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How Eye Dominance Strength Modulates the Influence of a Distractor on Saccade Accuracy

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How eye dominance strength modulates the influence of a distractor on

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saccade accuracy

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29 **Abstract**

30 Purpose. Neuroimaging studies have shown that the dominant eye is preferentially
31 linked to the ipsilateral primary visual cortex. However, its role in perception is still
32 misunderstood. Here we examine the influence of eye dominance and eye
33 dominance strength on saccadic parameters, contrasting stimulations presented in
34 the two hemifields.

35 Methods. Participants with contrasted eye dominance (left or right) and eye
36 dominance strength (strong or weak) were asked to make a saccade toward a target
37 displayed at 5° or 7° left or right of a fixation cross. In some trials a distractor at 3° of
38 eccentricity was also displayed either in the same hemifield as the target (to induce a
39 global effect on saccade amplitude) or in the opposite hemifield (to induce a remote
40 distractor effect on saccade latency).

41 Results. Eye dominance did influence saccade amplitude as participants with strong
42 eye dominance showed more accurate saccades toward the target (weaker global
43 effect) in the hemifield contralateral to the dominant eye than in the ipsilateral one.
44 Such asymmetry was not found in participants with weak eye dominance or when a
45 remote distractor was used.

46 Conclusions. Here we show that eye dominance strength influences saccade target
47 selection. We discuss several arguments supporting the view that such advantage
48 may be linked to the relationship between the dominant eye and the ipsilateral
49 hemisphere.

50 Keywords: *Eye dominance, Asymmetry, Saccadic eye movements, Distractor, Global*
51 *effect*

52 **Résumé**

53 Introduction : La neuroimagerie suggère qu'il existe une relation privilégiée entre l'œil
54 dominant et le cortex visuel primaire ipsilatéral. Cependant, le rôle de la dominance
55 oculaire dans notre perception et notre action reste mal connu. La présente étude
56 vise ainsi à étudier l'influence de la dominance oculaire et de sa force sur les
57 paramètres saccadiques en manipulant l'hémichamp visuel dans lequel apparaissent
58 les stimuli.

59 Méthode : 92 participants étaient répartis en quatre groupes selon leur dominance
60 oculaire (gauche ou droite) et sa force (forte ou faible). Leur tâche consistait à
61 effectuer une saccade vers une cible présentée à 5° ou 7° d'excentricité, à gauche
62 ou à droite d'une croix de fixation. Dans certains essais, un distracteur présenté à 3°
63 accompagnait la cible, dans le même hémichamp (afin d'induire un effet global) ou
64 dans l'hémichamp opposé (afin d'induire un *remote distractor effect*).

65 Résultats : Chez les participants ayant une forte dominance oculaire, les saccades
66 étaient plus précises (moins d'effet global) lorsqu'elles étaient dirigées vers une cible
67 présentée dans l'hémichamp controlatéral à l'œil dominant que dans l'hémichamp
68 ipsilatéral. Cet effet n'était en revanche pas présent chez les participants ayant une
69 faible dominance oculaire. Par ailleurs, aucune différence entre hémichamps n'a été
70 trouvée sur la latence des saccades lors de la présentation d'un distracteur éloigné.

71 Conclusion : Cette étude montre que la force de la dominance oculaire module la
72 précision de la sélection saccadique. Nous suggérons que cette modulation soit due
73 à la relation privilégiée entre œil dominant et hémisphère ipsilatéral.

74 Mots-clés : Dominance oculaire, Asymétrie, Saccades oculaires, Distracteur, Effet
75 global

76 **1. Introduction**

77 The sighting dominant eye (DE) is the one chosen when performing a
78 monocular task. It is classically determined based on the “hole-in-the-card test”¹,
79 which provides a binary measure: left or right DE, according to the eye chosen by the
80 participant for sighting through the hole in a piece of cardboard. However, it has
81 recently been suggested that eye dominance could be assessed more precisely with
82 binocular recordings². Participants are categorized according to eye dominance
83 strength (i.e., strong or weak eye dominance) based on the analysis of the peak
84 velocity of saccades directed toward an isolated target. Indeed, participants exhibiting
85 higher peak velocities toward the hemifield ipsilateral to the DE whatever the eye
86 being measured are considered as having strong eye dominance, while participants
87 exhibiting higher peak velocities toward the left hemifield with the left eye and toward
88 the right hemifield with the right eye (i.e., standard naso-temporal asymmetry³) are
89 considered as having weak eye dominance².

90 DE has also been studied with neuroimaging data, showing that it activates a
91 greater part of the primary visual cortex (V1) than the non-dominant eye⁴. Other
92 evidence^{5,6} suggests that the V1 ipsilateral to DE is larger⁵ and more activated⁶ than
93 the V1 contralateral to DE, suggesting a privileged relationship between DE and
94 ipsilateral V1. Due to the crossing of the optical pathways, the V1 ipsilateral to DE
95 initially processes information presented to the hemifield contralateral to the DE.
96 Recently, it has been examined whether such a relationship could lead to differences
97 in the visuomotor processing of information from the hemifield ipsilateral or
98 contralateral to DE⁷. Using the Poffenberger paradigm (manual response to a target
99 presented either in the left or in the right hemifield, using either the right or the left
100 hand⁸), participants exhibited faster reaction times when the target was presented in

101 the hemifield contralateral to the DE than in the ipsilateral one⁷. The authors suggest
102 that this advantage of the hemifield contralateral to the DE over the ipsilateral one is
103 linked to the relationship between DE and ipsilateral V1. Indeed, this relationship
104 would lead to a better perceptual processing in the hemifield contralateral to the DE
105 than in the ipsilateral one. Interestingly, in a subsequent study, the authors found this
106 advantage of the hemifield contralateral to the DE only in participants with strong eye
107 dominance⁹ according to the peak velocity criterion². The participants with weak eye
108 dominance exhibited the standard Poffenberger effect (i.e., faster reaction times
109 when both the stimulation and the hand are on the same side⁸), suggesting that the
110 relationship between DE and ipsilateral V1 and the induced perceptual advantage of
111 the hemifield contralateral to the DE occur only when participants have strong eye
112 dominance.

