance in the saccade orientation of ±5°, corresponding to those in pink).



Analyses

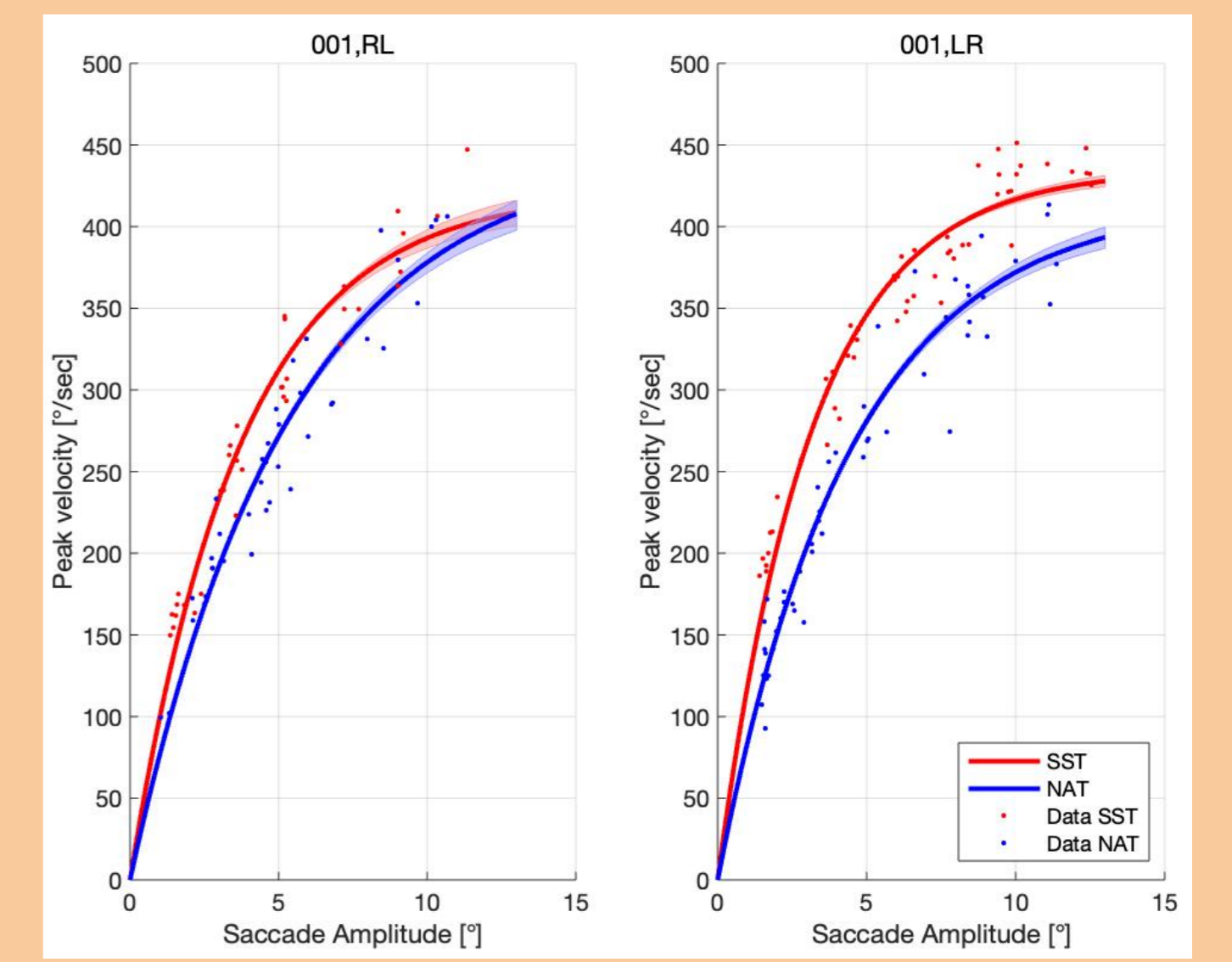
Main Sequence

Until now, there is no general consensus on the mathematical model describing the Main Sequence. Here, we chose a two-parameters exponential-fitting model which was considered to have one of the best performance (Gibaldi & Sabitini, 2021) and has also been used to test the programming of eye movements (Kauffmann et al., 2019).

