Go/No-Go Saccadic Reaction Times Towards Visual Field Targets differ between athletes and nonathletes

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***Abstract*—We studied whether performance (Correct Hits, Correct Rejections) on saccadic reaction time differs between ten professional hockey players and a control group of non-sportive young adults. We implemented a task during which observers were asked to make a movement towards a green dot with different eccentricities (Go trial) or to inhibit when a red dot is presented with same eccentricity (NoGo trial). First, our data showed no differences in the reaction time between both groups. However, within the group of hockey players, observers were faster for low eccentricity. Second, while the control group achieved better performance in the Correct Hit, Hockey players performed significantly better in the Correct Rejections (CR), with both groups were below chance level for the CR rates.**

Keywords- eye-movements;Correct Rejections;Correct Hits;reaction time;Go/NoGo task.

I. INTRODUCTION

Visual perception and attention are essential skills for athletes. They are both influenced and affected by each other. Athletes require excellent *vision* to anticipate opponents' movements [1] and to optimally perform in their sports. Using a meta-analysis on perceptual and visual aspects in different sports, Mann et al. (2007) found that these aspects are essential for performance [2].

Vision in athletes' sports has been excessively explored in the literature. Williams et al. (1975) investigated the differences between the vertical and horizontal fields of vision between athletes and nonathletes. They found that both fields of vision are higher for elites compared to the other group [3]. Another study explored the peripheral perception and demonstrated that athletes were significantly faster to respond compared to nonathletes when the target appears in the peripheral field [1]. Using a clinical battery of vision tests Christenson et al. (1988) revealed that athletes outperformed control groups in the visual reaction time and saccades [4]. Ando et al. (2001) showed that athletes tend to answer faster to a stimulus displayed in central as well as in peripheral positions compared to nonathletes [5]. Similarly, Muiños et al. (2014) showed that elites were faster when stimuli were shown at the peripheral visual field [6]. Other studies have also reported differences between elites and novice groups. A recent study conducted by Wimshurst et al. (2016), revealed the existence of dissimilarities in brain function activation of hockey players between an expert and a novice group [7]. Similarly, Williams et al. (2008) showed that elite athletes always perform better than novices in their domain of expertise [8]. Altogether, these studies show the importance of *vision* in athlete sports and that athletes outperforms nonathletes.

Besides these differences between athletes and nonathletes, other studies have explored whether vision can be trained and improved [9-10]. Appelbaum et al. (2018) reviews the training techniques in sports vision [11]. Wimshurst et al. (2012) showed that twenty-one Olympic hockey players who were tested before and after a ten-week visual training program presented significant improvements [12]. Alison et al. (2015) explored whether a preseason vision training program would improve visual skills and season success in an ice hockey team [13]. Their results indicate a positive influence of the training program on the players' visual skill. Similarly, Schwab et al. (2012) aimed at investigating if a vision training program would improve the performance's vision of young hockey players compared to a control group with no training. Results demonstrated significant differences between both groups [14]. These findings clearly show that *vision* can be trained and improved.

One of the reliable tools to enhance *vision* and *attention* is the D2 Visuomotor Training Device (D2). This tool is a light-training visuo-motor reaction time training device for high-performance athletics. It consists of a board with sixty-four buttons organized

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in 5 concentrical circles enclosing the center of the screen. These buttons can be lighted to be used as a stimulus for the participant [14]. Wells et al. (2014) showed that this tool is a reliable one to measure reaction time (RT) [15]. It has been used in different sports to improve peripheral vision for elite athletes and their reaction time [14].

Eye movements provide a functional signature on how vision is achieved. Interestingly, during the last decade novel statistical robust analytical methods of fixation mapping have been developed [16-18] contributing to the investigation of different visual processes. Interestingly, while using these methods, reliable eye movement differences have been found across cultures for face recognition [19-24], the recognition of facial expressions of emotion [25-26] ; for a review see: [27], for visual scenes [28-29], or between healthy and clinical patients [30-32]. Therefore, eye movements are an optimal technique to probe the hypothesis of better visual skills from visual information intake in professional athletes compared to healthy observers.

In this paper, we investigated performance and reaction time differences using a paradigm that is inspired from the Dynavision Visuomotor Training Device (D2) tool. We used a Go/NoGo task, in which a group of 10 professional athlete hockey players and students were required to follow or inhibit green and red dots, respectively. Instead of pressing a labeled key when a stimulus is on screen, participants are required to make a saccade (fast eye-movement) toward a green stimulus or to inhibit if the stimulus is red.