113 The aim of the present study is to further examine the relationship between DE
114 and ipsilateral V1 and its role in perception and action mechanisms. To do so, we
115 assessed the respective influence of eye dominance (left or right) and of eye
116 dominance strength (strong or weak) on a saccadic task. Participants were instructed
117 to make a saccade toward a lateralized target with a distractor presented
118 simultaneously in the same or in the opposite hemifield. It is now well established that
119 a distractor being presented close to the target position modifies saccade amplitude
120 by deviating the saccade to an intermediate position between the two stimuli (global
121 effect, GE) whereas a distractor remote from the target position increases saccade
122 latency (remote distractor effect, RDE)¹⁰⁻¹². We therefore hypothesize that a
123 modulation of both effects, depending on the hemifield in which the distractor is
124 displayed, will reflect the influence of eye dominance and of eye dominance strength
125 on saccadic parameters. Indeed, in participants with strong eye dominance the

126 perceptual advantage of the hemifield contralateral to the DE should result in a
127 greater impact of the distractor presented in this hemifield compared to the ipsilateral
128 one on saccade amplitude and latency. Conversely, we expect no differences
129 between the two hemifields in participants with weak eye dominance, as found in
130 previous studies based on manual reaction times⁹. Finally, another manipulation
131 involved varying distractor luminance. It was made either as bright as the target or
132 brighter than the target. Indeed, this manipulation is known to provide greater GE
133 when the distractor is brighter than the target¹³. Greater perceptual weight given to
134 the distractor should differentially modulate the effects of eye dominance and of eye
135 dominance strength.

136 **2. Methods**

137 **2.1. Subjects**

138 Ninety-two right-handed participants were divided into four groups according to
139 their eye dominance (left or right) and eye dominance strength (weak or strong) as
140 defined by the analysis of saccade peak velocity². This classification was made *a*
141 *posteriori* after recording eye movement data (See Figures 1 and 2). Hand
142 preference was determined by using the Edinburgh Handedness Inventory¹⁴ and eye
143 dominance by using the hole-in-the-card test¹ repeated three times.

144 Insert Figures 1 and 2 Here

145 All of the participants had reported normal or corrected to normal vision.
146 Twenty-two had a strong right DE (4M 18 F; mean age: 22.6 years old, SD: 6.41;
147 mean laterality score: 79%, SD: 22.9%). Thirty-five had a weak right DE (7 M 28F;
148 mean age: 21.3 years old, SD: 2.32; mean laterality score: 81%, SD: 16.2%). Ten

149 had a strong left DE (1 M 9 F; mean age: 21.9 years old, SD: 3.11; mean laterality
150 score: 77%, SD: 18.8%) and twenty-five had a weak left DE (7M 18 F; mean age:
151 23.8 years old, SD: 6.7; mean laterality score: 83%, SD: 20.9%).

152 They gave their informed consent after an explanation of the procedure. The
153 study adhered to the principles of the Declaration of Helsinki and the procedure was
154 approved by the ethics committee of Paris Descartes University (Comité d'Evaluation
155 Ethique en Recherche Biomédicale, IRB number 20130500001072).

156 **2.2. Stimuli**

157 The initial central fixation was a $0.5^\circ \times 0.5^\circ$ white cross. The saccade target
158 and the distractor were both a $0.5^\circ \times 0.5^\circ$ white circle. All were displayed on a
159 medium gray background with a luminance of 4.5 cd/m^2 . The fixation cross and the
160 saccade target had a luminance of 27 cd/m^2 and the distractor luminance was either
161 27 cd/m^2 or 54 cd/m^2 .

162 **2.3. Instruments and Eye Movement Recording**

163 Stimuli were presented on an Iiyama HM240DT monitor with a refresh rate of
164 170 Hz and a resolution of 800×600 pixels. The experimental sessions took place in
165 a dimly lit room. Subjects were seated 57 cm away from the screen and their heads
166 kept stable with a chin and forehead rest. Movements of the two eyes were recorded
167 with an EyeLink 1000[®] (SR Research, Ontario, Canada) sampled at 500 Hz and
168 0.25° .

169 Each session began with a 9-point calibration filling the screen. Before each
170 trial, a small circle was presented at the center of the screen in order to compare the
171 actual eye position with the previous calibration. The participants had to fixate the

172 circle and press a button on a pad. Trial began when comparison was successfully
173 detected (see procedure). Online saccade detection corresponded to above-
174 threshold velocity ($30^\circ/\text{s}$) and acceleration ($8000^\circ/\text{s}^2$).

175 **2.4. Procedure and design**

176 Each participant ran four blocks of 165 trials for a total of 660 trials. The
177 saccade target was always presented in the left hemifield in two blocks and in the
178 right hemifield in the other two blocks. Thus, the uncertainty of target location was
179 reduced by the hemifield blocked design in order to minimize the possible
180 contribution to the distractor effect of decisional and strategy-based processes¹¹. The
181 order of the blocks was counterbalanced across subjects by alternating target side.

