Training Scanning Behavior in Virtual Reality: Does it improve Decision-Making of Elite Football Players?

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Master Thesis - Talent Development and Creativity

s3674568
May 2024
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Abstract

This study investigates whether decision-making in virtual reality (VR) can be influenced by training visual scanning and discover which effect age has on this relation.

In football, gathering visual information through scanning is crucial for making the right decisions. But despite potential benefits, few known interventions on visual scanning have been conducted. Therefore, we conducted a longitudinal, experimental study containing 35 elite, youth football players from a professional academy in the Netherlands. In a virtual environment, players received match-like situations that required them to choose one of four available teammates to make a provisional pass to. Decision-making was measured in how accurate and how fast participants made this decision. During two intervention sessions, the intervention group was manipulated to engage more in scanning through receiving scanning-evoking situations. Whereas the control group received similar situations, but through changing minor details they were not evoked to engage in visual scanning. The most important results were that both groups made faster decisions after training in VR and that our intervention group showed higher improvements in reaction time than the control group. Together, these results suggest that decision-making can indeed be improved through training visual scanning in VR. We propose that with both further research in VR and scanning combined with improved technology, VR can serve as an easy, enjoyable and effective substitute for training elite athletes.

Keywords: head movements, visual exploratory behavior, training, soccer

Training Scanning Behavior in Virtual Reality:

Does it Improve Decision-Making of Elite Football Players?

Last season, the 22-year-old Norwegian striker Erling Haaland solidified his reputation as one of the best players in the world, by becoming the top goal scorer in Europe and collecting almost all major awards with his club Manchester City. Besides his physical power and his superb feeling for the goal, there is another salient aspect in what makes him an extraordinary striker: his ability to scan makes that Haaland is always a step ahead on his defenders (Went, 2022). Haaland scans 0.35 to 0.50 times per second before receiving the ball, more than any other striker in the English Premier League. Interestingly, Haaland is not an exception in this regard. Jordet and colleagues found that players who engage more in scanning played on a higher competitive level, because their scanning enables players to make the right decisions at the right time (e.g., playing a forward pass to a team member, turning with the ball in appropriate situations, see Jordet et al., 2020, McGuckian et al., 2019, Eldridge et al., 2013, see also Aksum et al., 2021).

In sports, gathering visual information is an important element of perceptual-cognitive skills, which are considered vital for delivering high-level athletic performances (Jordet et al., 2020, Zhou et al., 2022). This concept was first demonstrated in chess by Chase and Simon (1973). In their study they compared both novice and experienced chess players in their ability to recall meaningful chess configurations. In one task the participants had five seconds to observe the pre-set board with various meaningful chess positions. After five seconds the researchers removed the pre-set board, and participants had to recall the configurations by placing the pieces in the correct positions on the board. Chase and Simon (1973) found that Grand Masters exhibited superior recall abilities compared to less skilled players. This implies that expert players demonstrated superior perceptual-cognitive skills compared to amateur players. Consequently, with pro athletes showing superior skills in these areas, knowing more about perceptual-cognitive skills could be beneficial for various areas like talent identification and performance improvement (Wirth et al., 2021).

Contrary to chess, football is a more fluid, dynamical game in which perceptual-cognitive skills are even more important for performance (Jordet et al., 2020). Because this player-environment interaction in football is constantly changing in an unpredictable way, this dynamic creates certain opportunities for action for the players, so called affordances (Gibson, 1979). More specifically, affordances are defined as opportunities for action that individuals derive from their interaction with their environment (Reed, 1996). The idea of affordances is based upon the ecological theories by Gibson (1979), which argues that perception is a direct, interactive process of obtaining information from the environment through motor action. In daily life an affordance means that a chair affords sitting and a car affords driving. In football, these affordances could be space between moving players to run into or seeing an opportunity for an open pass to a teammate (Mcguckian et al., 2018).

Perceiving affordances is important for making the right decisions at the right time. Because football is a dynamic sport, affordances come up and shut down continuously. A gap between players for a pass might be open at one time, but closed just a moment later (Fajen et al., 2008). The ability to perceive affordances is also dependent on the action-capabilities, like the past experiences, technical skills, physical abilities and tactical understanding of the player (Vaughan et al., 2019). According to Fajen et al. (2008), expert players do not only possess better action-capabilities, but they are better in perceiving what actions are possible and which are impossible according to the environment and their action-capabilities. A football player with better dribbling abilities might focus more on spaces more suited for dribbling and a player with a good cross might focus more on long-range options for a pass. Expert players with the right action-capabilities are more sensitive to relevant cues in the environment and are more efficient in discriminating cues (Raab & Araujo, 2009). Suggesting that the ability to make decisions is reliant on the player's ability to be perceptually attuned to the right affordances (Raab & Araujo, 2009).

In order to make the right decisions with the ball a player should prospectively guide their actions. In this process there must be some sort of exploration through movements of the eyes, head and/or body (Gibson, 1979). In football this process is closely related to the concept of scanning. Jordet (2013) defined scanning as “A body and/or head movement in which the player's face is actively and temporarily directed away from the ball, seemingly with the intention of looking for team-members, opponents or other environmental objects, relevant to performing a subsequent action with the ball” (p. 2). Jordet (2005) concluded players must engage in scanning to obtain sufficient information for their prospective actions. The more a player is engaged in explorative behavior, the better their understanding of the environment (McGuckian et al., 2019). In a fast-changing environment like football rapid responses are necessary, making early knowledge of affordances crucial for efficient decision-making (McGuckian et al. 2019). However, despite the potential benefits of training perceptual-cognitive skills, coaches rarely include them in practice sessions and focus more on training physical and tactical skills (Zhou et al., 2022). According to Gibson (1979), the information gathering process is highly influenced by learning and there are endless opportunities to educate in attention and exploration. Therefore, acquiring new learning methods can likely be very beneficial for elite players (Jordet, 2005).

Visual Scanning in Football

In football, many studies show the importance of scanning. In laboratory settings, individuals involved in research of McGuckian et al. (2019) received a ball in a simulated football environment, and were required to pass to a free teammate. The free teammate was one of four projected, dynamical options on a screen located in the surrounding environment. After they received the ball, participants had to indicate their pass by kicking in the corresponding direction. They found that the more participants engaged in scanning before receiving the ball, the faster participants were able to make their decision. In a later study McGuckian et al. (2020) used a 'Footbonaut', which is an individual pass training machine. In this study a higher completed pass percentage was seen when a player was more engaged in scanning before receiving the ball. Additionally, in a 11-vs-11 training match McGuckian et al. (2018) found that a higher scanning frequency for elite players led to more attacking passes, that players had a higher likelihood of turning with the ball and were able to switch play more easily.

Real-match studies showed similar promising results. For instance, Eldridge et al. (2013) found that a higher scanning frequency for elite youth players was related to more forward passes, less experienced pressure from opponents and more turns with the ball in appropriate situations to face the opposing goal. Moreover, Aksum et al. (2021) analyzed the scanning behavior of 53 elite U17 (under 17 years) and U19 players. Their findings substantiated previous studies that found a positive relation between frequency of scanning and completed pass percentage, forward passes and turns with the ball. Identical effects were also evident on the highest level. Phatak and Gruber (2019) followed 35 midfielders from the Euro 2016 championship and found that scanning was related to higher completed pass percentage and less turnovers. Accordingly, in the largest study about scanning to date, Jordet et al. (2020) followed 27 English Premier league players and examined almost 10.000 ball possessions where they replicated the finding that scanning is positively related to completed pass percentage. In general, research suggests that an increase in scanning has a modest, yet beneficial impact on performance (Jordet, 2020).

