

**The rival doesn't catch my eyes: In-group relevance  
modulates inhibitory control over anti-saccades**

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## Group and inhibitory control of saccades

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## **Abstract**

We examined the effects of in-group relevance on inhibitory control in anti-saccades. In Experiment 1, following a central coloured cue, football fans were instructed to look at the target on pro-saccade trials or its mirrored position on anti-saccade trials. The targets were badges of participants' favourite football team (in-group), its closest rival, or a non-local neutral team. Our results revealed no significant differences on pro-saccade trials for in- versus out-groups.

However, on anti-saccade trials participants made more directional errors for the in-group badge compared to the badges of the neutral and rival teams. Moreover, the percentage of directional errors to in-group stimuli on anti-saccade trials was positively correlated with satisfaction toward the participant's own team.

Experiment 2, with separate blocks of pro- and anti-saccade and simple stimuli replicated the results of Experiment 1. Experiment 3, was conducted to test the effects of familiarity on the performance in pro- and anti-saccade tasks using items with no group relevance. Our results revealed that familiarity of the items with no group relevance did not modulate inhibitory control in anti-saccade trials. Further, Experiment 4 showed that for participants who did not have any interest in football the performance in anti-saccades did not differ for different football teams. Overall, our findings suggest that under conditions of real-world intergroup rivalry in-group relevance modulates inhibitory control over anti-saccades. Future studies should seek to unravel the mechanisms contributing to the effects of group relevance on inhibitory control.

**Keywords:** Pro-saccade, Anti-saccade, In-group, Rival, Directional error

## **Introduction**

Inhibitory control is an important aspect of human cognition (see Munoz, & Everling, 2004). Many studies have examined inhibitory control in visual attention by focusing on the contrast between pro- and anti-saccade tasks. Pro-saccade tasks represent the ‘natural’ action in viewing scenes, which is to direct an eye movement to a new imperative stimulus. Anti-saccade tasks are the opposite and require participants not to make the natural response (the pro-saccade) but to look away from the stimulus. Therefore, to perform an anti-saccade action, there needs to be inhibitory control over the naturally occurring pro-saccades (Everling & Fischer, 1998).

Previous studies have found different factors modulating inhibitory control in anti-saccade tasks. For example, the emotional relevance of the stimuli has been shown to modulate both pro- and anti-saccades. For example, in their study Kissler and Keil (2008) had participants make pro- and anti-saccades towards or away from highly arousing pleasant and unpleasant pictures. They found that high emotional content in the pictures (both pleasant and unpleasant) facilitated pro-saccades but disrupted anti-saccades, generating more incorrect eye movements to the stimuli.

In addition to the effect of emotional content on inhibitory control in anti-saccades, recent studies have shown that social relevance of stimuli can also modulate inhibitory control in an anti-saccade task (Gilchrist, Proske, 2006). For example, using mixed blocks of pro- and anti-saccades with social (faces) and non-social (cars, noise pattern) stimuli Morand and colleagues (2010) showed

that, compared to non-social stimuli, individuals made more directional errors towards social stimuli when they were instructed to look away from them.

Further, they showed that when participants were instructed to look at the stimuli they were significantly faster at making pro-saccades toward the social stimuli compared to the non-social stimuli. In addition, it has recently been shown that these effects are correlated with the activity in parieto-occipital cortex (Morand, Harvey, & Grosbras, 2014).

In line with this finding, studies have revealed that in-group relevance can also have an effect on performance in pro- and anti-saccade tasks. For example, Goldinger, He and Papesh (2009) instructed participants from different ethnic backgrounds to perform a face recognition memory test using both in-group (own race) and out-group (another race). They found that during encoding faces of the out-group, participants made longer and fewer fixations on the faces of out-group (compared to in-group). Moreover, pupil dilatation was larger for out-group compared to in-group faces.

In addition, it has been shown that in-group relevance affects the latency and accuracy of saccadic eye movements towards target items as well as the directional error in anti-saccade tasks (Harvey, Haensel, Konia, & Morand, 2011; Payne, 2005). For example, poor general inhibitory control (higher rate of directional error in the anti-saccade task) was linked to a greater racial bias (Payne, 2005). These findings provide evidence for the effect of social factors on inhibitory control of saccades, and suggest that in-group relevance modulates inhibitory control over anti-saccades.

In the real world and from an evolutionary perspective in-group relevance

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can be defined in the context of rivalry between in- and out-group. It has been suggested that a competitive relationship is an important motivating force for categorizing self and others into in- and out-groups (for example, see Fiske, 2013; Turner, Brown, & Tajfel, 1979). Rivalry creates a specific type of intergroup relationship, which can potentially have fundamental effects on different cognitive functions (Ruscher, Fiske, Miki, & Van Manen, 1991; Ruscher & Fiske, 1990; Van Bavel, & Cunningham, 2012).

One interesting question in this vein that remains unanswered is how rivalry between groups can potentially modulate inhibitory control in visual orienting. This was the main focus of our study. To answer this question, in Experiment 1 we had participants carry out pro- and anti-saccade tasks involving the badge of their in-group football team, the badge of the local rival team, and the badge of a neutral team with no competitive interaction history. We asked whether there was any effect of in-group relevance on performance in the anti-saccade task in the context of real world rivalry. For example, does the urge to look at one's favorite football badge result in a higher number of directional errors in the anti-saccade task for own vs. rival/neutral badges? Or similarly, does the motivation to look away from the rival team result in fewer directional errors in anti-saccades for the rival as opposed to in-group team? If this is the case how can we explain such effects?