182 Each trial of each session began with the presentation of a central fixation
183 cross randomly displayed for 500, 600, 700, 800 or 900 milliseconds. During this
184 delay, the eye position was checked and if the distance between eye position and the
185 center of the cross was greater than 0.75° , the trial was cancelled and repeated later
186 in the session. The initial fixation cross disappeared simultaneously with the target
187 appearance. In the no-distractor control conditions, the target was presented in
188 isolation 3° , 5° or 7° to the left or to the right of the fixation cross on the horizontal
189 axis. In the target-distractor conditions, the target was presented at an eccentricity of
190 5° or 7° to the left or to the right of the fixation cross with a distractor presented at 3°
191 of eccentricity in the same hemifield (testing the GE) or in the opposite one (testing
192 the RDE). Participants were instructed to make a saccade either toward the isolated
193 stimulus in case of no-distractor control condition or to the most eccentric stimulus in
194 case of target-distractor condition.

195 The whole experiment included 6 no-distractor control conditions (3
196 Eccentricities * 2 Hemifields) and 16 target-distractor conditions testing the GE or the
197 Remote distractor effect (2 target eccentricities * 2 target hemifields * 2 distractor
198 sides * 2 distractor luminances). Each condition included 30 trials. In each block, the
199 target hemifield was held constant whereas all other conditions were intermixed.

200 **2. 5. Data Analysis**

201 Saccade latency and amplitude were measured. In the no-distractor control
202 conditions, peak velocity of the rightward and leftward saccades was also measured
203 in order to classify participants according to eye dominance strength². In the target-
204 distractor conditions, we also derived two standard additional measures to examine
205 the effect of the distractor on saccadic behavior. The RDE corresponds to the
206 average saccade latency difference between a given experimental condition and its
207 corresponding control condition when the target is displayed at the same eccentricity
208 with no distractor. The global effect percentage^{15,16} (GEP) was used to examine the
209 deviation of the saccade endpoint induced by the distractor. The GEP was calculated
210 using the following formula: $GEP = 100 * ((A_{3+5or7^\circ} - A_{3^\circ}) / (A_{5or7^\circ} - A_{3^\circ}))$, where A_{3° is
211 the average saccade amplitude to targets presented in isolation at 3°, A_{5or7° is the
212 average saccade amplitude to targets presented in isolation at 5° or 7°, and A_{3+5or7° is
213 the average amplitude of saccades evoked by target-distractor pairs. A GEP of 0%
214 means that the saccade landed on the distractor position (maximal GE) and a GEP of
215 100% that the saccade landed on the target position (no GE). In other words, the
216 higher the GEP, the lower the GE. All analyses were run using data from both eyes
217 separately. As our hypotheses do not involve any differences between saccadic
218 parameters of the left and right eyes, and as we indeed do not report such
219 differences, we here present only the data from the right eye.

220 **3. Results**

221 **3.1. Preliminary analyses**

222 Trials with blinks (less than 0.01%) and with latency, amplitude or peak velocity
223 outliers diverging from individual distributions (0.06%) were discarded from further
224 analyses. A preliminary analysis showed there was an effect of the block rank on
225 saccade latency ($F_{(3,315)} = 8.86, p < .001$). Latency was longer on the first block than
226 on the other three blocks. Therefore, in order to keep the number of saccades
227 executed to the left and to the right hemifields constant, the first and the fourth blocks
228 were removed from following analyses.

229 Before analyzing the data on the derived measures to examine the effect of
230 eye dominance and of eye dominance strength on the GEP and the RDE, we
231 conducted a twofold preliminary analysis. We checked that the distractor presented in
232 the hemifield opposite the target increased saccade latency. We also checked that
233 the distractor presented in the same hemifield as the target deviated saccade
234 amplitude. Average saccade latency and amplitude obtained for each condition are
235 presented respectively in Table 1 and 2.

		Left Visual Field										
		T3°	T5°	T5° D3°		T5° D-3°		T7°	T7° D3°		T7° D-3°	
Luminance Distractor				D=T	D>T	D=T	D>T		D=T	D>T	D=T	D>T
Right DE	Strong	188 (±28)	181 (±22)	184 (±24)	184 (±26)	201 (±30)	199 (±28)	180 (±29)	185 (±31)	184 (±26)	201 (±31)	204 (±29)
	Weak	184 (±23)	173 (±18)	179 (±21)	177 (±19)	193 (±20)	193 (±20)	175 (±21)	183 (±20)	182 (±20)	190 (±24)	194 (±27)
Left DE	Strong	184 (±25)	177 (±17)	179 (±17)	179 (±19)	195 (±21)	200 (±22)	181 (±18)	182 (±19)	183 (±14)	196 (±26)	198 (±26)
	Weak	186 (±19)	180 (±22)	181 (±20)	182 (±19)	193 (±20)	194 (±18)	175 (±15)	184 (±19)	182 (±19)	194 (±18)	191 (±22)

		Right Visual Field										
		T3°	T5°	T5° D3°		T5° D-3°		T7°	T7° D3°		T7° D-3°	
Luminance Distractor				D=T	D>T	D=T	D>T		D=T	D>T	D=T	D>T
Right DE	Strong	195 (±31)	188 (±22)	188 (±23)	185 (±24)	205 (±28)	203 (±26)	181 (±21)	187 (±23)	188 (±22)	200 (±25)	204 (±28)
	Weak	189 (±25)	181 (±24)	183 (±24)	183 (±24)	197 (±27)	198 (±28)	179 (±25)	184 (±22)	187 (±24)	197 (±26)	199 (±29)
Left DE	Strong	186 (±16)	177 (±14)	183 (±16)	180 (±16)	196 (±17)	197 (±17)	174 (±17)	182 (±22)	185 (±24)	195 (±18)	197 (±23)
	Weak	188 (±22)	180 (±22)	184 (±22)	185 (±20)	199 (±23)	198 (±23)	177 (±20)	186 (±18)	185 (±19)	194 (±19)	201 (±25)

236 Table 1 : Average latencies (and standard deviations) in milliseconds. Participants were categorized into four groups according to their eye dominance (Right DE; Left DE)
237 and eye dominance strength (Strong; Weak). Their task was to make a saccade toward a target presented either in the Left or in the Right visual field. In no-distractor
238 control conditions, the target (T) could be presented at an eccentricity of 3 (T3°), 5 (T5°) or 7° (T7°) from the initial fixation cross. In target-distractor conditions, the target
239 was presented at an eccentricity of 5 or 7° from the initial fixation cross with a distractor (D) presented either in the same visual field at an eccentricity of 3° (T5° D3° and
240 T7° D3°) or in the opposite visual field at an eccentricity of 3° (T5° D-3° and T7° D-3°). When presented, the distractor could have the same luminance as the target (D=T) or
241 could be brighter than the target (D>T).