Playing position might be an influential factor on the frequency of scanning. Jordet et al. (2020) found that some positions scanned more than others. Besides the goalkeeper, a football team consists of ten different positions. In their study Jordet et al. reduced those ten positions into five general units; central defenders, side defenders, central midfielders, wingers and forwards. The results of their study showed that central midfielders tend to scan the most, followed by central defenders and wingers. Side defenders and forwards engaged the least in scanning. These results are consistent with findings of McGuckian et al. (2020) and Aksum et al. (2021) which showed that players in central roles scanned more when they, or their team, were in possession of the ball. According to Jordet et al. (2020) and McGuckian et al. (2020), this could well be explained by position-related demands. For instance, central midfielders are more surrounded by teammates and opponents than wide-position players and wide-position players can omit some visual information because they play near the sideline (Aksum et al, 2021). Therefore, central midfielders might need to scan more often to see which affordances are opening up and which are closing down (Jordet, 2020).

Another contextual factor related to scanning is age. Aksum et al. (2021) found in their study that players from the U19s scanned more than the U17s and McGuckian (2020) found that players from the U23s scanned more than players from the U13s. This is in line with the theory that the ability to perceive affordances is dependent on the player's action-capabilities (Fajen et al., 2008). Researchers agree that both experience and practice are underlying this age-effect (Craig, 2013). Young players possess relatively less experience and had less practice compared to their older counterparts. Moreover, older players possess better action-capabilities, allowing them to be more perceptually attuned to cues from the environment (Raab & Araujo, 2009). Additionally, because age is positively related to action-capabilities, the physical demands from the game of older (elite) players are generally higher, therefore older players need more scans to keep their information up-to-date (Aksum et al., 2021). It is known that adolescence (age 10-19) is a critical stage for developing cognitive skills and thus for perceptual-cognitive skills (Mann et al., 1989; Mukherjee et al., 2002). Hence, perceptual-cognitive skills, like scanning, increase with age, experience and practice, and a focus on developing these skills is therefore important for football players (Aksum et al., 2021).

Visual Scanning Interventions

Despite the learning potential there are few known interventions focused on scanning among elite players. Jordet (2005) and Pocock et al. (2019) both conducted studies with imagery training sessions, guided by a sports psychologist. In both studies, participants had to imagine themselves in game-like situations engaging in scanning before receiving the ball, with the goal of detecting possible opportunities. Results reveal that an imagery intervention can lead to an increase in scanning. However, an increased scan rate under these circumstances did not result in improved ball performance. Reason for this could be that enhancing cognitive-perceptual skills in sport is highly susceptible to its context (Fajen et al., 2008). Meaning that for an intervention to succeed the training environment should be representative with the performance environment and should reproduce the same behavior and task demands (Pinder et al., 2011). However, field studies and interventions are hard to reproduce because of their time investment and high financial costs (Wirth et al., 2021). Still, the promising findings about scanning should encourage coaches and researchers to develop new representative training situations that promote scanning (McGuckian et al., 2020).

VR (virtual reality) has been recognized as a promising learning method with the possibility to preserve representative behaviors and task demands (Craig, 2013). VR is a computer-technology based simulation that generates a multiple sensory environment, enabling users to directly and freely, engage and interact with their environment (Banos et al., 2016). Because videos in VR are from the first-person perspective, VR allows for a greater degree of presence in the environment leading to bringing training experiences closer to a realistic game context and thus preserving psychological fidelity (Wirth et al., 2021). Additionally, VR can be used as a tool to enhance motivation, self efficacy and the enjoyment of a task (Wirth et al., 2021). Since differences between elite players are small, innovative instruments like VR might provide a competitive edge over their competitors (Zhou et al., 2022).

Several studies have shown the potential of using VR to train perceptual-cognitive skills related to football (Kittel et al., 2020; Ferrer et al., 2020; De Sousa Fortes et al., 2021). VR can provide endless training scenarios and the user has complete control over what is presented in those situations (Craig, 2013). Moreover, training in VR doesn't attach an extra physical strain to the players and VR can provide scenarios to train skills that are impractical to train in real life (Wood et al., 2021). Wood et al. (2021) already showed that expert players in VR performed better in exercises related to scanning than novice players. Meaning that perceptual-cognitive skills from VR at least partially overlap with perceptual-cognitive skills in the real-world. Wood et al. (2021) argues that the extent of this overlap is determined by similarities in perceptual-cognitive and motor demands of the tasks in both worlds. According to Craig (2013), scanning might meet the requirements for an overlap and therefore be an interesting skill to train in VR. Therefore, it might be beneficial for improving scanning by training players to look at the right place, at the right time (Craig, 2013). However, to our knowledge no study to date has been conducted that directly promotes scan frequency to obtain better decision-making in VR. And while it remains a question whether improving perceptual-cognitive skills in VR will lead to improved performance in real-life, an important first step would be linking improvements in scanning to better decision-making in VR. What is clear is that VR is an exciting new technology that has the potential to enhance performance in sports by developing innovative training methods (Craig, 2013).

Current Study

In this study we are trying to bridge the gap between VR and the real-world. The aim of this study is to see whether an intervention on promoting scan frequency of the players in VR will lead to better decision-making and discover which effect age has on this relation. To answer the research question three hypotheses are set.

First, we expect that training in VR has a positive effect on decision-making in the VR environment. Decision-making will be measured by accuracy (whether the participants provide the right answer) and reaction time (time in seconds the respondent takes to provide their answer).

The second hypothesis is that the group receiving a visual scanning intervention will show better improvements in decision-making than the control group. During the intervention period, the intervention group will be manipulated to perform more scans than the control group. We expect that the intervention group will therefore train their scanning abilities which subsequently should lead to higher improvements in decision-making.

The final hypothesis is that younger players from the intervention group will achieve the highest improvement in decision-making. As previously stated, researchers agree that both experience and practice are underlying age effects in scanning (Craig, 2013). Because young players possess relatively less experience and have had less practice compared to their older counterparts, they will gain relatively more experience. Therefore, we expect that younger players show higher improvements in decision-making.

Method

Participants

The study consisted of 35 elite youth football players from a professional football club situated in the Netherlands. The study initially included 37 players, but due to first team obligations and injuries, two players were unable to continue. The respondents played for the under-16, under-18 or under-21 team in the academy. The participants were all males between 14 and 20 years old. The U16s and U18s both provided 12 players (34%), while 11 players participated from the U21s (32%). Out of the 35 remaining participants, 40% were classified as midfielders, 23% as side defenders, 14% as central defenders, while the wingers and forwards each made up 11%.

The selection of players was made in collaboration with the coaches of the representative teams. In this process, goalkeepers and players from the under-21 team who had first team obligations were not involved. Players had the voluntary choice to participate in the study and could decide to drop out at any moment. Participants did not receive compensation for their efforts in the study, they only received additional football training that they would not have received otherwise.

The study's design was granted approval by the Ethics Committee of the Faculty of Behavioural and Social Sciences of the University of Groningen. Written informed consent was obtained from the adult participants and the parents or guardians from the non-adult participants (see appendix E).