Further, Experiment 2 was designed to test a similar hypothesis to that of Experiment 1 (effects of in-group relevance on inhibitory control in anti-saccade) in different settings with separate blocks of pro- and anti-saccades using abstract stimuli. Here, we used circles in different colours representing different university

rowing teams, two of which were traditional rivals (Oxford and Cambridge).

There is ample evidence on the role of both familiarity (see, for example, Zebrowitz, Bronstad, & Lee, 2007) and in-group relevance (e.g. Van Bavel, Packer, & Cunningham, 2011) on enhanced visual attention to in-group stimuli. However, the extent to which the effect is driven by in-group relevance, especially in the context of real world rivalry, is not clear. To better understand the role of familiarity on (potential) differential visual orienting to the in-group we conducted two more experiments. Experiment 3 provided a control study to test whether differential familiarity of the stimuli (rather than in-group relevance) modulates inhibitory control in anti-saccades. Experiment 3 was conducted as a control study using items with no group relevance (vegetables) but with different levels of familiarity ratings. If familiarity plays a pivotal role, we would expect participants to make more directional errors toward the more familiar items (in Experiment 3) compared to unfamiliar ones. However, if in-group relevance rather than familiarity has a critical effect on inhibitory control in anti-saccades, then we should see no difference in anti-saccade performance for the familiar and unfamiliar items. In addition, Experiment 4 provided an extra control study to test whether visual properties rather than group relevance could affect inhibitory control in anti-saccade trials. In this study participants with no interest in football performed the same task as that of the Experiment 1. If visual properties play an important role in inhibitory control in anti-saccades we expect the participants with no interest in football to perform differently for different team badges. However, if the group relevance drives any potential effects on inhibitory control in anti-saccades, participants with no interest in football should perform similarly for all the teams regardless of the differences in the visual properties of the team

badges.

We hypothesized that the urge to look at the in-group badge would result in more directional errors (poorer performance) on anti-saccade trials for the in-group stimulus compared with the rival and neutral stimuli (in both Experiments 1 and 2). Although our research did not directly test the exact underlying mechanisms, we speculate that the attentional bias might reflect the attraction and positive affect toward in-group stimulus (here favourite football team). To clarify the potential motives that might affect visual orienting we used the hierarchical in-group identification questionnaire, which measured the strength of five different subcomponents of in-group identification including solidarity, satisfaction, centrality, self-stereotyping and in-group homogeneity (Leach et al., 2008). (Please refer to the supplementary materials).

We hypothesized that the subcomponents of the questionnaires that tap into positive feelings about one's in-group might explain any potential effect that we might find in eye movement patterns. Therefore, we planned to perform correlations between the results of an eye movement task and the satisfaction subcomponent of the hierarchical in-group identification questionnaire (Leach et al., 2008).

In pro-saccade trials we asked whether it would be easier to look at the in-group in comparison to neutral and rival teams. By including the neutral team as a target (in addition to the rival and in-group) we aimed to better understand whether the potential effect of group relevance on pro- and anti-saccades resulted from the attraction of the in-group and/or the rejection of the rival.



## **Experiment 1**

### **Method**

#### ***Participants***

Forty-three participants (eleven females), mean (SD) age =  $30.07 \pm 8.26$ , range = 19-45, right handed, with normal or corrected-to-normal vision, and no reported neurological or psychiatric conditions, took part. Participants were recruited via an online advertisement asking for supporters of Oxford United Football Club. All participants had been supporters of Oxford United for at least two years at the time of testing mean (SD) time =  $20.00 \pm 11.02$ , range 2-40 years. Prior to the experiment, all participants signed a written consent form approved by the University of Oxford research ethics committee.

#### ***Apparatus***

Eye movements and pupil diameters were recorded from the left eye using Tobii eye tracking equipment (TX300, Tobii, Stockholm) running at 300Hz. First, a nine-point calibration procedure was conducted, with a spinning ball target of  $2^\circ$  visual angle. Calibration was repeated if the participant failed to fixate on the target on fewer than seven points out of nine. The experiment did not proceed if the calibration failed three times.

#### ***Stimuli and Procedure***

The target stimuli were square football badges,  $2^\circ$  visual angle, appearing at  $9^\circ$  visual angle off-centre on the horizontal axis to the left or right of the central fixation cross. The badges belonged to three football teams: Oxford United (in-

group), Swindon Town (rival) and Liverpool (neutral). All the images were presented against 50% grey background. The display of the three different badges had similar overall luminance.

Prior to the experiment participants were asked to identify each badge. They were also asked to rate (i) the level of familiarity they had with each football club using a scale from 1 (*not familiar*) to 7 (*perfectly familiar*) and (ii) how much they liked each team, from 1 (*not at all*) to 7 (*very much*). Participants also filled in the multicomponent in-group identification survey (adapted from Leach et al., 2008) and the football interest survey (adapted from Funk et al., 2004). In both surveys participants expressed their agreement with each statement on a 7-point Likert scale from 1 (*strongly disagree*) to 7 (*strongly agree*).

Participants sat 58 cm away from a 22-inch screen (51×32 degree of visual angle, 1920×1080 pixels, 100ppi, 60 Hz refresh rate) in a normally lit room with their chin on a chinrest. The experiment was implemented and run in Matlab (32-bit version R2012a; The MathWorks, Natick, MA) with Psychophysics toolbox (Brainard, 1997). Each participant was tested in one experimental session, lasting about 40 minutes.