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		Left Visual Field										
		T3°	T5°	T5° D3°		T5° D-3°		T7°	T7° D3°		T7° D-3°	
Luminance Distractor				D=T	D>T	D=T	D>T		D=T	D>T	D=T	D>T
Right DE	Strong	2.9 (±0.2)	4.7 (±0.3)	4.0 (±0.4)	4.1 (±0.3)	4.8 (±0.2)	4.8 (±0.2)	6.6 (±0.3)	5.8 (±0.5)	5.7 (±0.6)	6.7 (±0.3)	6.7 (±0.3)
	Weak	2.9 (±0.2)	4.6 (±0.3)	4.1 (±0.3)	4.0 (±0.3)	4.7 (±0.3)	4.7 (±0.3)	6.4 (±0.4)	5.6 (±0.6)	5.6 (±0.6)	6.6 (±0.4)	6.5 (±0.4)
Left DE	Strong	2.8 (±0.2)	4.6 (±0.3)	3.8 (±0.6)	3.9 (±0.5)	4.7 (±0.3)	4.7 (±0.3)	6.5 (±0.4)	5.4 (±1.0)	5.4 (±0.9)	6.6 (±0.3)	6.6 (±0.3)
	Weak	3.0 (±0.1)	4.8 (±0.2)	4.1 (±0.3)	4.1 (±0.3)	4.8 (±0.3)	4.8 (±0.3)	6.6 (±0.3)	5.7 (±0.6)	5.6 (±0.7)	6.6 (±0.4)	6.6 (±0.4)

		Right Visual Field										
		T3°	T5°	T5° D3°		T5° D-3°		T7°	T7° D3°		T7° D-3°	
Luminance Distractor				D=T	D>T	D=T	D>T		D=T	D>T	D=T	D>T
Right DE	Strong	3.0 (±0.2)	4.8 (±0.2)	4.1 (±0.4)	4.1 (±0.4)	4.9 (±0.2)	4.9 (±0.3)	6.6 (±0.4)	5.7 (±0.6)	5.6 (±0.6)	6.8 (±0.3)	6.8 (±0.3)
	Weak	3.0 (±0.2)	4.8 (±0.3)	4.2 (±0.3)	4.2 (±0.4)	4.9 (±0.2)	4.9 (±0.3)	6.7 (±0.4)	5.9 (±0.7)	5.8 (±0.8)	6.8 (±0.3)	6.8 (±0.3)
Left DE	Strong	3.0 (±0.2)	4.8 (±0.3)	4.2 (±0.4)	4.2 (±0.4)	4.9 (±0.4)	4.9 (±0.3)	6.7 (±0.3)	6.0 (±0.7)	6.1 (±0.6)	6.8 (±0.4)	6.8 (±0.4)
	Weak	3.1 (±0.2)	4.9 (±0.2)	4.3 (±0.3)	4.2 (±0.3)	5.0 (±0.2)	5.0 (±0.2)	6.7 (±0.3)	6.0 (±0.6)	5.8 (±0.7)	6.9 (±0.2)	6.9 (±0.3)

245 Table 2: Average amplitudes (and standard deviations) in degrees. Participants were categorized into four groups according to their eye dominance (Right DE; Left DE) and
246 eye dominance strength (Strong; Weak). Their task was to make a saccade toward a target presented either in the Left or in the Right visual field. In no-distractor control
247 conditions, the target (T) could be presented at an eccentricity of 3° (T3°), 5° (T5°) or 7° (T7°) from the initial fixation cross. In target-distractor conditions, the target was
248 presented at an eccentricity of 5° or 7° from the initial fixation cross with a distractor (D) presented either in the same visual field at an eccentricity of 3° (T5° D3° and T7°
249 D3°) or in the opposite visual field at an eccentricity of 3° (T5° D-3° and T7° D-3°). When presented, the distractor could have the same luminance as the target (D=T) or
250 could be brighter than the target (D>T).

251 ANOVAs were run on the average saccade latency (Table 1) and on the
252 average saccade amplitude (Table 2) with eye dominance and eye dominance
253 strength as between-subject factors and distractor condition (No distractor, Distractor
254 as bright as the target, Brighter distractor), saccade target eccentricity (5° or 7°) and
255 target presentation hemifield (Left or Right) as within-subject factors. Note that
256 regarding the average saccade latency, the no-distractor control conditions were
257 compared to the opposite-hemifield distractor conditions. Regarding the average
258 saccade amplitude, the no-distractor control conditions were compared to the same-
259 hemifield distractor conditions.

260 A main effect of the distractor was found on saccade latency ($F_{(2,176)} = 255.52$,
261 $p < .001$) as well as on saccade amplitude ($F_{(2,176)} = 505.67$, $p < .001$). As expected,
262 compared to the no-distractor condition, the presentation of a distractor in the
263 opposite hemifield simultaneously with the target induced an increase of 19 ms of
264 saccade latency ($F_{(1,88)} = 341.23$, $p < .001$) whereas the presentation of a distractor
265 within the same hemifield induced a deviation of the saccade of 0.8° closer to the
266 distractor ($F_{(1,88)} = 341.23$, $p < .001$). RDE and GE were thus well observed in our
267 experiment.