Apparatus and Materials

This study utilized a VR program developed by AIONSPORTS. The VR device used for the program was the VIVE Pro headset (FOV 110°, 90 Hz). The equipment was situated in the same room as the gym within the youth facility of FC Groningen. The VR area was distinguished by artificial grass, separating it from the gym devices. AIONSPORTS designed a VR environment capable of creating realistic 3D gameplay situations in football. In this environment, players saw scenarios from a first-person perspective. The players could perceive the whole pitch in VR by their movement and by rotating their head and body. In essence, they could move freely in the VR environment, but the VR headset was attached to the main device with a cable containing a range of 2.5 meters.

The VR system was the core material of this study. In addition to the VR-system, scoresheets were used to note down participants choices (a-b-c-d) and decision times, which were rounded to one decimal place. To review the scanning behavior of the participants, the program OBS (Open Broadcaster Service) was used to record the respective screen. Additionally, to measure experienced presence in VR, the Dutch version of the Igroup Presence Questionnaire was conducted (Schwind et al., 2019). The questionnaire comprises four subscales: Spatial presence, Involvement, Realism and General presence. The scores are measured on a 7-point Likert scale. At the request of the associated club, a question was added to determine whether participants felt more aware of their scanning behavior due to this study.

VR-situations

The VR scenarios were created by the researcher in collaboration with the coaches of the under-16, under-18, and under-21 teams to align with the club's tactical vision. An example of the club's tactical vision was that players should prefer progressive passes, meaning forward passing options towards the opponents goal over a backwards or sideway pass. In total, 90 situations were created. Both the intervention and control group had four sessions consisting of 15 unique situations. The situations for the pre- and post-measurement were identical for both groups. During the pre- and post-measurement and the intervention sessions participants received a ball from the left center back, which they were faced to, while having the first-person perspective of a midfielder (see figure 1). During the intervention period, the control group had similar sessions, however the participants already had possession of the ball and were rotated 180°, facing towards the opponents goal (see figure 3). Every situation would begin in a stationary period of one second to orientate. Afterwards, the moving period begins. In five seconds fellow players and opponents would move and make runs, opening up and closing down affordances. In contrast to the control group, for the intervention group the ball will be moving towards them during those five seconds. In the control group players already had possession of the ball, and the ball remained stationary during the moving period. After the movement phase, fellow players and opponents returned to a stationary end-position and four possible passing options (a-b-c-d) popped up in planes above certain teammates on the field. In general, the options displayed for the pre- and post-measurement required progressive passes. A possible progressive passing option could be a forward pass to a striker or winger. Sometimes a more sideway option was presented, which could be a fellow midfielder or an upcoming back. Very seldom, a backward pass option to a defender was presented.

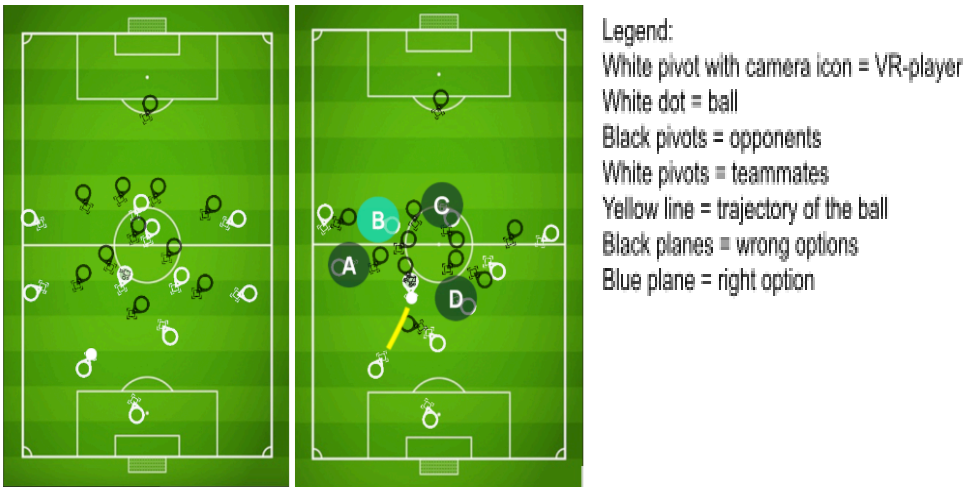

Figure 1. Bird-eye presentation from an intervention VR-situation, the left picture is representing the stationary period, right is the situation after the moving period.

Procedure

The aim was to have one session a week for four weeks straight. As said, the pre- and post-measurement were identical for both groups. The intervention period contained two sessions, spread out over two weeks. Because the situations were from the midfielders perspective, the midfielders were divided equally among the control and intervention group to preserve the representativeness of the sample. The rest of the participants were distributed in a random manner. Both groups trained 4 times in VR, and thus gained an equal amount of experience. The exact schedule for the study can be seen in figure 2.

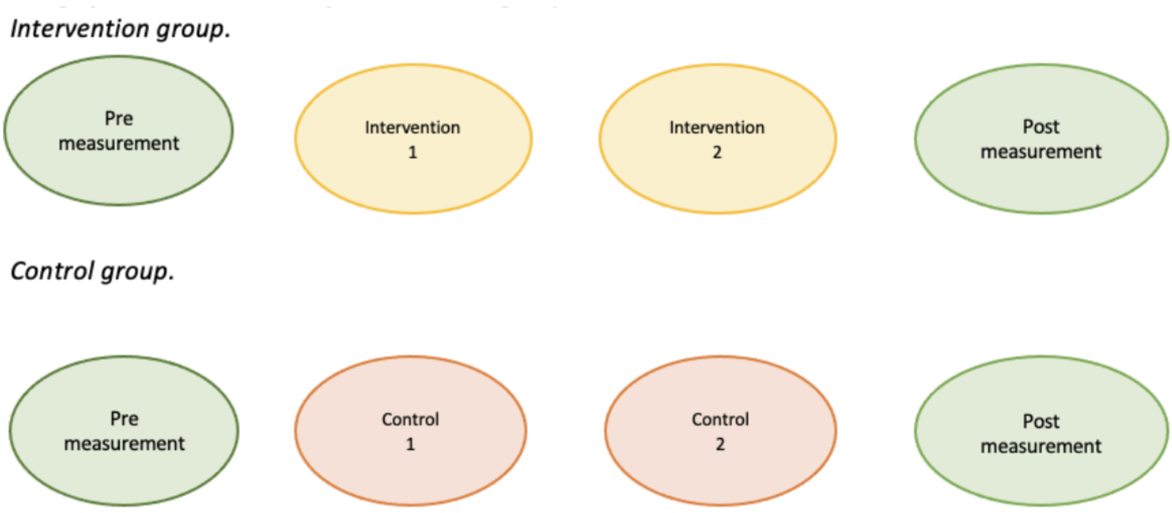

Figure 2. Design for intervention- and for the control group.

When participants entered the study area for the first time, the guidelines of instructions in appendix 1 were followed. In short, the participants received basic instructions about the study, after which they were asked whether they still wanted to participate in the study and asked to sign an informed consent paper. The most important instructions were that participants had to make the VR environment as realistic as possible for themselves. Meaning they had to perform the same actions in VR as in real-live before receiving the ball. These actions included using the body in an appropriate way to shield the ball from a pressing opponent, standing on your tip-toes and looking and touching the virtual ball when it arrives. To preserve representativeness, players also had to take the offside rule into account and were instructed not to pass the ball to a teammate in a situation where the teammate was facing the other way. The players were asked to give their responses in a verbal manner and as fast and accurate as possible. After the instructions, participants did three test situations (with obvious answers) to get comfortable with the system and the instructions. ensuing the test phase, the real situations started. After the four possible answers popped up in each situation, participants needed to provide their answer. At this moment, the researcher stopped the timer by pressing the spacebar and the researcher noted the reaction time and answers on the scoresheet.