Each trial started with a black fixation cross (1° visual angle) at the centre of the screen for the minimum of 500 ms. The trial proceeded if the participant fixated within a 2° visual angle area around the fixation cross for at least 100ms. If necessary, the fixation presentation was repeated up to two more times. If the participant failed to fixate after three attempts, the trial was skipped.

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The trial continued with a cue for 500 ms, consisting of a fixation cross either green or red. The cue was followed by a blank screen (fifty percent grey background) of 200ms, after which the target was presented for 500 ms either on the right or left part of the screen. Participants were instructed to look at the target for the green cue, and away from the target for the red cue. A random inter-trial interval (ITI) of 1 to 2 seconds was inserted after each trial to avoid trial-to-trial directional effects (see, Barton, Goff, & Manoach, 2006).

Pro-saccade and anti-saccade trials were presented in a random order. Each participant was presented with 6 blocks of 48 mixed pro- and anti-saccade trials, for the total of 288 trials. Participants took up to a two-minute break after each block. There was a short practice block (12 trials) prior to the test block. The timeline of a trial is presented in Figure 1, including examples of the targets. By using the practice block, we made sure that all participants understood the instructions and followed those instructions throughout the experiment. None of the participants reported any explicit/conscious effect of the badges on their peripheral visual orienting.

Figure 1. about here

### ***Data Processing***

Gaze data was processed using custom Matlab scripts. Saccade onset was determined as the time when the eyes exceeded the velocity and acceleration of  $30^{\circ}/s$  and  $8,000^{\circ}/s^2$  respectively (see, DeSimone, Everling, & Heath, 2015). Trials were excluded from analysis if the latency of the saccade was

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shorter than 100 ms. or longer than 800 ms. Overall, 11% of the trials were discarded. For the valid trials, we calculated the directional error rate<sup>1</sup>, the latency of the corrective saccades (the saccades that start in the opposite direction of the first erroneous saccades) and the saccade latency.

## Results

Two participants were excluded as they reported extreme eye tiredness and low concentration during the task. Data for these two participants was discarded due to their high percentage of invalid trials (in excess of 50%). Therefore, the analyses were conducted on the remaining forty-one participants. Participants identified all three badges correctly. All participants correctly classed Swindon Town football club as the rival to Oxford United football club (the in-group team) and all classed Liverpool as being neutral in relation to the Oxford United. On average 75% of the participants reported that the team they supported was their family's favourite too. On average participants reported that they went to  $22.53 \pm 10.49$  matches per season (range 3 to 40). The mean (SD) score for the subcomponents of the in-group identification questionnaire were solidarity =  $18.56 \pm 2.12$  (max 21), satisfaction =  $21.97 \pm 4.70$  (max 28), centrality =  $15.24 \pm 3.88$  (max 21), in-group homogeneity =  $8.92 \pm 2.38$  (max 14), and self-stereotyping =  $9.78 \pm 2.42$  (max 14).

The mean (SD) familiarity ratings were: in-group =  $6.17 \pm .80$ , rival =  $4.85 \pm .83$ , and neutral =  $6.02 \pm .87$ . A repeated measures analysis of variance (ANOVA) with team as within subject variable with three levels (neutral, in-group and rival) was used to test whether familiarity differed with respect to group relevance.

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<sup>1</sup> Directional errors are responses with a horizontal vector in the wrong direction (e.g. left instead of right).

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Since the assumption of sphericity was not fulfilled, the degrees of freedom were adjusted using Greenhouse-Geisser. The results showed that these ratings differed significantly,  $F(1.39, 55.76) = 85.74$ ,  $p < .001$ ,  $\eta^2 = .68$ , with both in-group,  $t(40) = 9.92$ ,  $p < .001$  (mean difference =  $1.31 \pm .84$ ,  $d = 1.55$ ), and rival,  $t(40) = 9.71$ ,  $p < .001$  (mean difference =  $1.17 \pm .77$ ,  $d = 1.57$ ), being rated as more familiar compared to the neutral team.

Similarly, a repeated measure ANOVA with team (in-group, neutral and rival) as within subject variable was used to test whether liking rating differed for different teams. The mean (SD) liking ratings were: in-group =  $6.60 \pm .58$ , rival =  $3.31 \pm .79$ , and neutral =  $4.14 \pm 1.08$ . These ratings differed significantly for different teams,  $F(2, 80) = 189.26$ ,  $p < .001$ ,  $\eta^2 = .82$ . The differences were due to the in-group being rated as more liked than both the neutral,  $t(40) = 14.37$ ,  $p < .001$  (mean difference =  $2.46 \pm 1.09$ ,  $d = 2.27$ ), and rival teams,  $t(40) = 15.05$ ,  $p < .001$  (mean difference =  $3.29 \pm 1.40$ ,  $d = 2.41$ ). Also, the neutral team was rated as being more liked compared to the rival team,  $t(40) = 6.61$ ,  $p < .001$  (mean difference =  $.82 \pm .80$ ,  $d = 1.09$ ).

## ***Latency***

Next, we used a  $2 \times 3$  repeated measures ANOVA to test whether there was any effect of the trial type (pro- and anti-saccade) as well as the team (in-group, neutral and rival) on the time to initiate a saccade in a correct direction for pro- and anti-saccade trials. Results revealed that there was a significant main effect of trial type on saccade latencies,  $F(1,40) = 118.13$ ,  $p < .001$ ,  $\eta^2 = .74$ . Anti-saccade trials were started significantly later than pro-saccade trials (mean

difference (SEM) =  $64 \pm 6$  ms.). However, there was no significant main effect of team,  $F(2,80) = .416$ ,  $p < .66$ ,  $\eta^2 = .02$ , and no significant interaction,  $F(2,80) = .393$ ,  $p < .67$ ,  $\eta^2 = .02$ . Table 1 shows a summary of the results of Experiment 1 regarding the latency and error rate for both pro- and anti-saccades.