II. Methods

A. Participants

Ten male elite hockey players from Fribourg Gotteron (average age = 25 ± 5) and 10 male students of Fribourg's university (average age = 22 ± 3) participated in our experiment.

B. Stimuli and Paradigm Go/NoGo

Visual stimuli were dots that subtended a 0.4° of visual angle and were displayed at an eccentricity of 2°,5°,8° or 11°, see Figure 1. A dot with a green (red) color is defined as the Go (NoGo) condition respectively.

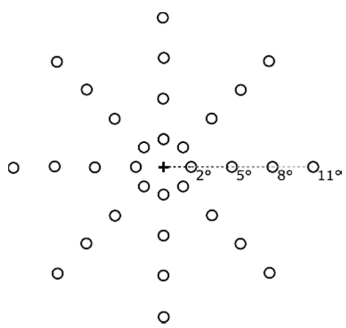

Figure 1. Representation of all possible locations of dots with an eccentricity of 2°,5°,8°,11° respectively.

During experiment, participants were instructed to either move their eyes towards a green dot or to inhibit it when a red dot is presented. The experiment included 10 blocks of 64 trials each (32 green and red dots per block). Each trial begun with a fixation cross shown randomly between 500 and 700ms followed by a 200ms blank screen and subsequent dot displayed for 700ms in a specific color and eccentricity. Before the next trial starts a blank screen for 500ms was displayed. The paradigm is illustrated in Figure 2.

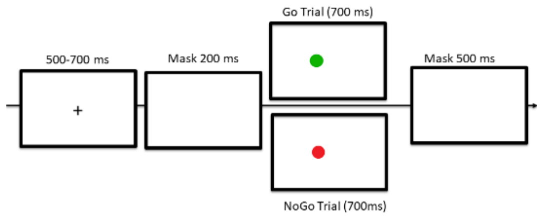

Figure 2. An example of a Go and NoGo trial. In this example, the eccentricity of the dot is 2°.

B. Procedure

We implemented the Go/NoGo task in Matlab (version 2013b), using the Psychtoolbox (PTB-3) [33-35] and EyeLink Toolbox extensions [36]. The experiment was displayed on a 1920 x1080 pixels VIEWPixx monitor. We recorded the eye movements of participants at a sample rate of 1000 Hz (only left eye was recorded) with an SR Research Desktop-Mount EyeLink . Participants were invited to sit in front of the screen at a viewing distance of 70 cm and were instructed about the Go/NoGo task (see Section B). At the beginning of the experiment and between the blocks of the experiment, a 9-points calibration procedure was conducted.

III. Analyses

Preprocessing: The algorithm of Nystrom & Holmqvist [37] was applied to detect the onset of the first saccade (RT in ms) for the Go condition. For each participant, RT that were higher or equal to 2.5SDs from the mean were discarded (1.81%).

Performance: The generalized linear mixed model (binomial family) was conducted [38] to investigate both Correct Hit (CH) and Correct Rejections (CR) performances. CH refers to a presence of a saccade for the Go condition and CR refers to an absence of a saccade for the NoGo condition. The *group* (hockey players vs students) and the *angle eccentricity* of the dot were considered as predictors with their interaction terms. The variable *participant* was considered as a random factor to account for the dependency.

RT: The linear mixed model was performed to investigate the reaction time (RT) of participants for the Go condition trials, only the correct trials were analyzed. The *group* (hockey players vs students) and the *angle eccentricity* of the dot were considered as predictors with their interaction terms. The variable *participant* was considered as a random factor to account for the dependency.

We fitted all models in R [39] using the lme4 and lmerTest packages [40].

IV. Results

A. Performance

Correct Hits: The results revealed significant effect of *group* ($\beta_{control}$ = 2.19, CI = [2.47,4.16], z(6391) =3.09, p<0.01) and *angle eccentricity* (β_{angle5} = 0.66, CI = [0.80,3.58], z(6391)=2.51, p<0.05, β_{angle8} = 0.63, CI = [0.15, 1.18] z(6391) =2.43, p<0.05). The control group performed better (M = 99.6%] compared to the hockey players (M = 96.5%), see Figure 3. Furthermore, while the performance of the control group was similar for all angles, the hockey players were better for angle 5 (98.17%) and 8 (98.11%) compared to 2 (96.50%).