During the intervention phase, participants from the intervention group received the same kind of situations as in the pre- and post-measurement phase. However, they received instructions to scan more during the five seconds when the ball was traveling towards them and fellow players and opponents would move. As told, the control group had situations where they already had possession of the ball and were facing towards the goal of the opponent. Because in general the options in VR required progressive passes, the passing options in the control group were presented in front of them. In contrast, the participants from the intervention group were faced towards their own left center back (see figure 1). As a result, we expected that the intervention group received scan-evoking situations, meaning situations that required more scans from the participant. Conversely, for the control group we believed that the situations were non scan-evoking because the situations were already presented in front of them.

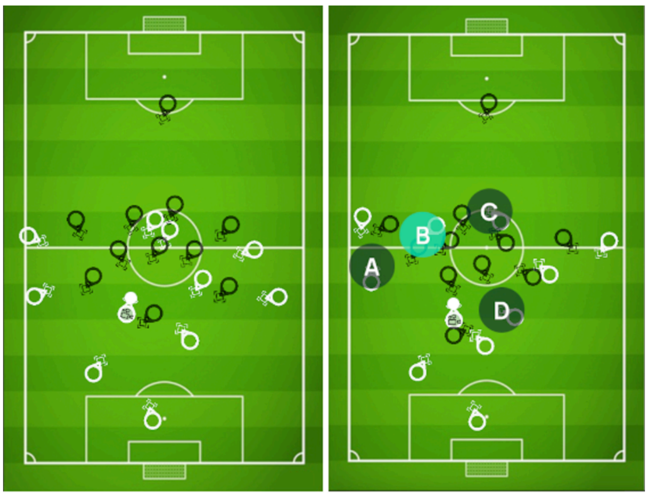

Figure 3. An example of a VR-situation for the control group. The situation is almost identical to the one presented in figure 1, only the VR-player is faced forwards and does already have possession over the ball.

Analysis

In this study, we tested if decision-making (dependent variable) can be influenced by training visual scanning (independent variable). Decision-making consists of both accuracy and reaction time. Accuracy was measured by whether the participants provided the right verbal answer for a passing option and reaction time was measured by the speed in which they provided their answer. Because the intervention group was manipulated to engage more in scanning, we expected the intervention group to show greater improvements in decision-making compared to the control group. Additionally, we explored what the impact of age group (independent variable) is on this relationship. Repeated-measures analyses were conducted to measure these relationships and the alpha for this study was set at $p < 0.05$.

According to the G*Power v.3.1.9.7, 34 participants (17 per group) contained sufficient power for performing a statistical analysis of two-way repeated measures ANOVA (Faul et al., 2009). The number of groups was two (intervention and control), together with the number of measurements (pre measurement and post-measurement). Default parameters for a two-way repeated measures were used for these calculations, meaning that the normal effect size was set at $f = 0.25$, an $\alpha = 0.05$, a statistical power of $1 - \beta$ of 0.80, and a correlation between the repeated measurements of $r = 0.5$ coefficient of 0.5 (two way repeated measurements of $r = 0.5$, and no violation of sphericity ($\varepsilon = 1$). Therefore, the 35 players that participated in this study supplied enough statistical power.

We expect that younger players will benefit more from the intervention and will therefore achieve the highest improvement in decision-making. To test this hypothesis we divided the participants into their respective teams: under-16, under-18 or under-21. Performing the same calculations with identical parameters (only changing the number of groups to 3), power calculations showed that a sample size of 42 participants (14 per group) would be sufficient. Hence, the 6 or 5 players available per intervention group did not approach the 14 participants required for adequate statistical power.

Results

Manipulation Checks

To verify whether the intervention group indeed engaged more in scanning than the control group, we recorded the screens of what the participants saw in VR and noted how many times they engaged in scanning during the moving period. To quantify the scans the zonal division diagram was used from Ferrer et al. (2020) (Figure 3). In total, 30 sessions have been tested, including at least one session for each team, condition or training. One scan was defined as eye movements from zone 1 (exceeding 45 degrees) to zone 2 or 3, returning to zone 1. On average the intervention group performed 2.54 scans per situation (38.1 scans per session, $N = 15$) and the control group 0.96 per situation (14.5 scans in one session, $N = 15$). After performing a t-test this difference was deemed significant ($t = 11.8$, $p = < .001$). When only considering scans that exceeded 90 degrees (zone 3 scans), the differences were even higher. 95% of the total scans from the intervention group involved zone 3 scans, while the total scans of the control group consisted of 9% of zone 3 scans. This means that the intervention group indeed engaged more in situations that evoke visual scanning.

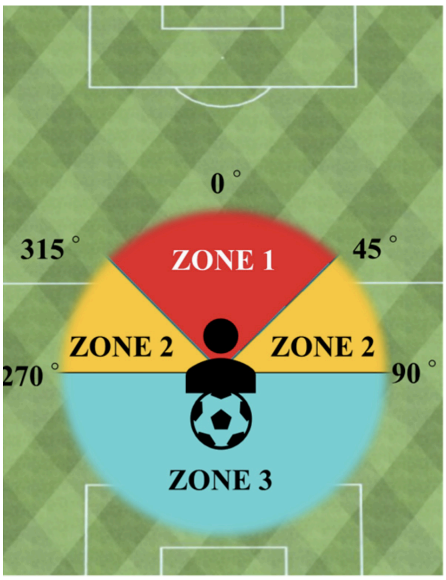

Figure 3. Zonal division of the visual exploratory activity, retrieved from Ferrer et al. (2020)

The results of the Igroup Presence Questionnaire show that the perceived presence in VR is marginally acceptable (Melo et al., 2023). On the subscale General Presence the participants scored on average 5.4 (SD = 1.45) which is excellent according to the qualitative scales of Melo et al. (2023). Participants scored marginally on the subscale Spatial Presence (M = 4.2, SD = 1.3) and had satisfactory scores on the subscale Involvement (M = 4, SD = 1.5) and Experienced Realism (M = 3.7, SD = 1.4). More information about the scaling can be found in Appendix C.

Accuracy of Decision-Making

With regard to decision-making, our two-way repeated measures ANOVA showed no significant main effect for accuracy over time (F (1, 33) = .410, p = .526, $\eta 2$ = .005, from 88%, *SD* = 8%, to 87%, *SD* = 9%). However, results did reveal a significant main effect for group on accuracy (F(1, 33) = 6.454, p = .016, $\eta 2$ = .097). On average, the intervention group achieved an accuracy of 90% (*SD* = 8%), while the control group achieved an average accuracy of 85% (*SD* = 8%). Lastly, we found no group x time interaction effect regarding accuracy (F(1, 33) = 1.238, p = .274, $\eta 2$ = .014). Interestingly, an extra post-hoc Tukey test did conclude that the intervention group scored significantly higher on the post-measurement than the control group (*M* = .070, *SE* = .026, p = .049). As shown in figure 4, the intervention group achieved 91% accuracy (*SD* = 8%) for the posttest, which was 1% higher compared to the pretest. The accuracy slightly dropped for the control group from 87% to 84% (*SD* = 8%).