Table 1. about here

### ***Directional errors***

We first calculated the average directional error (movement in the opposite direction as instructed) on the x-axis for pro- and anti-saccade trials. As expected more directional errors occurred on anti-saccade trials (mean (SD) =  $23\% \pm 15\%$ ) compared to pro-saccade trials (mean (SD) =  $5\% \pm 3\%$ ). Since the percentage of directional errors on pro-saccade trials was very low, the analyses were carried out only on anti-saccade trials.

We tested whether there was any effect of the team on the percentage of directional errors on anti-saccades. Our results revealed that there was a significant main effect of the team,  $F(2, 80) = 6.72$ ,  $p < .002$ ,  $\eta^2 = .15$ . Since the mean directional errors on neutral and rival teams were very close (neutral = .205 vs. rival = .207) for the post hoc comparisons we compared in-group against neutral and rival teams, and no comparison was performed between the neutral and the rival teams. Therefore, the significance level for multiple comparisons was defined based on only two comparisons rather than three ( $.05/2 = .025$ ). The results of the post hoc multiple comparisons revealed that participants made more directional errors to in-group targets compared to the rival team,  $t(40) = 3.33$ ,  $p <$

.002 (percentage mean difference =  $3 \pm 7$ ,  $d = .53$ ). The difference between in-group and neutral was also statistically significant,  $t(40) = 3.16$ ,  $p < .003$  (percentage mean difference =  $3 \pm 6$ ,  $d = .50$ ). The results regarding directional errors are shown in Figure 2.

Figure 2. about here

### ***Corrective saccades***

Next, we tested the time that it took participants to correct their directional errors. This analysis was performed only on anti-saccade trials for two reasons. First, as mentioned earlier, the percentage of directional errors was very low on pro-saccade trials compared to anti-saccade trials. Second, an initial inspection showed that, on pro-saccade trials, participants rarely corrected their directional error (mean (SD) correction =  $14\% \pm 9\%$ ), whereas on anti-saccade trials participants normally corrected their directional errors (mean (SD) corrections =  $58\% \pm 18\%$  of the trials). The mean (SD) latency for the corrective anti-saccades were: in-group =  $361 \pm 103$ , neutral =  $359 \pm 102$  and rival =  $352 \pm 94$ . We used a repeated measure ANOVA analysis of the test the effect of team (in-group, neutral, rival) on the latency of corrective anti-saccades. The result revealed no significant main effect of team,  $F(2,78) = .25$ ,  $p < .78$ ,  $\eta^2 = .006$ .

### ***Correlational analyses***

Our results indicated that the percentage of directional errors in the anti-saccade task was greater for in-group stimuli relative to neutral and rival stimuli. We next investigated how the effect of group relevance on directional errors

might be related to subcomponents of the in-group identification questionnaire. In a previous study on the effect of in-group bias on perceptual matching we showed a positive correlation between in-group bias (the performance difference for in- and out-groups) and both solidarity and satisfaction subcomponents of the in-group identification questionnaire (see, Moradi, Sui, Hewstone, & Humphreys, 2015). Here, we asked whether there is any relationship between performance on the anti-saccade task and the different subcomponents of the in-group identification measure. The results regarding correlation analyses are shown in Figure 3.

Figure 3. about here

Our results revealed a positive correlation between the percentage of directional errors for in-group stimuli on anti-saccade trials and the satisfaction subcomponent of the in-group identification questionnaire (Leach et al., 2008),  $r = .350$ ,  $p < .025$ ,  $N = 41$ . The correlations between the directional errors on in-group anti-saccades and the other subcomponents of the in-group identification questionnaire were not significant.

We further asked whether there was any correlation between the percentage of directional errors on anti-saccades trials and liking scores (for in-group and rival); we did not find any significant correlations.

## Discussion

The results of Experiment 1 showed that participants who supported a certain team made more directional errors toward the badge of the in-group team



compared to those of rival and neutral teams. This can be taken as the evidence for the role of intergroup rivalry on inhibitory control in an anti-saccade task.

The second interesting finding of Experiment 1 was the positive correlation between the percentage of directional errors in the anti-saccade task and in-group satisfaction. In line with our hypothesis, this finding provides evidence for the role of in-group driven positive affect on inhibitory control in anti-saccades. However, we did not find any evidence of the effect of in-group relevance on the latency of pro-saccade trials. This could be related to the very simple nature of the task.

Another interesting aspect of the study is that the participants here did show differential familiarity for two of the teams (in-group and rival) over the third team (neutral). Despite the statistically significant difference between the rival and the neutral teams, there was no evidence of eye movements being attracted to the rival compared to the less familiar neutral team. These results provide evidence against the idea that the effects of the in-group relevance on the directional errors, in Experiment 1 were due to the in-group badge's familiarity.

## **Experiment 2**

Experiment 2 was conducted to test whether the effects of in-group relevance on inhibitory control that we found in Experiment 1 are replicable. Here, we introduced two changes: first we used abstract items for the groups (circles of different colours instead of football badges). Second, instead of having mixed blocks of pro- and anti-saccades we had separate blocks of each task. This

design ensures that the potential directional errors are not affected by the repeated or alternating order of the trials.