For each subject : the individual Main Sequence model was estimated for both tasks using bootstrapping. Two models were fitted : one for the saccades from right to left (RL) and another for the saccades from left to right (LR) (This was done because we visually observed the differences).

$$V_p(A) = c_1 \left(1 - \exp\left(-\frac{A}{c_2}\right) \right)$$

- V_p is peak velocity (in degree/s)
- A is amplitude of the saccade (in degree)
- c_1, c_2 are two parameters of the fitting model (with the units of degree/s and degree, respectively)



Examples of Main Sequence for SST and NAT

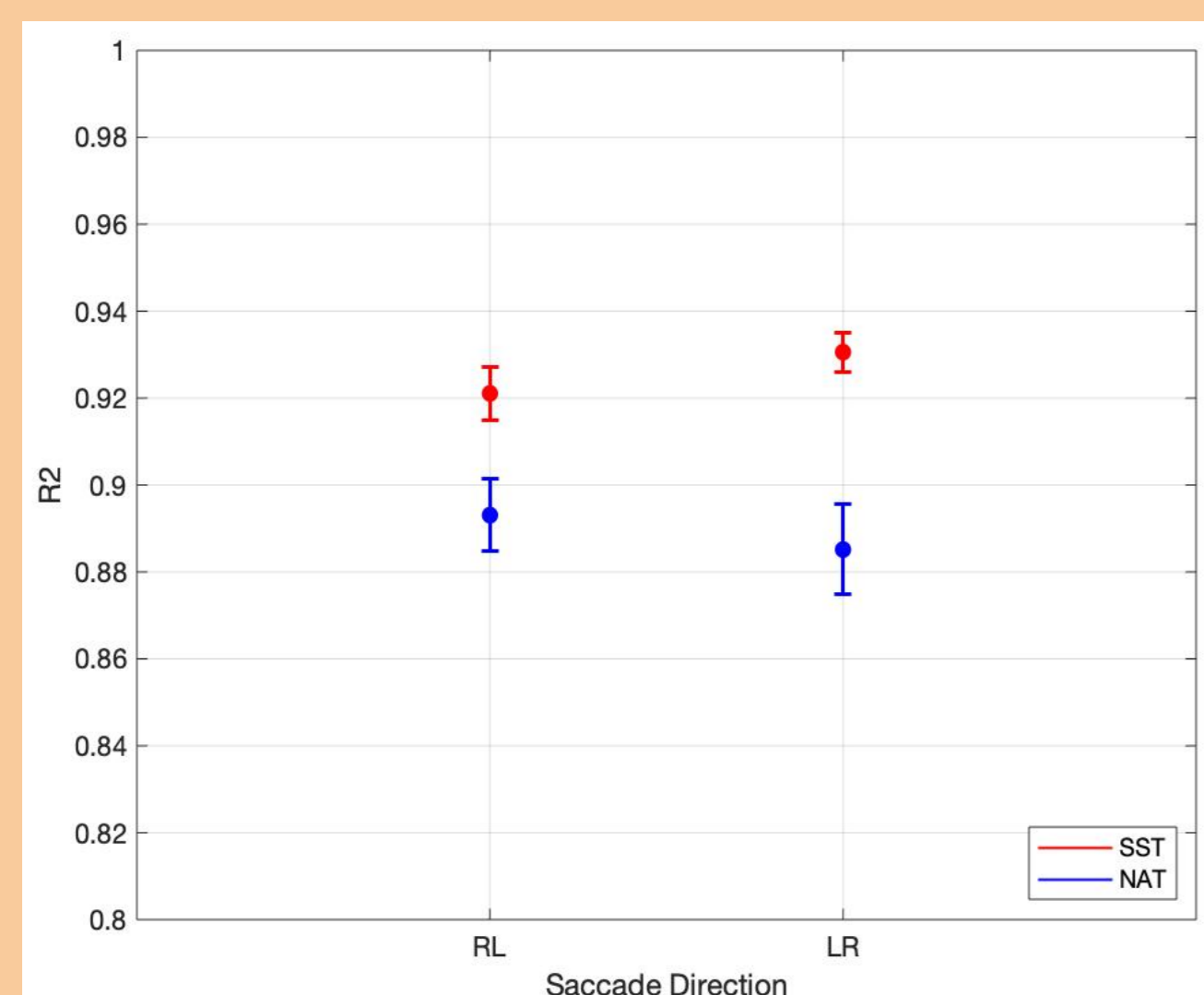
Results

Coefficient of determination

To assess the performance of the Main Sequence model adjustment, we calculated the R^2 for the two tasks (SST vs NAT) and the saccade directions (RL vs LR) for each participant.

	RL	LR
SST	0.92 ± 0.006	0.93 ± 0.004
NAT	0.89 ± 0.008	0.88 ± 0.010

The ANOVA performed on R^2 revealed a main effect of task but no significant effect of direction.