268 **3.2. Main results**

269 We then conducted several analyses on the derived measures to examine
270 whether the effects of the distractor could be modulated by eye dominance and eye
271 dominance strength. We expected greater effects of the distractor located in the
272 hemifield contralateral to the DE in the case of strong eye dominance and no
273 difference between the two hemifields in the case of weak eye dominance. Average

274 saccade latency difference (remote distractor effect) and average global effect percentage are presented respectively in Table 3
 275 and 4.

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		Left Visual Field				Right Visual Field			
		T5° D3°		T7° D3°		T5° D3°		T7° D3°	
Luminance Distractor		D=T	D>T	D=T	D>T	D=T	D>T	D=T	D>T
Right DE	Strong	19 (±17)	18 (±13)	21 (±13)	24 (±12)	17 (±21)	15 (±14)	20 (±14)	24 (±15)
	Weak	20 (±11)	19 (±11)	15 (±12)	19 (±15)	16 (±15)	17 (±12)	18 (±17)	19 (±16)
Left DE	Strong	18 (±9)	23 (±11)	15 (±17)	17 (±18)	19 (±14)	21 (±16)	21 (±10)	23 (±13)
	Weak	13 (±10)	14 (±14)	20 (±14)	16 (±17)	19 (±18)	18 (±12)	17 (±13)	24 (±20)

280 Table 3: Average remote distractor effect (and standard deviations) in milliseconds. Participants were categorized according to their eye dominance (Right
 281 DE; Left DE) and eye dominance strength (Strong; Weak). Their task was to make a saccade toward a target (T) that could appear in the left or in the right
 282 visual field, at 5 or 7° of eccentricity. Simultaneously with the target, a distractor (D) was presented at 3° of eccentricity in the visual field opposite the target.
 283 This distractor could either have the same luminance as the target (D=T) or be brighter than the target (D>T).

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		Left Visual Field				Right Visual Field			
Luminance Distractor		T5° D3°		T7° D3°		T5° D3°		T7° D3°	
		D=T	D>T	D=T	D>T	D=T	D>T	D=T	D>T
Right DE	Strong	63.0 (±12.4)	63.6 (±13.9)	78.0 (±9.9)	76.2 (±11.9)	62.4 (±14.1)	59.9 (±14.1)	74.0 (±13.4)	71.3 (±12.2)
	Weak	67.2 (±10.2)	63.4 (±9.2)	75.7 (±13.2)	76.0 (±11.9)	69.7 (±11.3)	69.5 (±13.2)	78.4 (±15.9)	76.1 (±17.5)
Left DE	Strong	55.8 (±19.5)	57.1 (±16.1)	68.7 (±21.8)	68.2 (±17.4)	69.4 (±12.2)	65.9 (±11.8)	81.4 (±12.0)	84.8 (±10.4)
	Weak	64.5 (±12.3)	62.8 (±11.6)	74.7 (±12.9)	73.6 (±15.8)	68.8 (±11.7)	64.6 (±13.2)	78.5 (±14.4)	74.7 (±15.7)

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Table 4: Average global effect percentage (and standard deviations). Participants were categorized according to their eye dominance (Right DE; Left DE) and eye dominance strength (Strong; Weak). Their task was to make a saccade toward a target (T) that could appear in the left or in the right visual field, at 5 or 7° of eccentricity. Simultaneously with the target, a distractor (D) was presented at 3° of eccentricity in the same visual field as the target. This distractor could either have the same luminance as the target (D=T) or be brighter than the target (D>T). Remember that the higher the GEP, the lower the distractor effect on saccade amplitude.

304 Two ANOVAs were conducted on the average saccade latency difference
305 (Table 3) and on the GEP (Table 4) with eye dominance (Left or Right) and eye
306 dominance strength (Strong or Weak) as between-subject factors and saccade target
307 eccentricity (5° or 7°), hemifield of target presentation (Left or Right) and distractor
308 luminance (Same or Brighter than the target) as within-subject factors. Concerning
309 the average saccade latency difference (Table 3), we found no main effect or
310 interaction between factors (all $p > .10$) with the exception of a significant effect of the
311 distractor luminance ($F_{(1,88)} = 4.57, p < .001$). Saccade latency increased very slightly
312 with a brighter distractor (1.5 ms on average). Data on the GEP (Table 4) indicated a
313 significant effect of target eccentricity ($F_{(1,88)} = 131.95, p < .001$): GE was higher with
314 shorter target-distractor distance (difference of 11.5%). Distractor luminance also
315 significantly affected GE ($F_{(1,88)} = 9.82, p < .005$): GE was higher with a brighter
316 distractor with a very slight difference (1.4%). We found no main effect either of eye
317 dominance ($F < 1$) or of eye dominance strength ($F_{(1,88)} = 1.05, ns$). However, a main
318 effect of the hemifield of presentation was found ($F_{(1,88)} = 7.73, p < .01$), the deviation
319 of the saccade toward the distractor being greater in the left hemifield (69.1%) than in
320 the right one (71.6%). More interestingly for our purpose, such an effect interacted
321 with eye dominance and eye dominance strength ($F_{(1,88)} = 8.86, p < .005$). Figure 3
322 presents this interaction between eye dominance (left or right) and hemifield (left or
323 right) in participants with strong (figure 3a) and weak (figure 3b) eye dominance. The
324 effect of the hemifield of presentation did not reach the significance threshold for
325 people with weak eye dominance ($F_{(1,58)} = 2.975, p < .10$) regardless of their DE ($F < 1$),
326 whereas it was amplified in participants with a strong left DE, the saccade being more
327 deviated toward the distractor presented in the left than in the right hemifield (62.4%
328 vs 75.4%, $F_{(1,9)} = 11.92, p < .007$). Participants with a strong right DE seemed to show

329 the reverse effect, with a distractor impact greater in the right hemifield than in the left
330 one, but the difference failed to reach the significance threshold (Figure 3a, $F_{(1,21)} =$
331 2.92, $p < .10$). However, it should be noted that an effect of eye dominance strength
332 was found in the right hemifield in participants with a right DE ($F_{(1,55)} = 3.87$, $p < .05$)
333 with the distractor effect being greater in participants with strong eye dominance
334 (66.9%) than with weak eye dominance (73.4%).