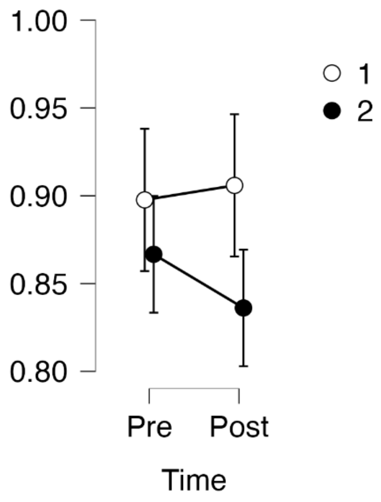

Figure 4. Developments in accuracy (vertical axis, measured in percentages) for the intervention (group 1) and the control group (group 2) over time.

Reaction Time of Decision-Making

A two-way repeated measures ANOVA revealed a significant main effect for reaction time over time ($F(1, 33) = 101.592$, $p = < .001$, $\eta 2 = .516$). Participants improved their reaction times on average by 0.9 seconds (from 2, $SD = 0.5$, to 1.1, $SD = 0.2$). Implying that regardless of group, training in VR led to improvements in reaction time. No significant main effect of group on reaction time was found ($F(1, 33) = 0.743$ $p = .395$ $\eta 2 = .006$). The results did show a significant group x time interaction ($F(1, 33) = 4.711$, $p = .037$, $\eta 2 = .024$). The intervention group demonstrated an average improvement of 1.1 second (from 2.2 to 1.1; $SD = 0.6$), whereas the control group showed an improvement of 0.7 seconds (from 1.9 to 1.2; $SD = 0.4$). A post-hoc-tukey-test revealed significant mean differences between pre- and post-measurements of the control group ($M = .672$, $SE = .118$, $p = < .001$) and intervention group ($M = 1.041$, $SE = .148$, $p = < .001$). Only, the intervention group exhibited bigger mean differences than the control group. Meaning that as depicted in figure 5, the intervention group displayed better improvements in decision-making than the control group.

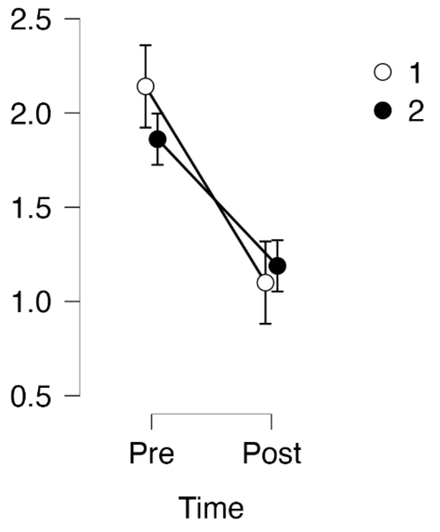

Figure 5. Developments in reaction time (vertical axis, measured in seconds) for the intervention (group 1) and the control group (group 2) over time.

Decision-Making for Different Age Groups

Within the intervention group, no significant main effect was found on accuracy regarding time ($F(1, 14) = .126$, $p = .728$, $\eta 2 = .004$). However, it did show a significant main effect for age groups ($F(2, 14) = 5.774$, $p = .015$, $\eta 2 = .241$). The under 16's scored an average accuracy of 85% (*SD* = 8%), the under 18's 93% (*SD* = 7%) and the under 21's 90% (*SD* = 7%). Lastly, no age x time interaction was found regarding the different age groups within the intervention group ($F(2, 14) = .586$, $p = .570$, $\eta 2 = .036$).

Regarding reaction time, a significant main effect was found within the intervention group (F(1, 14 = 45.700, $p = < .001$, $\eta 2 = .537$). As told, the respondents from the intervention group improved on average with 1.1 second, from 2.2 (*SD* = 0.7) to 1.1 (*SD* = 0.2). The two-way repeated measures ANOVA showed no significant main effects concerning the different age groups ($F(2, 14) = .161$, $p = .853$, $\eta 2 = .007$). Moreover, no significant interaction effect was found between age and time within the different age groups ($F(2, 14)$ =

.331, $p = .724$, $\eta 2 = .008$). In general, these results show no significant differences for improvements in decision-making within the intervention group between the different age groups.

Discussion

This study aimed to investigate whether decision-making in VR can be influenced by training visual scanning. In total, 35 players from an elite youth academy in the Netherlands participated in our study. We hypothesized that all participants would improve their decision-making after training in VR. Moreover, we manipulated the intervention group to engage more in scanning and expected them to achieve better improvements in decision-making. Finally, we hypothesized that players from a younger age group would benefit the most from our intervention. Decision-making was measured by both accuracy and reaction time.

Overall, our main finding is that decision-making indeed can be improved through training visual scanning in VR. Participants that were manipulated to engage more in scanning showed better improvements in reaction time than the control group. Conversely, participants of both groups did not improve their accuracy after training in VR and no interaction was found between the groups. Finally, our results did not support that players from a younger age group would benefit more by showing higher improvements in decision-making after our intervention.

Effects VR-Training on the Accuracy of Decisions

After the training period in VR, no significant differences were found on the accuracy of decisions. This is in contrast to findings of Kittel et al. (2020) and De Sousa Fortes et al. (2021), both studies found improvements in accuracy after training in VR. A reason for this might be, in contrast with Kittel et al. (2020) and De Sousa fortes et al. (2021), this study had only two VR-training sessions. The study of Kittel et al. (2020) consisted of five intervention sessions and the study of De Sousa Fortes et al. (2021) consisted of in total 18 intervention sessions. Thus, it might be that two intervention sessions are insufficient to create substantial improvements in accuracy.

Besides no significant differences on improvements in accuracy after training in VR, no significant differences were found between the improvements of the intervention and control group. This is in line with previous outcomes of interventions which also improved the frequency of scanning (Jordet, 2005; Pocock et al., 2019). In those studies researchers increased the frequency of scanning through an imagery intervention but it didn't lead to better on-ball performance. According to Fajen et al. (2008), a reason for this can be that perceiving opportunities for action need to be embedded within the player's technical and physical skills. Engaging more in scanning can lead to more information, resulting in players perceiving more affordances (Fajen et al., 2008). However, opportunities for action are embedded within the player's technical and physical skills, meaning that a player can perceive more passing affordances through scanning, but still needs the technical and physical skills to successfully act on those affordances. According to Pocock et al. (2019) calibrating those complex perceptual-motor skills to act on the perceived affordances takes time. This process of recalibration may have required more practice and time than our study had to offer.

Additionally, during this study it was difficult to differentiate players based on accuracy. From the outset, players' demonstrated high levels of accuracy, resulting in a ceiling effect in which players had less room to improve. During the testing phase we tried to improve the difficulty of the VR-situations, but increasing the difficulty of the situations left room open for interpretation of multiple right answers. Thus, in collaboration with coaches we tried to find a sweet spot between maintaining maximum difficulty while still requiring one clear answer. One approach to this involved instructing participants to provide their answer as swiftly as possible. But despite this instruction, participants still had an average accuracy during the pre-measurement of 90%. One reason for this was that players who didn't know the answer first hand, took more time to provide the right answer and therefore achieved the same accuracy as fast decision-making participants. On the other hand it did work because during the post-measurements the intervention group achieved a significantly higher accuracy score than the control group.

Effects VR-Training on the Reaction Time of Decisions

Our research showed that only a few sessions in VR can be enough to induce improvements in reaction time. Studies such as Kittel et al. (2020) and De Sousa Fortes et al. (2021) focused only on improvements in decision-making involving accuracy, not reaction time. This while reaction time is a crucial part of decision-making, especially in sports (McGuckian et al., 2019). Hence, in situations where reaction time is critical for decision-making, engaging in VR-training can be worthwhile.

