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Eye dominance strength modulates the global effect on saccade accuracy

Introduction

The dominant eye is the one chosen to perform a monocular task. Vergilino-Perez et al. (2012) showed with binocular recordings that participants could exhibit **weak or strong eye dominance**.



Weak eye dominance: saccades exhibit a naso-temporal asymmetry (i.e., peak velocities higher for leftward saccades with the left eye and for rightward saccades with the right eye; Robinson, 1964).



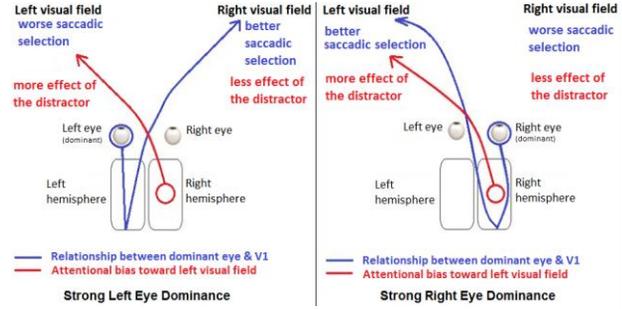
Strong eye dominance: For both eyes, saccades have higher peak velocities toward a same hemifield (i.e., higher peak velocities for leftward or rightward saccades, for both eyes).

The dominant eye is known to be preferentially related to the ipsilateral V1 (Erdogan et al., 2002; Shima et al., 2010). Recently, we have shown (Tagu et al., 2016) that for strong eye dominance, the influence of a distractor proximal to the target on saccade accuracy ("global effect", Walker et al., 1997) is reduced in the visual field contralateral to the dominant eye (controVF). This was not the case for weak eye dominance. We concluded that for **strong eye dominance, the relationship between dominant eye and ipsilateral V1 induces a better selection of the saccadic target in the controVF**. This advantage of the controVF was enhanced for strong left eye dominance and reduced for strong right eye dominance. We proposed this difference could be due to the co-occurrence of a leftward attentional bias giving more weight to the distractor because of the right specialization for visuo-spatial attention.

A way to test this interpretation is to give more weight to the saccade target by increasing saccade preparation time, which is known to boost saccade accuracy (Coëffé & O'Regan, 1987).

Aim of Current Research

To dissociate between the saccade target selection process linked to eye dominance from the leftward attentional bias proposed in Tagu et al. (2016) by using the global effect paradigm with protocols inducing short (gap-200 and step) and long (overlap-600) saccade latencies (Becker, 1989).



Hypotheses

The co-occurrence of the eye dominance effect and the attentional bias depends on the saccade preparation time:

⇒ In the **Gap-200 block**: Leftward attentional bias for all the participants (i.e., more influence of the distractor on saccade amplitude in the LVF than in the RVF).

⇒ In the **Step block**: Replication of Tagu et al. (2016), i.e., more accurate saccades in the controVF for participants with strong eye dominance but not for participants with weak eye dominance.

⇒ In the **Overlap-600 block**: For strong eye dominance, observation of the selection of the saccadic target in the controVF linked to the eye dominance, without any leftward attentional bias. This was not expected for weak eye dominance.

Tagu et al., Invest. Ophthalmol. Vis. Sci., 2016

Methods

Participants:

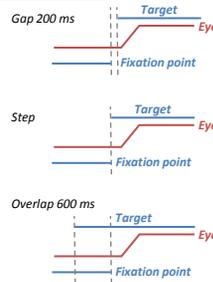
58 right-handed participants (47♀, 23±7 y.o.)
4 groups according to **eye dominance** (« Hole-in-card test ») and **eye dominance strength** (Vergilino-Perez et al., 2012):

- 11 R+ (right and strong eye dominance)
- 25 R- (right and weak eye dominance)
- 09 L+ (left and strong eye dominance)
- 13 L- (left and weak eye dominance)

Stimuli:

- Central fixation cross: 0.5 x 0.5° white cross, 4.5 cd/m²
- Saccade target and distractor: 0.5 x 0.5° white circles, 27 cd/m²
- Medium gray background, 4.5 cd/m²

Protocols:



Procedure:

• 3 blocks of 200 trials:
Gap-200 ms | Step | Overlap-600 ms
(order counterbalanced across subjects)

• Each trial of each block began by the presentation of the initial central fixation cross during 500 to 900 ms.