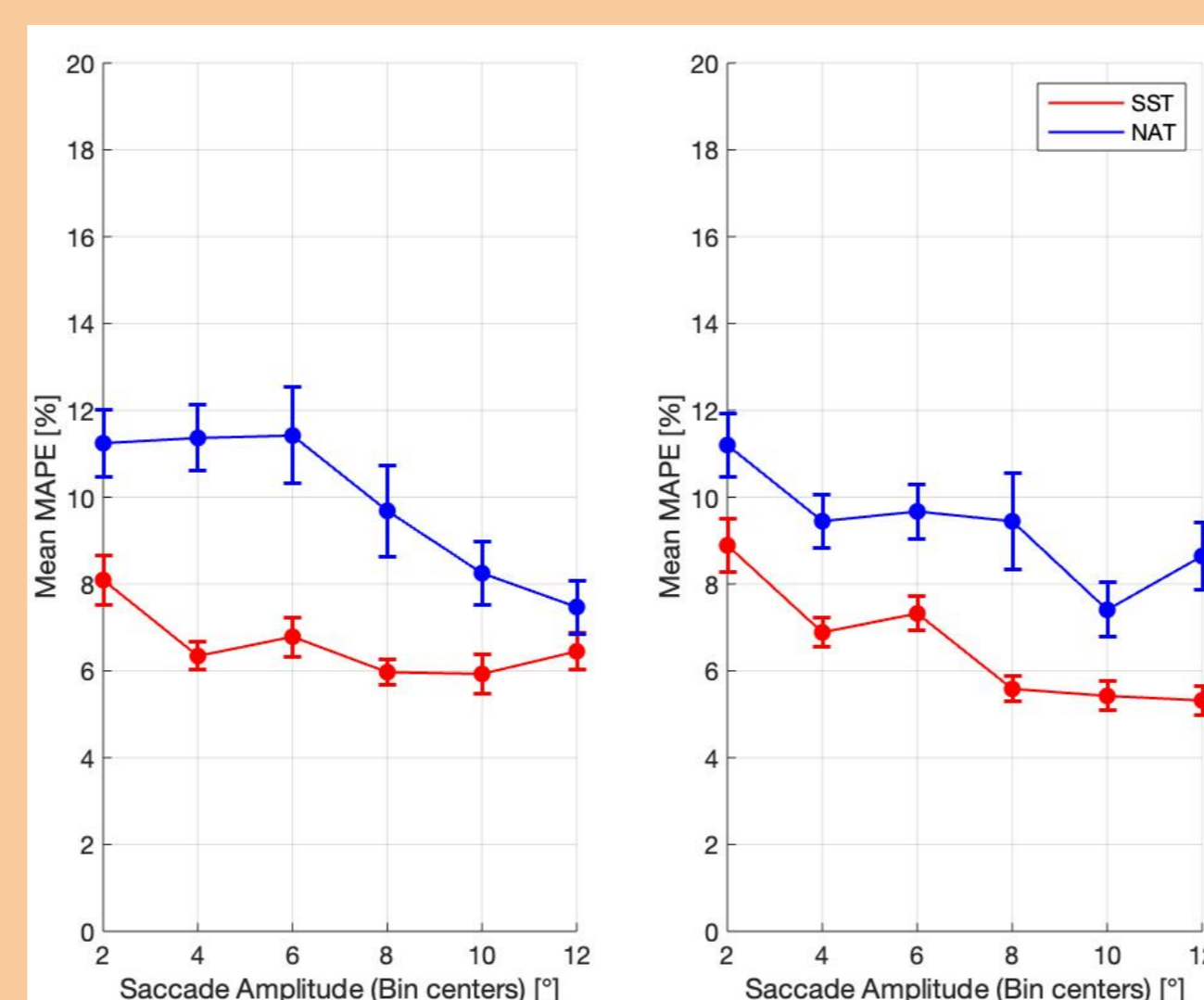
Mean value of R^2 for SST and NAT

Mean Absolute Percentage Errors

For each amplitude bin of 2° from 1° to 13°, the MAPE scores were computed between actual peak velocities of saccades (V_p) and those estimated by the same saccade amplitude on the Main Sequence curve (\hat{V}_p). This score is a measure of errors between predicted and observed saccade peak velocity.

$$\text{MAPE} = \frac{1}{n} \sum_{i=1}^n \frac{|V_p(A_i) - \hat{V}_p(A_i)|}{V_p(A_i)}$$

The results of ANOVA performed on MAPE scores showed that there was a main effect of task and eccentricity, but no significant effect of direction.