335 Insert Figure 3 Here

336 4. Discussion

337 4.1. Measuring eye dominance strength: The peak velocity criterion

338 Analyses of saccade peak velocities have been shown useful to estimate eye
339 dominance strength based on binocular recording of eye movements made toward
340 an isolated target². Accordingly, participants exhibit higher peak velocities toward the
341 hemifield ipsilateral to the DE in case of strong eye dominance and exhibit a naso-
342 temporal asymmetry³ in case of weak eye dominance². However, note that 2 of the
343 18 participants in the 2012 study exhibited higher peak velocities toward the
344 hemifield contralateral to DE whichever eye they used. In the present study, when we
345 categorized the 92 participants according to eye dominance strength, we noticed that
346 those with strong eye dominance also did not systematically exhibit higher peak
347 velocities toward the hemifield ipsilateral to the DE (see Figure 1). Indeed, 37.5%
348 (12/32) exhibited higher peak velocities toward the hemifield contralateral to the DE.
349 However, the results on the GEP for those 12 participants matched the patterns
350 observed in their eye dominance groups as defined by the hole-in-the-card test, with
351 lower GE (i.e., higher GEP) in the hemifield contralateral to the DE than in the

352 ipsilateral one. Therefore, these results on GEP as well as the different patterns of
353 peak velocities in the two studies suggest that the criterion for strong eye dominance
354 should finally be to exhibit higher peak velocities toward the same hemifield (left or
355 right) with both eyes, and not only toward the hemifield ipsilateral to the DE.

356 **4.2. Distractor Luminance**

357 In order to manipulate the perceptual weight of the distractor, the distractor
358 was either as bright as the target or brighter. We did not find a strong modulation of
359 the distractor effect neither for the remote distractor effect nor for the global effect. In
360 remote distractor effect conditions, we observed an only very slight effect of distractor
361 luminance on saccade latency, but no interaction with eye dominance, eye
362 dominance strength or hemifield. A very slight effect of distractor luminance was also
363 found on the GEP. Overall, the manipulation of distractor luminance we used
364 appeared to be not enough important to modify the pattern of results depending on
365 eye dominance and eye dominance strength.

366 **4.3. Remote distractor effect**

367 A distractor displayed in the hemifield opposite the target hemifield produced a
368 RDE. However, neither eye dominance nor eye dominance strength modulated this
369 effect. Unlike saccade amplitude or saccadic peak velocity², the presence of
370 asymmetries on saccade latency is unclear in the literature: some studies reported
371 average left-right asymmetries^{17,18} while others not^{19,20}. However, these studies never
372 took into account eye dominance or even manual laterality. Very few studies have
373 looked the effect of eye dominance but again without consistent results^{2,21,22}. The
374 present study tested these asymmetries on a large sample of participants, and failed
375 to find any left-right asymmetries on saccade latency. The fact that RDE did not differ

376 between the two hemifields in participants with strong eye dominance suggests that
377 eye dominance does not influence saccade latency, at least in the conditions we
378 tested.

379 **4.4. Global effect**

380 When the distractor was in the same hemifield as the target, our results show
381 that the distractor had more impact on saccade amplitude (GE) when presented in
382 the hemifield ipsilateral to the DE than in the contralateral one. This was true only in
383 participants with strong eye dominance. However, this contrasts with our assumption
384 based on findings involving the presentation of a unique stimulus^{2,7,9}. Interestingly,
385 the presentation of two stimuli, one of which is the saccade target as used in the
386 present study, specifies the perceptual processing advantage of the hemifield
387 contralateral to the DE, which would finally not occur in the overall hemifield, but
388 would be restricted to the saccade target location. Therefore, in a saccadic task we
389 suggest that the relationship between DE and ipsilateral V1 would lead to a more
390 accurate selection of the saccadic target in this hemifield (i.e., smaller effect of the
391 distractor on saccade amplitude) than in the ipsilateral one.

392 Note that the accurate selection of the saccadic target in the hemifield
393 contralateral to DE for participants with strong eye dominance is hypothesized in light
394 of the relationship between DE and ipsilateral V1, but V1 is only the starting point of
395 the sensori-motor transformation. The signals are then transmitted to the parietal eye
396 fields in the posterior parietal cortex and to the frontal eye fields, close to the
397 precentral sulcus^{23,24}. So, it remains open whether the relationship between DE and
398 ipsilateral V1 will then lead to left-right asymmetries in parietal eye fields and frontal
399 eye fields activations. Future neuroimaging studies could help to clarify this point,

424 5. Conclusion

425 Researchers can now precisely measure participants' handedness based on
426 questionnaires assessing a percentage of handedness. However, eye dominance is
427 still evaluated based on binary measures. Much research has been carried out to
428 develop a more graduated measure of eye dominance^{2,9,29-35}. We here show different
429 visuomotor influences of eye dominance according to eye dominance strength.
430 Moreover, the use of two stimuli helped to specify the link between DE and ipsilateral
431 V1 (previous studies used a simple target stimulus^{2,7,9}). Indeed, the better processing
432 that it involves in the hemifield contralateral to the DE seems not to operate in the
433 whole hemifield, but seems restricted to the saccade target location. These findings
434 point out the importance of taking into account participants' eye dominance and eye
435 dominance strength in further visual or visuomotor studies.