## **Method**

### ***Participants***

Twenty-one participants (fourteen females) mean age =  $22 \pm 2.5$ , range = 19-27, right handed, with normal or corrected-to-normal vision, and no reported neurological or psychiatric conditions took part. All the participants were current members of the University of Oxford rowing team and had been in this position for at least 2 months (mean time =  $10.5 \pm 9$ , range 2-42 months). These participants were naïve to the study. None of the participants took part in other three experiments relevant to this study. Participants were recruited via an internal advertisement. Prior to the experiment a written consent form approved by the University of Oxford research ethics committee was completed by all participants. The study was approved by the ethics committee of the University of Oxford and, prior to the experiment, written informed consent was taken from all participants.

### ***Stimuli and Procedure***

The stimuli were coloured circles,  $2^\circ$  of visual angle in size and were presented against 50% grey background (RGB 128,128,128) at  $9^\circ$  eccentricity either to the right or left of the fixation cross ( $1^\circ$  of visual angle in size) which was located at centre of the screen. The grey was used as a background colour to prevent chromatic aberration (Charman, 1991) and to keep the background colour consistent with Experiment 1s and 2. Three colours were used. The colours were chosen to represent the identity of the three University boat teams: Oxford

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University (RGB 0, 33, 71; dark blue), Cambridge University (RGB 163, 193, 173; light blue), and Newcastle University (RGB 11, 18, 238; intermediate blue). All participants correctly identified the colour of own and rival university rowing teams. However, all participants except for two did not recognise the colour of the neutral team. The neutral team was chosen so that its colour sat mid-way between the other two. The procedure was similar to that of Experiments 1 except that the session comprised 240 trials, with two blocks of the pro-saccade task (60 trials each) and three blocks of the anti-saccade task (40 trials each) in an alternating order (anti-/pro-/anti-/pro-/anti-). The alternating order remained the same for all participants. (For more details on methodological aspects of the design see, Antoniadou et al., 2013).

### *Data Processing*

Trials were excluded from the analysis if there was no fixation on the cross prior to cue onset (in total 5 % of the trials), and/or if the saccadic movement had started more than 2° away from the central fixation cross (1% of the trials).

## **Results**

### *Anti-saccade task*

One participant was excluded from the analyses due to the high number of invalid trials. The analyses were then conducted on the remaining twenty participants. We tested the effect of group relevance across three levels (in-group, neutral, rival) on the percentage of directional errors in the anti-saccade task using a repeated measure ANOVA. Our results showed that there was a significant effect of group relevance on the percentage of directional errors in the anti-

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saccade task,  $F(2, 38) = 168.20$ ,  $p < .001$ ,  $\eta^2 = .89$ . Post hoc comparisons revealed that in the anti-saccade task participants made fewer directional errors for the target representing the rival group compared to both in-group,  $t(19) = 20.47$ ,  $p < .001$  (mean difference % =  $8.00 \pm 1.74$ ),  $d = 5.85$ , and neutral targets,  $t(19) = 12.33$ ,  $p < .001$  (mean difference % =  $7.68 \pm 2.76$ ),  $d = 4.21$ , which did not significantly differ from one another,  $t(19) = .23$ ,  $p < .82$ . The results are depicted in figure 4.

Figure 4. about here

### ***Pro-saccade task***

We tested the effect of group relevance on saccade latency in the pro-saccade task. Although the mean saccade latency was faster for both in-group and rival target stimuli (mean =  $157 \pm 27$ ,  $156 \pm 21$  respectively) compared to the neutral stimuli (mean =  $178 \pm 63$ ), the effect of group relevance on latency was not statistically significant,  $F(2,38) = 2.00$ ,  $p < .14$ ,  $\eta^2 = .09$ . We further investigated the directional errors in the pro-saccade task. On average, participants made fewer than 7% directional errors in pro-saccade task. Since, on average the error rates were very low no further analysis was conducted on pro-saccade directional errors. The mean error rates on pro-saccade trials are shown in Table 1

## **Discussion**

In this Experiment we tested whether the effects of in-group relevance on inhibitory control (as found in Experiment 1) were replicable under different settings. Our results indicated that anti-saccades were easier to make away from the rival shape compared to the in-group shape. These data suggest that there was

a reduced approach response for the out-group (rival) stimuli, and hence a reduced tendency to make directional errors by making a saccade to the target on an anti-saccade trial. Consistent with the results from Experiment 1, it can also be argued that looking away from the in-group stimuli was more difficult (compared to stimuli associated with the rival group).

There was also a tendency for a reduction in directional errors to neutral compared with in-group targets, but this was not statistically significant. This result may be at least partially due to the fact that the colours associated with the in-group and neutral were slightly similar (and therefore more difficult to differentiate from one another) compared to the colour of the rival target, that was easier to differentiate from the in-group (please refer to the RGBs in p. 20). All in all these findings suggest that group relevance can modulate inhibitory control in anti-saccades, and the effects are (at least partially) replicable and stable throughout different settings.

## **Control Experiments**

So far, across two experiments we found that the in-group relevance affects the inhibitory control in anti-saccade task. However, one might argue that the effects shown in Experiment 1 and 2 could be due to the higher familiarity of the in-group stimulus or the differences in visual properties of the different stimuli. To compensate for these confounders we conducted two control studies presented in the following section.