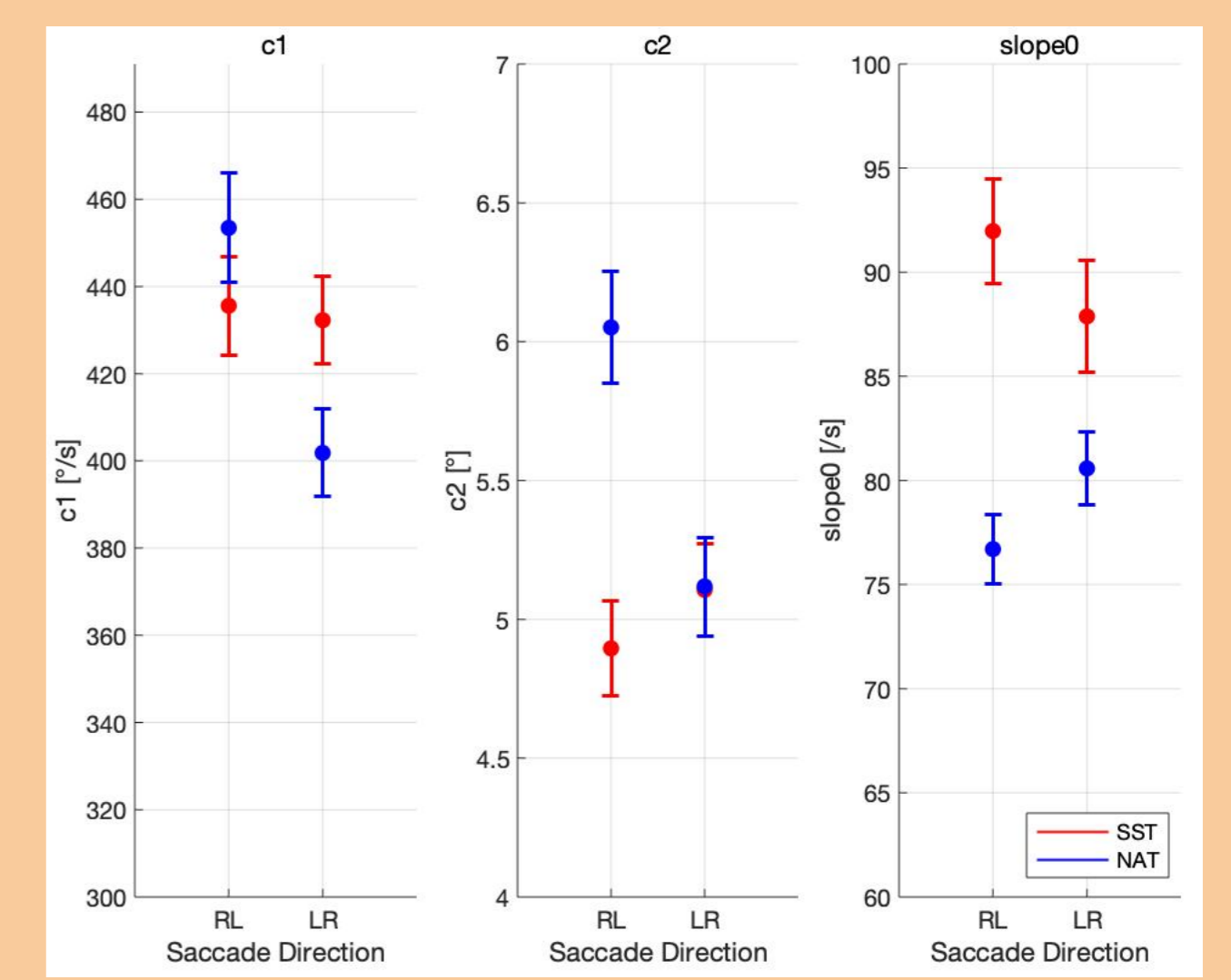
Mean MAPE Scores for SST and NAT

Parameters of Main Sequence model

For each participants, we computed three parameters of Main Sequence model taking into account : c_1 , c_2 and slope0 (with the unit of /s), which is the ratio of c_1 to c_2 , corresponding to the slope at the origin.

$$\text{slope0} = \frac{c_1}{c_2}$$

The ANOVA revealed that the task had a main effect on the exponential factor c_2 and the slope0 but no significant main effect on the scaling factor c_1 , while the direction had a main effect on c_1 as well as slope0 but no main effect on c_2 .



Mean value of parameters for SST and NAT

Conclusion

The Main Sequence varies with the saccades types (visually-guided or free-viewing). These results need to be discussed considering the fact that Main Sequence also depends on other factors like saccade latency, saccade gain and target size (Guadron et al. 2009).

References

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