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519 **Figure legends:**

520 Figure 1: Average differences of peak velocities of saccades toward isolated targets
521 in left and right visual fields indicating strong eye dominance.

522 Participants were categorized into two groups according to their eye
523 dominance (Left or Right) measured with the hole-in-the-card test. Negative values
524 indicate that saccades toward the left visual field exhibit higher peak velocities than
525 saccades toward the right visual field, and positive values indicate the opposite.
526 Those differences have been calculated for saccades made toward isolated targets
527 presented at 3, 5 or 7° of eccentricity for the right eye (R eye) and the left eye (L
528 eye). All the participants presented in this graph exhibit higher peak velocities toward
529 a same visual field whatever the eye being measured for at least two of the three
530 eccentricities tested. Therefore, they have been categorized as having strong eye
531 dominance.

532 Figure 2: Average differences of peak velocities of saccades toward isolated targets
533 in left and right visual fields indicating weak eye dominance.

534 Participants were categorized into two groups according to their eye
535 dominance (Left or Right) measured with the hole-in-the-card test. Negative values
536 indicate that saccades toward the left visual field exhibit higher peak velocities than
537 saccades toward the right visual field, and positive values indicate the opposite.
538 Those differences have been calculated for saccades made toward isolated targets
539 presented at 3, 5 or 7° of eccentricity for the right eye (R eye) and the left eye (L
540 eye). All the participants presented in this graph exhibit higher peak velocities toward
541 the right visual field with the right eye and toward the left visual field with the left eye
542 (i.e., naso-temporal asymmetry) for at least two of the three eccentricities tested.
543 Therefore, they have been categorized as having weak eye dominance.

544 Figure 3: Interaction between Eye dominance strength, Eye dominance and
545 Visual field on Global Effect Percentage (GEP).

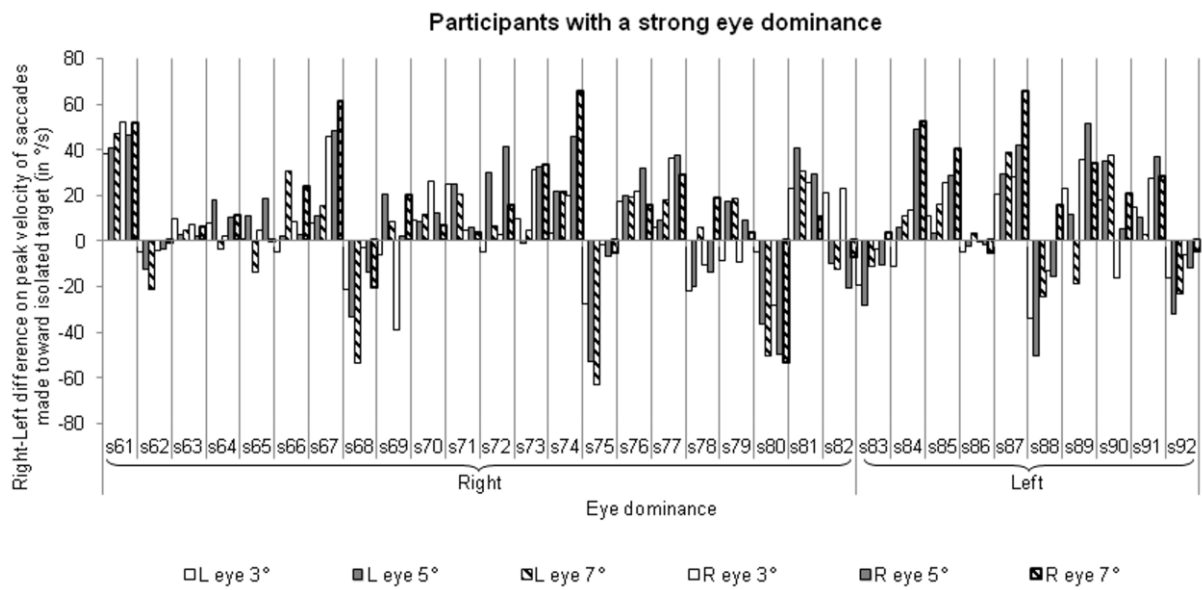
546 Figure 3a shows the interaction between Eye dominance (L = left DE; R = right
547 DE) and Visual field (LVF = left visual field; RVF = right visual field) in participants
548 with strong eye dominance. Figure 3b shows the same interaction in participants
549 with weak eye dominance. In both graphs, the significant differences are indicated
550 with the symbol * ($p < .05$) and the differences that failed to reach significance with
551 the symbol \approx ($.05 < p < .10$). Error bars represent standard errors.

552 Figure 4: Illustration of the two phenomena inferred from our results on the global
553 effect percentage (GEP).

554 Black indicates the relationship between DE and ipsilateral V1, leading to a
555 more accurate saccadic selection in the visual field contralateral to the DE than in
556 the ipsilateral one. This phenomenon occurs in opposite visual fields in
557 participants with a strong left DE (Figure 4a) and with a strong right DE (Figure
558 4b). Gray indicates the second phenomenon, an attentional bias toward the left
559 visual field due to the right hemisphere specialization for visuo-spatial attention,
560 giving more weight to the distractor in this visual field than in the right one.