Moreover, our research shows that increasing frequency of scanning can lead to faster responses in VR. These findings are somewhat in line with results conducted from a lab study of Mcguckian et al. (2019). As explained in the introduction, participants were required to pass a ball, within a simulated football environment, to a free teammate. Mcguckian et al. (2019) found that the more participants engaged in scanning before receiving the ball, the faster participants were able to make their decision. As said, football contains a fast-response context in which fast decisions are vital for proper decision-making (McGuckian et al., 2019). This study could be another argument for the importance of engaging in exploration of the environment in order to perceive more affordances and thus make better decisions. Building upon previously named lab (McGuckian et al., 2019; McGuckian et al., 2020) and in-field studies (McGuckian et al., 2018; Elridge et al., 2013; Aksum et al., 2021; Phatak & Gruber., 2019; Jordet et al., 2020), which all relate higher scanning frequency to better decision-making. Only, all of those studies found an association between the frequency of scanning and aspects of better decision-making while this study directly improved decision-making by manipulating scanning frequency.

Effects Visual Scanning Intervention on Different Age Groups

We found no significant effects within the intervention group regarding accuracy and reaction time between age-groups. Contrary to our hypothesis, this means that younger players from the intervention group didn't achieve the highest improvement in decision-making. A reason for this might be that training in VR was relatively new to all age groups and thus players gained the same experience through practice. However, if the task in VR demanded the same skills as the respective task from the real-world, this would not be the case. Our findings are in contrast to earlier research from Wood et al. (2021), which was able to successfully distinguish between various skill levels in VR regarding exercises related to scanning. Their study used novice players with a couple years of experience on a recreational level, academy players with an average age of 14.5 (SD = 2) and professional players with an average age of 28.4 (SD = 6). Since our study contained only elite academy players from 3 age groups, aging from 14 to 20, differences in perceptual-cognitive skill were likely less prominent than for participants in the study of Wood et al., 2021).

Another, perhaps most plausible reason for the absence of higher improvements of younger players could be due to sample size. Our study consisted of 5 or 6 participants per group, while power calculations showed 14 participants per group were needed for sufficient statistical power. A larger sample size is needed to see whether the VR-simulator is sensitive enough to differentiate perceptual-cognitive skills on an elite level where performance variability is generally lower between players (Wood et al., 2021).

Implications

Kittel et al., (2020) argued that more longitudinal research consisting of elite level participants is needed for further research regarding improvement of decision-making through VR. Besides having elite level participants, our VR-situations were made in collaboration with elite coaches, making sure that the VR-situations were representative of high-level, real-life scenarios. With scanning being recognized as an incentive for proper decision-making, a call for methods to analyze and train scanning without being too costly and time consuming was growing (Jordet et al., 2020; Wirth et al., 2021). Therefore, our study contributes to the existing literature by gaining a deeper understanding of the development of perceptual-cognitive skills through innovative methods in elite sport performance.

Furthermore, our results show that only a couple sessions in VR are enough to induce improvements in reaction time and thus in decision-making, emphasizing the potential of using innovative training methods like VR. Moreover, the improvements in reaction time show that speed plays an important role within training and measuring decision-making in VR. Until now, studies about enhancing perceptual-cognitive skills in football have only focused on the improvement of accuracy and not on reaction time (Kittel et al., 2020; De Sousa Fortes et al., 2021).

Finally, our study is the first to prove that decision-making can be trained by enhancing perceptual-cognitive skills like scanning. Many previously named researchers showed the importance of visual scanning by making positive associations between scanning and various aspects of decision-making. Other interventions had successfully improved scanning frequency, but failed to subsequently improve accuracy of decision-making (Jordet et al., 2005; Pocock et al., 2017). In general, trainers tend to underestimate the value and trainability of perceptual-cognitive skills in football (Pulling et al., 2018). Training sessions in football are more aimed at improving the physical and tactical aspects of the game. However, common football practice exercises like a rondo or a pass-receive exercise evoke less scanning activity than actual 11-vs-11 games (de Vries et al., 2017). In VR, real-match play can be reproduced and therefore it can be an easy way to stimulate visual scanning (Craig, 2013). Above that, training in VR has proven to be an effective tool for enhancing motivation, the enjoyment and self-efficacy of performing a task (Wirth et al., 2021).

Limitations

Because of limitations in the VR-program, options for actions with the ball were fewer and therefore less representative than in real-live. Through instructions, players were asked to consider only options that required a pass over the ground into the feet of a teammate. In real-live, players might choose to engage in a dribble or choose to simply hold the ball at their feet. Moreover, if they choose for a pass, they can decide if they want to perform a pass through the air and to send a through ball, instead of playing a pass into their feet. All these factors might take away some of the representativeness of these exercises.

Furthermore, the quality of the material and VR-program may have impaired the representativeness. The utilized head-set had a field of view of 110° which is 25° less than a normal, human field of view. Furthermore, the headset was bound with a cable to the main device and contained extra weight. Leaving some room for movement, but having inevitable restrictions in the sense of freedom. Above that, the graphics lacked some realistic features. For example, the ball and players were sliding unnaturally over the field which might take some realism away from the experience.

As told, enhancing cognitive-perceptual skills in sport is highly susceptible to its context (Fajen et al., 2008). Meaning that for an intervention to succeed the training environment should be representative with the performance environment and should reproduce the same behavior and task demands (Pinder et al., 2011). In real-live perceptual-cognitive skills are embedded within the technical and physical skills of an athlete (Pokolm et al., 2022). However, the technology regarding our VR-system was not that far developed to demand the same technical and physical aspects of the game. Players were asked to control and pass an imaginary ball, but in contrast to real-live situations they did not need to have the technical skills to do so. An argument against the representativeness of our VR-environment and tasks is that our results show no significant differences between age groups. Since perceptual-cognitive skills develop with age and practice we would expect older players to achieve better results. Meaning that unlike Wood et al. (2021), our study, also due to a small sample size, wasn't able to differentiate between perceptual-cognitive skill levels. Moreover, the Dutch version of the Igroup Presence Questionnaire revealed that the feelings of presence for participants in VR were marginally acceptable. Thus, it remains the question whether our improvements in decision-making in VR translate to improvements in decision-making in real-live.

Future Research

In the future more research and better equipment is needed to further close the gap between VR and the real world. Studies like Wood et al. (2021) already have proven some overlap between perceptual-cognitive skills in the real-world and in VR. Subsequent studies should focus on differentiating elite players of different and maybe even the same age category on level of perceptual-cognitive expertise. On the other hand, enhanced quality of the VR-program and instruments would automatically increase the feeling of being present in a virtual environment by taking away some previously called limitations. Many studies, including this one, are establishing the potential of VR and are contributing to a need for further collaboration with designers of such technologies to discover the possibilities of the virtual world.

In our research we trained visual scanning by improving scanning frequency. However, scanning is more than just frequency (McGuckian et al., 2018). Previous studies already showed the size of head excursion to be predictive for various on-ball performance (mcGuckian). Aksum et al. (2021) showed with eye-tracking studies that gaze behavior and scan duration is different in various positions around the pitch. Furthermore, Aksum et al. (2021) showed that the last performed scan was predictive for a better body-position and thus a higher chance of making the best decision. Earlier named contextual demands like positional demands and age pressure on the ball all have effect on visual scanning (Jordet et al., 2020). Recent studies also show that perceived pressure is a factor on scanning (Pokolm et al., 2022). Furthermore, factors like psychological anxiety and fatigue are likely to play a role in visual scanning (Williams et al., 2011). More research is needed to create a holistic view of visual scanning and further visual scanning interventions should consider the contextual demands by making use of representative training settings.