### **Experiment 3: Control for familiarity**

Experiment 3 was conducted to disentangle the effects of familiarity on inhibitory control on anti-saccade. Here we used items that were not related to any team but had different familiarity ratings. If the higher rate of directional errors in anti-saccade task for in-group (Experiment 1) was driven by the in-group's higher familiarity, we should see similar results for the familiar stimulus in Experiment 3. However, if familiarity does not account for the higher rate of directional errors in anti-saccades, the performance should be similar for familiar and unfamiliar stimuli in Experiment 3.

### **Method**

Unless otherwise stated, the procedure was the same as that in Experiment 1.

#### ***Participants***

Twenty-three students (thirteen females) from the University of Oxford (mean (SD) age =  $24.91 \pm 5.29$  years, range = 18-35) took part in this study. These participants were naïve to the study. None of the participants took part in other three experiments. Participants were all right handed, and had normal or corrected to normal visual acuity. None of the participants reported any neurological or psychiatric conditions. The study was approved by the Ethics Committee of the University of Oxford and prior to the experiment a written consent was taken from all participants.

### ***Stimuli and Procedure***

The football badges were replaced with outline drawings of vegetables taken from a standard database (Snodgrass & Vanderwart, 1980) and presented in the same size as the badges. First, fifty independent participants rated the familiarity of sixteen different fruits and vegetables. The average familiarity rating for each item was calculated. Then three round-shaped vegetables were selected, two with a high familiarity rating (onion and tomato), and one with a low familiarity rating (artichoke). Familiarity and liking ratings were also collected from the group of participants who took part in the eye tracking experiment.

### **Results**

The mean (SD) familiarity ratings were:  $6.82 \pm .42$  for tomato,  $6.65 \pm .72$  for onion, and  $4.69 \pm 1.76$  for artichoke. Using a repeated measure ANOVA we tested whether there was any significant difference regarding familiarity ratings for three different vegetables that we used in the eye-movement task. Our results revealed that the familiarity ratings differed significantly for different vegetables,  $F(2,44) = 38.08$ ,  $p < .001$ ,  $\eta^2 = .63$ . Post hoc comparisons revealed that familiarity ratings for tomato,  $t(22) = 6.48$ ,  $p < .001$  (mean difference  $\pm$  SD =  $2.13 \pm 1.57$ ),  $d = 1.91$  and onion,  $t(22) = 6.16$ ,  $p < .001$  (mean difference  $\pm$  SD =  $1.86 \pm 1.45$ ),  $d = 1.76$ , were significantly higher than that of artichoke. The mean liking ratings were: tomato =  $5.52 \pm 1.53$ , onion =  $4.95 \pm 1.63$ , and artichoke =  $3.60 \pm 1.72$ . These ratings differed significantly for different vegetables,  $F(2,44) = 10.59$ ,  $p < .001$ ,  $\eta^2 = .32$ . Post hoc comparisons revealed that liking ratings for tomato,  $t(22) = 4.06$ ,  $p < .001$ ,  $d = .85$  (mean difference  $\pm$  SD =  $1.91 \pm 2.25$ ), and onion,  $t(22) = 2.98$ ,  $p$

## Group and inhibitory control of saccades

$<.007$ ,  $d = .62$  (mean difference  $\pm$  SD =  $1.34 \pm 2.16$ ), were significantly higher than that of artichoke.

### ***Data Processing***

We used similar processing procedures to those for Experiment 1. Overall, 8 % of the trials were discarded.

### ***Directional errors***

We used a repeated measure ANOVA to test whether the directional errors were significantly different for the three vegetables with different familiarity ratings. The analysis was conducted only on anti-saccades. Our results revealed that there was no significant main effect of familiarity on anti-saccade directional errors,  $F(2, 44) = 1.28$ ,  $p < .287$ ,  $\eta^2 = .05$ .

### ***Corrective saccades***

Taking only anti-saccade trials we did not find an effect of familiarity on the latency of corrective saccades,  $F(2,44) = .597$ ,  $p < .555$ ,  $\eta^2 = .03$ .

### ***Latency***

As before, there was a significant main effect of the trial type on the latency of saccades,  $F(1,22) = 272.70$ ,  $p < .001$ ,  $\eta^2 = .92$ . The anti-saccade trials were started significantly later than the pro-saccade trials (mean difference (SE) =  $62 \pm 4$  ms.). However, there was no significant main effect of familiarity,  $F(2,44) = .154$ ,  $p < .86$ ,  $\eta^2 = .01$ , and there was no significant interaction,  $F(2,44) = .752$ ,  $p < .48$ ,  $\eta^2 = .03$ ). Table 1 shows the results of Experiment 2 regarding saccade latencies and the directional error rate.



## **Discussion**

In Experiment 3, we tested whether familiarity has any direct effect on the inhibitory control over anti-saccades. Our results revealed that for the items with different familiarity ratings the percentage of errors in anti-saccades did not significantly differ. Furthermore, we did not find any effect of familiarity on the latency of pro- or anti-saccades. This provides evidence that the effect we found in Experiment 1 is likely to be driven by in-group relevance rather than familiarity. Here, familiarity ratings mimicked those of Experiment 1 with two items (in-group and rival team in Experiment 1, and tomato and onion in Experiment 2) being rated more familiar as opposed to the third item (neutral team in Experiment 1 and artichoke in Experiment 2). Yet, the results of Experiment 3 do not support the notion that familiarity critically modulates the anti-saccade directional errors.

## **Experiment 4: Control for physical properties of the stimuli**

Experiment 4 was identical to Experiment 1, and conducted with individuals who had no interest in football. We tested whether or not the effects that we found in Experiment 1 were due to the physical properties of the badges.