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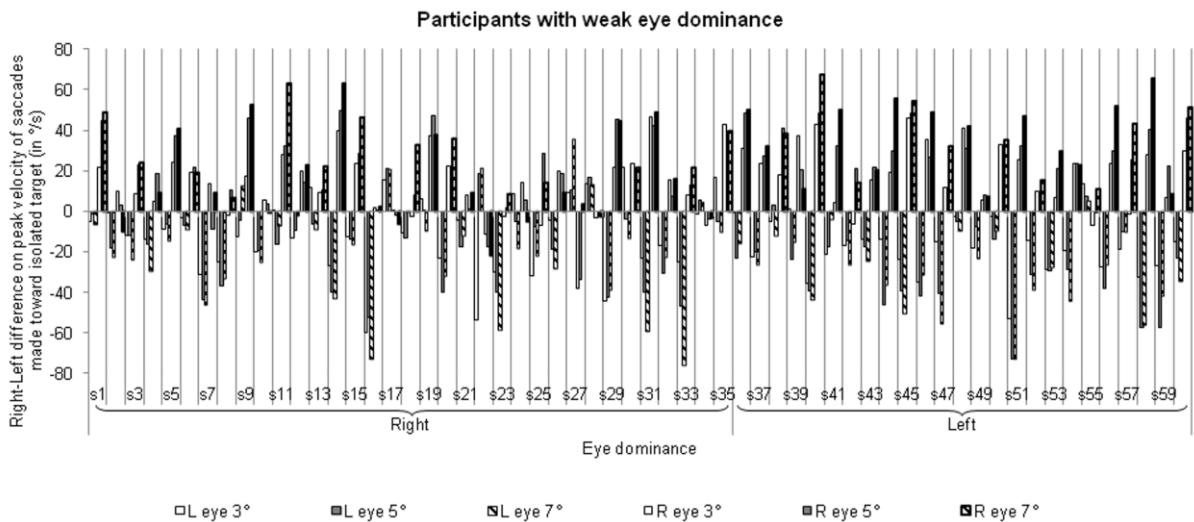
562 Figure 1:



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565 Figure 2:

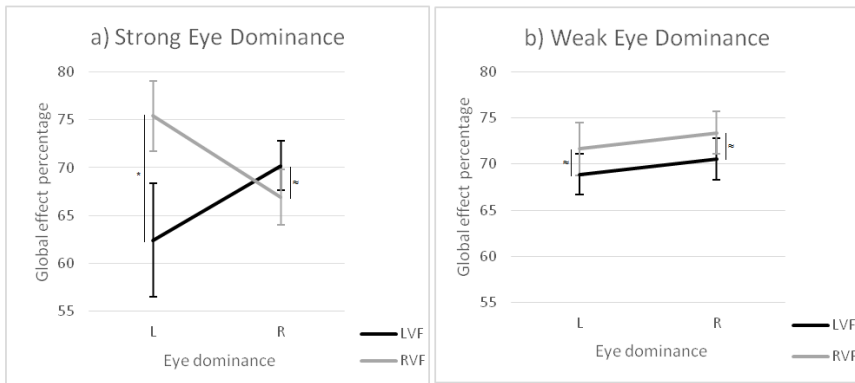


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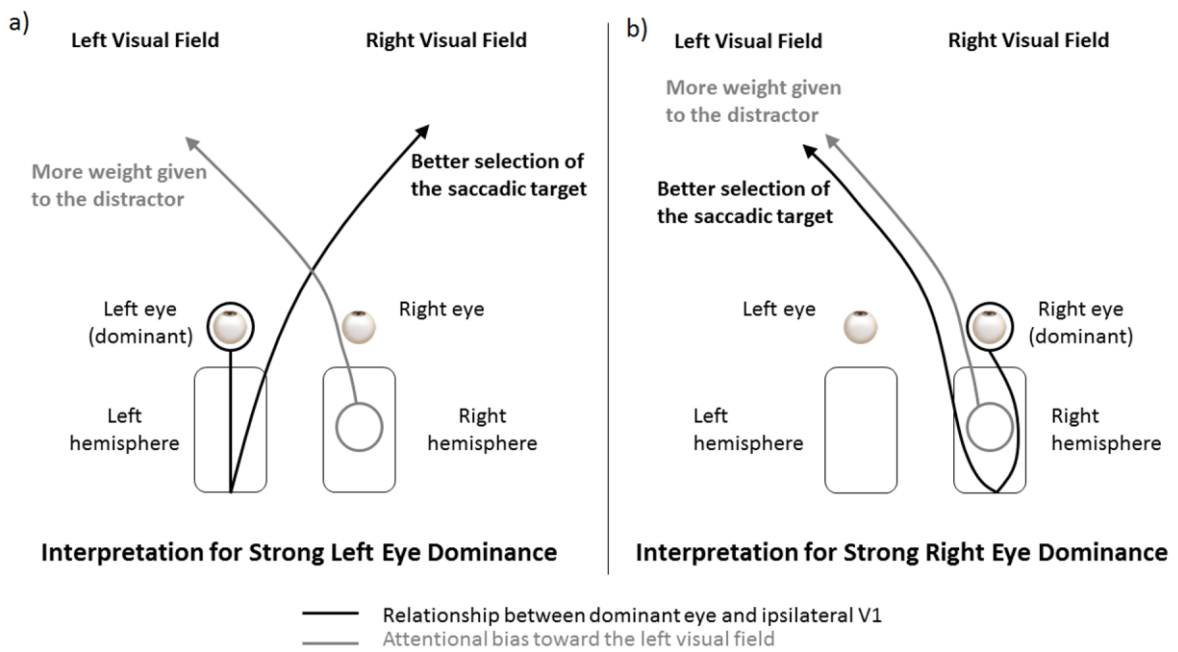
569 **Figure 3:**



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572 **Figure 4:**



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