Conclusion

Our study established the potential of innovative training methods like VR. We showed that decision-making of elite players can be improved through an intervention on visual scanning, making our study the first to do so. Differences in elite sports are small and using innovative training methods to enhance the still underrated perceptual-cognitive skills might give clubs a cutting edge over their competitors. We propose that with both further research in VR and scanning combined with improved technology, VR can serve as an easy, enjoyable and effective substitute for training athletes in elite sports.

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Appendix A

Procedure

Voorbereiding

- Kort verbale uitleg van het onderzoek. “We gaan onderzoek doen of beslisgedrag van spelers kunnen beïnvloeden door middel van training in Virtual Reality. Elke sessie bevat 15 situaties die ongeveer 10 minuten duren. In totaal zullen er vier sessies plaatsvinden.”
- Informatiebrief laten lezen en informed consent ondertekenen. Spelers onder de 16 nemen de informatiebrief en vragen de ouders om de informed consent te ondertekenen.
- Vragen naar eerdere ervaringen met VR. Kijken en meten of de bril goed op het hoofd van de participant zit. Tijdens hoofdbewegingen moet de bril strak zitten, maar niet te strak dat de participant er hinder van heeft. Begeleid de participant naar de plek precies onder het VR-systeem, hier heeft hij het minst last van het snoer.

Instructies VR

- Je bent een middenvelder en je krijgt de bal aangespeeld van de linker centrale verdediger. Doe net alsof je in het echt de bal zou krijgen: dus voorvoetjes, door de knieën en neem de bal aan als deze virtueel bij je is.
- Als ik op start druk gaan de spelers bewegen en komt de bal naar je toe. Na 5 seconden stoppen de spelers met bewegen en moet je zo snel mogelijk uit 4 keuzes A, B, C, D zeggen naar wie je de bal gaat passen.
- De bal komt dus langzaam, binnen 5 seconden, probeer in die 5 seconden wel te scannen maar Let ondertussen ook op de bal en neem de bal aan als die er is.
- Je krijgt soms ook een tegenstander in de rug, positioneer je lichaam zo dat hij er niet bij kan en neem de bal met het juiste been aan, dus komt de tegenstander vanuit links in de rug dan neem je in principe met rechts aan en vice versa. Je kan hiervoor een stapje opzij doen of je handen gebruiken om het weer zo echt mogelijk te maken.

Aandachtspunten

- De bal zou alleen laag en in de voeten van een teamgenoot kunnen gespeeld worden, hij kan dus niet in de diepte of hoog naar de speler.
- In principe willen jullie zo snel mogelijk naar het doel van de tegenstander toe spelen, dus als de mogelijkheid er is, is een pass vooruit richting het doel van de tegenstanders beter dan een pass opzij of terug. Dus als de spits vrijstaat is dat beter dan naar de back spelen.
- Buitenspel doet mee, dus let daarop. Verder heeft de keeper van de tegenstander heeft hetzelfde tenue aan als de rest van de tegenstanders wat een beetje verwarrend zijn.
- Vragen of alles duidelijk is. Zo niet, herhalen.

Situaties

- Eerst de voorbeelditems.
- Speler geeft verbaal zijn antwoord aan. Onderzoek drukt op stop en schrijft het antwoord plus tijd op.
- Aangeven dat de volgende situatie wordt opgestart en de speler.

Nabespreking

- Vraag naar hoe ze het vonden.
- Individueel moment inplannen voor volgende week.

Appendix B

Questionnaire

Igroup Presence Questionnaire (IPQ)[1]

Nogmaals bedankt namens de club, de Rijksuniversiteit en mijzelf voor het meedoen aan dit onderzoek. Hieronder zie je een aantal statements over jouw ervaring in het Virtual Reality systeem. Geef aan in hoeverre een statement op jouw ervaring van toepassing is. Er zijn verder geen goede of foute antwoorden, alleen jouw mening telt. Je zult misschien merken dat sommige vragen erg op elkaar lijken, dit is noodzakelijk voor statistische redenen.

Naam speler:

Datum:

1. Ik had het gevoel aanwezig te zijn in de computerwereld

-3 = Helemaal niet +3 = Heel erg

○	○	○	○	○	○	○
-3	-2	-1	0	+1	+2	+3

2. Ik had het gevoel omgeven te zijn door de virtuele wereld

-3 = Helemaal mee oneens +3 = Helemaal mee eens

○	○	○	○	○	○	○
-3	-2	-1	0	+1	+2	+3

3. Hoe bewust was jij van de echte omgeving (bv. geluiden van buiten, kamertemperatuur), terwijl jij je bevond in de virtuele ruimte.

-3 = Helemaal niet bewust +3 = Zeer bewust

○	○	○	○	○	○	○
-3	-2	-1	0	+1	+2	+3

4. Hoe echt kwam de virtuele omgeving op jou over

-3 = Helemaal niet echt +3 = Heel echt

○ ○ ○ ○ ○ ○ ○

-3 -2 -1 0 +1 +2 +3

5. Ik had het gevoel slechts plaatjes te aanschouwen

-3 = Helemaal mee oneens +3 = Helemaal mee eens

○ ○ ○ ○ ○ ○ ○

-3 -2 -1 0 +1 +2 +3

6. Ik was me niet bewust van mijn echte omgeving

-3 = Helemaal mee oneens +3 = Helemaal mee eens

○ ○ ○ ○ ○ ○ ○

-3 -2 -1 0 +1 +2 +3

7. In hoeverre kwam jouw ervaring in de virtuele omgeving overeen met jouw ervaringen in de echte wereld?

-3 = Geen overeenstemming +3 Volledige overeenstemming

○	○	○	○	○	○	○
-3	-2	-1	0	+1	+2	+3

8. Ik had niet het gevoel in de virtuele ruimte aanwezig te zijn

-3 = Helemaal mee oneens +3 = Helemaal mee eens

○	○	○	○	○	○	○
-3	-2	-1	0	+1	+2	+3

9. Ik lette nog op de echte omgeving

-3 = Helemaal mee oneens +3 = Helemaal mee eens

○	○	○	○	○	○	○
-3	-2	-1	0	+1	+2	+3

10. Hoe werkelijk kwam de virtuele wereld op jou over

-3 = Zoals een denkbeeldige wereld +3 = Niet te onderscheiden van de echte wereld

○ ○ ○ ○ ○ ○ ○

-3 -2 -1 0 +1 +2 +3

11. Ik ging volledig op in de virtuele wereld

-3 = Helemaal mee oneens +3 = Helemaal mee eens

○ ○ ○ ○ ○ ○ ○

-3 -2 -1 0 +1 +2 +3

12. De virtuele wereld kwam echter op mij over dan de werkelijke wereld

-3 = Helemaal mee oneens +3 = Helemaal mee eens

○ ○ ○ ○ ○ ○ ○

-3 -2 -1 0 +1 +2 +3

13. Ik voelde me aanwezig in de virtuele ruimte

-3 = Helemaal mee oneens +3 = Helemaal mee eens

○ ○ ○ ○ ○ ○ ○

-3 -2 -1 0 +1 +2 +3

Optioneel: Extra vragen

Heb jij op- en/of aanmerkingen over het VR-systeem?