## **Method**

Unless otherwise mentioned, the method was the same as for Experiment 1.

### ***Participants***

Twenty-one students (four females) from the University of Oxford (mean (SD) age =  $25 \pm 7$  years, range = 18-41) took part. These participants were taken

from a new sample rather than those who took part in Experiment 2 and 3.

Participants were all right handed, and had normal or corrected to normal visual acuity. None of the participants reported any neurological or psychiatric conditions. The study was approved by the Ethics Committee of the University of Oxford and prior to the experiment written consent was taken from all participants. Participants were asked to indicate (Yes/No) whether or not they actively supported a football team, attended matches and/or watch football matches on television. They were also asked if they had a family member supporting one of the teams in our study.

## ***Results***

All participants confirmed that they were not interested in football and did not support any particular football team. In addition, none had a family member who supported any of the teams that we used in Experiment 1. All participants also indicated that they did not actively attend the football matches. The mean (SD) familiarity ratings were Liverpool =  $4.80 \pm .61$ , Oxford United =  $3.90 \pm .60$  and Swindon =  $3.51 \pm .60$ . These ratings differed significantly,  $F(2, 38) = 35.87$ ,  $p < .001$ ,  $\eta^2 = .65$ . Liverpool was rated as more familiar than Swindon Town,  $t(19) = 6.72$ ,  $p < .001$ ,  $d = 2.14$ , and Oxford United,  $t(19) = 5.66$ ,  $p < .001$ ,  $d = 1.27$ . Oxford was also rated as more familiar than Swindon,  $t(19) = 3.94$ ,  $p < .001$ ,  $d = .88$ .

The mean (SD) liking ratings were: Liverpool =  $4.45 \pm .60$ , Oxford United =  $4.05 \pm .82$ , and Swindon Town =  $4.15 \pm .49$ . These ratings differed significantly,

$F(2, 38) = 3.43, p < .044$ .<sup>2</sup> Post hoc comparisons with the significance level of  $p < (.05/3 = .016)$  revealed that the liking score was significantly higher for Liverpool compare to Swindon,  $t(19) = 2.65, p < .016, d = .60$ . The difference between Swindon and Oxford United was not significant,  $t(19) = .490, p < .62$ ; nor was the difference between Oxford United and Liverpool,  $t(19) = 2.10, p < .049$ .

### ***Data Processing***

Unless otherwise stated the pre-processing was the same as Experiment 1. In Experiment 4, 13% of the trials were discarded overall.

### ***Directional errors***

The data from one participant was discarded due to very high percentage of directional error in anti-saccades (more than 70%). For the remaining participants, we used a repeated measure ANOVA with team as a within-subject variable to test whether the directional errors were significantly different for the three teams. The analysis was conducted only on anti-saccade trials. Our results revealed that there was no significant main effect of team,  $F(2, 38) = 2.48, p < .097, \eta^2 = .11$ .

### ***Corrective saccades***

Taking only anti-saccade trials we failed to show an effect of team,  $F(2,38) = 1.31, p < .281, \eta^2 = .06$

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<sup>2</sup> Note that since control participants did not identify with any of the teams, all the teams were “Neutral” to them..

### ***Latency***

Again, we used a repeated measure ANOVA to test whether there was any effect of the team (three different teams) and trial type (pro- vs. anti-saccades) on the latency for the movement started in correct direction. Our results revealed that there was a significant main effect of the trial type on the latency of saccades,  $F(1,19) = 39.44$ ,  $p < .001$ ,  $\eta^2 = .67$ . As expected, the anti-saccade trials were significantly slower than the pro-saccade trials (mean difference (SE) =  $58 \pm 13$  ms.). However, there was no significant main effect of team,  $F(2,38) = .732$ ,  $p < .49$ ,  $\eta^2 = .04$ , and there was no interaction,  $F(2,38) = 2.18$ ,  $p < .13$ ,  $\eta^2 = .11$ .

### **Discussion**

In contrast to the data from Experiment 1, when the performance of football fans was assessed, there was no effect of presenting different team badges on inhibitory control in anti-saccade of the participants here, who were not fans of any of the teams used. This indicates that effects found in Experiment 1 could not be due to the physical properties of the stimuli that were used (e.g., the colours of the Oxford United badge vs. that of Liverpool or Swindon Town). If the yellow and blue of the Oxford United badge attracted attention, then we should have seen equivalent effects here to those we observed in Experiment 1. We did not.

A second interesting aspect of the study is that the participants here did show differential familiarity for one of the teams (Liverpool) over the others (Oxford United, Swindon Town). This is not surprising given that, at the time of testing, Liverpool played in the Premier League and Oxford United and Swindon Town in lower divisions of the English football hierarchy. Despite the differential

familiarity favouring Liverpool, there was no evidence of eye movements being attracted to the Liverpool team badge here. These data provide evidence against the idea that the effects of the in-group badge, in Experiment 1, were due to familiarity.

## General Discussion

Our findings revealed that in-group relevance affects the inhibitory control of looking behaviour. Experiment 1 recruited football fans and compared pro- and anti-saccades to badges of three different teams, two of which were traditional rivals. The results of Experiment 1 showed that anti-saccades were more difficult to make (generating more directional errors) to the in-group badge compared to the rival badge. This indicates that it was more difficult to inhibit any tendency to orient to in-group stimuli. It appears that the competitive relationships might play an important role in generating differential inhibitory control in anti-saccades. This finding is important in that it shows how real world rivalry can in fact modulate inhibitory control in visual attention even in such a simple task. This is consistent with the in-group badge attracting attention and therefore leading to more incorrect pro-saccades on anti-saccade trials.