• Leftward and rightward trials were intermixed.

• Task: Make a saccade toward the farthest stimulus (the saccade target).

Instruments:

Binocular recording with an EyeLink 1000 system, SR Research®, sampled at 500 Hz and 0.25°.

Stimuli were displayed on a Iiyama HM240DT monitor (170 Hz refresh rate, 800 x 600 pixels resolution).

	3°	5°	7°	
x	•			Control no-distractor conditions
x		•		
x			•	
x	•	•		Distractor-Target conditions
x		•		
x			•	

Results

Latencies:

Effect of the Paradigm: Latencies Gap-200 (176±23 ms) < Step (201±25 ms) < Overlap-600 (235±36 ms) (F[2,108]=82, p<.0001; Tukey HSD all p<.001)

Global effect percentage (GEP): $GEP = 100 \times \frac{Amp - Amp_{3^\circ}}{Amp_{5^\circ \text{ or } 7^\circ} - Amp_{3^\circ}}$

- If GEP = 0% → saccade lands on the distractor
- If GEP = 100% → saccade lands on the target



• **Effect of the Paradigm:** GEP Gap-200 (48±16%) < Step (51±15%) < Overlap-600 (83±15%)

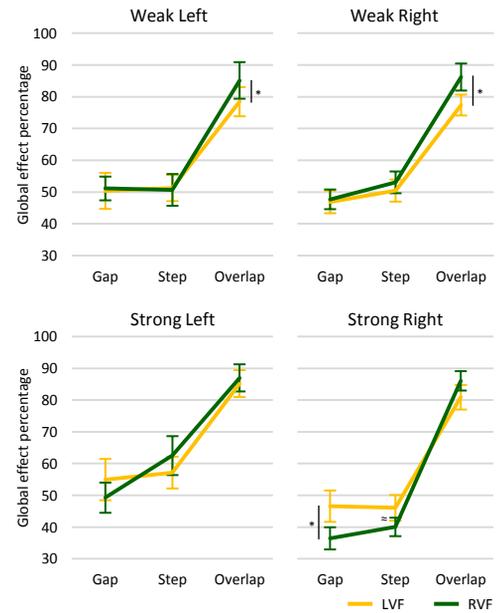
(F[2,108]=171, p<.0001; Tukey HSD all p<.05)

• **Paradigm x Hemifield interaction** (F[2,108]=9.05, p<.001): GEP in LVF and RVF differ only in the Overlap-600 block, with LVF (80±16%) < RVF (86±18%). Accuracy is thus higher in the RVF than in the LVF.

• **Interaction of interest (n. s.): Hemifield x Paradigm x Eye dominance x Eye dominance strength** (F[2,108]=1.7, p=.19), see table and figures

	Weak eye dominance	Strong eye dominance
Gap-200	GEP in LVF and RVF do not differ	GEP in LVF > RVF
Step	GEP in LVF and RVF do not differ	GEP in controVF > ipsiVF
Overlap-600	GEP LVF < RVF	GEP in LVF < RVF

• Note that in this study, when we have a look to the GEP in the RVF (the hemifield without any attentional bias), participants with strong left eye dominance are always more accurate than participants with strong right eye dominance. This reflects the "pure" effect of eye dominance on saccadic target selection in the controVF.



Conclusion

Our results showed an influence of eye dominance strength on the global effect on saccade accuracy, which depends on the saccade preparation time:

- Similar to Tagu et al. (2016), in Step conditions participants with strong eye dominance elicit more accurate saccades toward the controVF than toward the ipsiVF.
 - In Gap-200 conditions, for strong eye dominance the saccades are more accurate in the LVF than in the RVF, suggesting that the leftward attentional bias has not emerged yet.
 - In Overlap-600 conditions, all the participants elicit more accurate saccades in the RVF than in the LVF. This suggests that in this condition, the leftward attentional bias has emerged.
- Surprisingly, our preliminary results suggest that the leftward attentional bias due to the right hemispheric specialization for visuo-spatial attention needs time to emerge.