Correct Rejections: The results indicated significant effect of *group* ($\beta_{control}$ = -0.77, CI = [-1.38,-0.15], z(6391) = -2.44, p<0.01). The hockey players performed better (M = 54%) compared to the control group (M = 35%). However, both groups were below chance level (Figure 3).

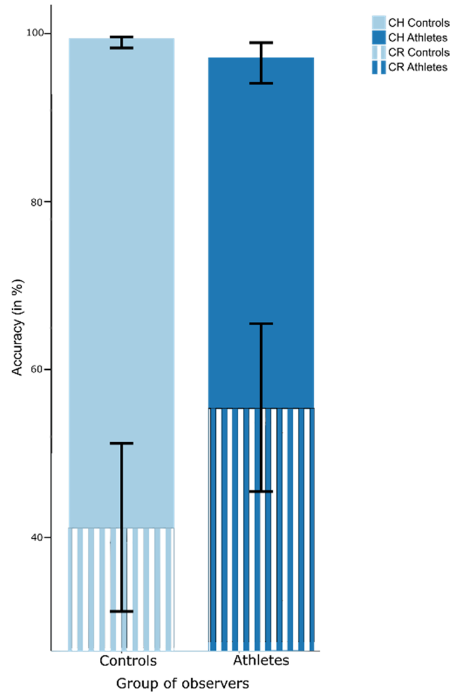

Figure 3. Accuracy (in %) correct hits (CH) and Correct Rejections (CR) considering all angles together. Error bars represent 95% confidence intervals of the mean.

B. RT

The results showed no main effects of the *group* ($\beta_{control}$ = 17.75, CI = [-9.30,44.81], t(21) = 1.28, p >0.05), see Figure 4. However, significant effects of the eccentricity was revealed for the control group with β_{angle5} = 15.52, CI = [7.30,23.55], t(6194) = 3.69, p <0.05, β_{angle8} = 42.47, CI = [34.28,50.66], t(6194) = 10.17, p <0.01, $\beta_{angle11}$ = 68.18, CI = [59.92,76.44], t(6194) = 16.17, p <0.01. This result indicates that the control group was faster for angle 2 (M = 269) compared to angle 5 (M =302.58), angle 8 (M = 318.44) and angle 11 (M = 345.92), however the reaction time seems not affected by the eccentricity for the hockey group.

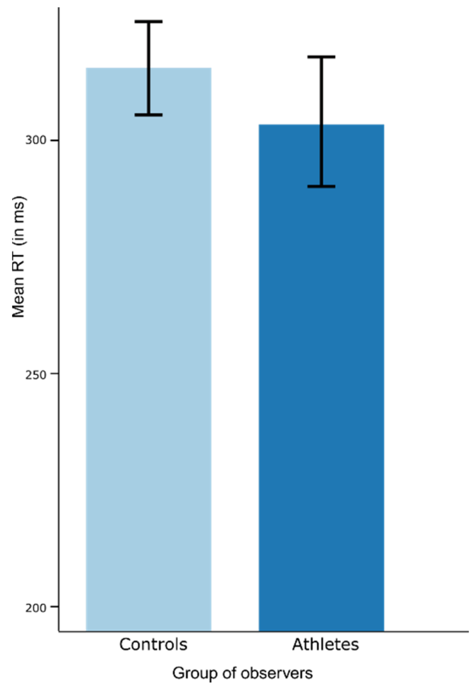

Figure 4. Reaction Times (ms) for both groups considering all angles together. Error bars represent 95% confidence intervals of the mean.

V. Conclusion

The aim of this study was to investigate if a difference exists between elite Hockey players and a control group during a Go/NoGo task. First, our data show no significant differences in the reaction time between both groups; second, while the control group performed better in the Correct Hit (CH), Hockey players achieved better performances in the Correct Rejections (CR), as they were better in inhibiting reflexive saccades in the NoGo condition. However, both groups were below chance level in the Correct Rejections. These results suggest that the paradigm design is maybe not suitable for both groups. We thus believe that an additional paradigm should be designed to explore the accuracy (CH and CR) and the reaction time. A follow-up study in which participants press a key (instead of making a saccade) when a green dot appears and inhibit a response when a red dot appears could be interesting to analyze and compare the results obtain in this present study. One future direction could be to explore performance at the individual level, for example before and after concussion.

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