Another interesting result regarding Experiment 1 was that positive correlations were found between the percentage of directional errors for in-group stimuli and in-group satisfaction individuals experienced in relation to their in-group team. This finding suggests that the positive association participants had with their favourite football team plays a role in driving the differential directional pattern on anti-saccades. There may be various underlying factors that

play a role in these effects. Although we did not directly test the exact underlying mechanisms for the effect that we found, we can speculate that the positive association fans had with the in-group, reflected in satisfaction, could lead to decreased inhibitory control and therefore a higher rate of anti-saccade directional errors for in-group compared to the rival. Stimuli related to an in-group have been shown to be associated with positive concepts (for review see Fazio & Olson, 2003) and such stimuli may consequently evoke satisfaction. The draw of attention to a stimulus with positive valence may in turn impair inhibitory control over anti-saccades (Kissler & Keil, 2008).

The results of Experiment 3, with a significantly lower percentage of directional errors for the rival team, further confirmed that across different settings in-group relevance indeed modulated inhibitory control in an anti-saccade task. Although the findings of Experiment 3 might explain the effects of in-group relevance in a different way from that of Experiment 1, the results of the two experiments are at least in partial agreement. Such difference in the results of Experiment 1 (higher percentage of directional error for in-group compared to the rival and neutral groups) and Experiment 3 (lower percentage of directional errors for rival compared to the in-group and neutral group) might be due to the underlying mechanisms of the effects of group relevance on inhibitory control in anti-saccades. Further studies are needed to clarify whether the effects we found are due to the rejection of the rival (and therefore facilitation of avoidance response, in this case anti-saccade) or attraction of the in-group (and therefore generation of the approach response, in this case pro-saccade).

Our results on the effect of in-group relevance on eye movements mesh with other studies using eye tracking to examine group processes. For example, Goldinger et al. (2009) and also Wu, Laeng and Magnussen (2012) both recorded eye movements when participants performed a face-memory task. In the encoding phase at each trial, participants viewed a face (belonging either to their own race or another race) for a short time. They were then tested for their memory on faces. Wu and colleagues (2012) found that individuals made shorter fixations and more frequent saccades to own-race faces compared with faces from another race. The authors argued that such pattern of eye movements reflected the easier encoding of the own-race faces. On the other hand, using a similar paradigm Goldinger and colleagues (2009) found that while encoding faces of the other race, participants made fewer and longer fixation on the faces of the other race (compared to own race). Moreover, the pupil dilatation was larger for out-group compared to in-group faces. They interpreted these results as more effortful face encoding for out-group compared to in-group.

Whether own-race faces attract eye gaze, however, is more controversial. For example, Hirose and Hancock (2007) and also Humphreys, Hodsoll and Campbell (2005) examined change blindness to scenes containing images of the same or a different race as that of the participants. While changes applied to own-race faces were detected more easily, there was no evidence that this reflected differences in how eye movements were directed to the stimuli.

On the other hand, Cao, Wang, Rao and Fu (2013) showed that there was a delay in initiating a saccade to a location where an own-race face had previously appeared. They suggested that the own-race face initially attracted attention and

subsequently induced inhibition of return on eye movements, consistent with own-race faces attracting attention. Our results add to this literature and provide evidence that the in-group relevance of a stimulus modulates inhibitory control in anti-saccades.

We further directly tested whether familiarity can have similar impact to that of in-group relevance on inhibitory control in anti-saccade. In contrast to the data from football fans (Experiment 1), we found no differential effects of the items with different familiarity in Experiment 2. Participants in Experiment 2 rated their familiarity with two items (tomato and onion) as being higher than that with the third item (artichoke). Despite this, the vegetables did not differentially affect eye movement behaviour in Experiment 2. The data indicate that performance was not affected either by the differences in familiarity of the stimuli (for more details on the relationship between familiarity and in-group bias see, Moradi et al., 2015). This clearly shows that the effect we found in Experiment 1 (higher percentage of directional errors on anti-saccades for in-group) did not simply result from the in-group badge being more familiar. We therefore conclude that in-group relevance rather than familiarity resulted in a higher rate of directional errors in anti-saccade trials for in-group stimuli.

Future research may start to examine the generalizability of these effects and whether the effects of in-group identification on basic aspects of eye movement behaviour can predict in-group bias in real life. For example, the effects for both the in-group and the rival teams appeared to emerge automatically as they went against the task demands, and the procedure may be adopted as a new implicit measure of in-group bias.



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## Figure and table legends

**Figure 1.** Example (Left) pro-saccade and (Right) anti-saccade task used in Experiment 1. The original background was fifty percent grey and the badge represents *Swindon Town football club* (Original colour red and white). The green fixation cross was used to cue the target for pro-saccade and the red was used for the anti-saccade task.

**Figure 2.** Mean percentage (SE) error rate in anti-saccade task in Experiment 1 as a function of group relevance.

**Figure 3.** The positive correlation between in-group satisfaction ratings and the percentage error in the anti-saccade task in Experiment 1.

**Figure 4.** Mean percentage (SE) error rate in the anti-saccade task in Experiment 3 as a function of group relevance.

**Table 1.** Mean (SD) latency (ms.) and error rate (percentage) as a function of group relevance (in-group vs. neutral and rival) in Experiments 1, 2 & 3.