- Ja
- Nee

Door dit onderzoek ben ik bewuster geworden van mijn eigen scangedrag

- Ja
- Nee
- Weet ik niet

Appendix C

Scaling Igroup Presence Questionnaire (IPQ)

Presence	Spatial Presence	Involvement	Experienced Realism	Grade	Adjective	Acceptability
≥ 4.41	≥ 5.25	≥ 4.87	≥ 4.50	A	Excellent	
≥ 4.07	≥ 4.76	≥ 4.50	≥ 3.75	B	Very Good	Acceptable
≥ 3.86	≥ 4.50	≥ 4.00	≥ 3.38	C	Satisfactory	
≥ 3.65	≥ 4.25	≥ 3.75	≥ 3.00	D	Marginal	Marginally acceptable
≥ 3.47	≥ 4.01	≥ 3.38	≥ 2.63	E	Unsatisfactory	
< 3.47	< 4.01	< 3.38	< 2.63	F	Unacceptable	Not Acceptable

Figure 5: Scaling of the Igroup Presence Questionnaire (IPQ) according to the qualitative scales of Melo et al. (2023)

Appendix D

Information Letter

Beslisgedrag van voetballers beïnvloeden door middel van Virtual Reality

Informatie voor spelers

Achtergrondinformatie over het project

FC Groningen werkt samen met de Rijksuniversiteit Groningen om sportwetenschappelijk onderzoek uit te voeren, op basis waarvan de ontwikkeling van voetballers geoptimaliseerd kan worden. Via de bijgevoegde toestemmingsverklaring wordt jouw toestemming gevraagd om je gegevens te gebruiken voor de wetenschap.

De studie waarvoor jouw toestemming wordt gevraagd is gericht op het onderzoeken van of beslisgedrag van spelers te beïnvloeden is vanuit Virtual Reality. Vanuit de wetenschappelijke literatuur is nog niet duidelijk of Virtual Reality beslisgedrag van spelers kan beïnvloeden. Tactische training wordt voornamelijk gedaan door middel van 2d visualisatie op een magneet bord of 2d videoanalyse. Virtual Reality zou een betere fit kunnen zijn omdat het brein beter leert, opereert en ontwikkeld in een multisensorische 3d omgeving. Het doel van het huidige onderzoek is daarom om in kaart te brengen of beslisgedrag van spelers beïnvloedt kan worden door middel van training in het virtual reality systeem.

Wat betekent deelname voor jou?

Voor dit onderzoek wordt data (gegevens) gebruikt, die over twee of maximaal vijf metingen bij jou zijn verzameld. Het gaat dus om de situaties die jij hebt beoordeeld, waarbij jij zo snel mogelijk moest kiezen naar welke speler (a-b-c-d) je de bal zou passen. Bij de eerste en de laatste meting is ook de Igroup Presence Questionaire afgenomen, om te bekijken hoe jij de virtual reality ervaring hebt ervaren. Als jij de toestemmingsverklaring ondertekent, betekent dit dat je ermee instemt dat jouw data ook voor wetenschappelijk onderzoek worden gebruikt. Technisch gezien betekent dit dat jouw gegevens binnen FC Groningen worden gepseudonimiseerd (dat je persoonlijke gegevens niet uit de data gehaald kan worden) en op een veilige manier worden gedeeld met onderzoekers van de Rijksuniversiteit Groningen. Dit betekent dat je naam wordt vervangen door een willekeurig getal of een code. Verder kunnen onderzoekers en studenten betrokken bij het project (Ruud den Hartigh, Rienk Wagenaar) via de Rijksuniversiteit Groningen wetenschappelijke analyses uitvoeren op gegevens die bij jou verzameld zijn. Resultaten van die analyses kunnen gebruikt worden voor mastertheses, maar mogelijk ook publicaties in (sport)wetenschappelijke tijdschriften en presentaties op congressen. Hierbij zal nooit direct-identificeerbare informatie, zoals je naam, vermeld (kunnen) worden.

Vrijwilligheid van deelname

Als je besluit medewerking te verlenen aan dit onderzoek, wil ik je vragen om de toestemmingsverklaring (*informed consent)* te ondertekenen onder “Ik doe mee aan het onderzoek”. Indien je wenst dat jouw gegevens niet gebruikt worden voor wetenschappelijk onderzoek, teken je onder “Ik doe niet mee aan het onderzoek”. Als je hebt bevestigd dat je meedoet aan het onderzoek, blijf je de vrijheid behouden om wegens voor jou relevante redenen, al jouw gegevens te laten verwijderen voor verder wetenschappelijk onderzoek. Gegevens kunnen echter niet meer verwijderd worden als hierover is gerapporteerd in een wetenschappelijke publicatie of masterthese. De onderzoeker zal het formulier eveneens ondertekenen en bevestigt dat hij jou heeft geïnformeerd over het onderzoek, deze informatiebrief heeft overhandigd en bereid is om waar mogelijk in te gaan op nog opkomende vragen.

Vragen
Indien je na het lezen van de brief, voor of tijdens het onderzoek nog nadere informatie wil ontvangen over het onderzoek, dan kun je contact opnemen met:

Contactpersonen FC Groningen:
Mees van der Linde
E: meesvanderlinde@fcgroningen.nl

Contactpersonen RUG:
Dr. Ruud den Hartigh
Heymans Instituut voor Psychologisch onderzoek, afdeling Ontwikkelingspsychologie
E: j.r.den.hartigh@rug.nl

Rienk Wagenaar
Master student Talent Development and Creativity, afdeling Psychologie
n.a.wagenaar@student.rug.nl

Appendix E

Written Consent

Toestemmingsverklaring
Voor deelname aan wetenschappelijk onderzoek

"*Beslisgedrag van voetballers beïnvloeden door middel van Virtual Reality.*"

- Ik verklaar op een voor mij duidelijke wijze te zijn ingelicht over de aard en het doel van het onderzoek. Ik ben in de gelegenheid gesteld om vragen over het onderzoek te stellen en mijn vragen zijn naar tevredenheid beantwoord.
- Ik weet hoe de gegevens en resultaten van het onderzoek opgeslagen en gebruikt worden.
- Ik geef toestemming om de gegevens te verwerken voor de doeleinden zoals beschreven in de informatiebrief.
- Ik begrijp dat ik mijn deelname op ieder moment, om wat voor reden dan ook, mag en kan beëindigen zonder dat hieraan enige consequenties verbonden zijn.

Toestemming van de deelnemer

Ik doe mee aan het onderzoek Ik doe NIET mee aan het onderzoek

Naam: Naam:

Geboortedatum: Handtekening:

Handtekening:

Datum:

Verklaring onderzoeker
Ondergetekende verklaart dat de hierboven genoemde persoon over het bovenvermelde onderzoek geïnformeerd is. Hij zal resterende vragen over het onderzoek naar vermogen beantwoorden. De deelnemer zal van een eventuele voortijdige beëindiging van deelname aan dit onderzoek geen nadelige gevolgen ondervinden.

Naam: Rienk Wagenaar

Functie: Masterthesis student van de Rijksuniversiteit Groningen

Datum: 12-09-2023

Appendix F

Scoresheets

Speler:		
Voormeting	**Antwoord**	**Tijd**
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

Speler:		
Interventie/Controle sessie 1	**Antwoord**	**Tijd**
1		
2		
3		

4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

Speler:		
Interventie/Controle sessie 2	**Antwoord**	**Tijd**
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

13		
14		
15		

Speler:		
Nameting	**Antwoord**	**Tijd**
1		
2		
3		
4		
5		
6		
7		
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12		
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15		