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Assessing the effectiveness of goal-directed versus stimulus driven visual search training at improving goalkeepers’ penalty kick save responses

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ASSESSING THE EFFECTIVENESS OF GOAL-DIRECTED VERSUS STIMULUS-DRIVEN VISUAL SEARCH TRAINING AT IMPROVING GOALKEEPERS' PENALTY KICK SAVE RESPONSES

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Approval of Thesis

We, the faculty supervising the work of Annabelle Treacy, affirm that the thesis, *Assessing the Effectiveness of Goal-Directed versus Stimulus-Driven Visual Search Training at Improving Goalkeepers' Penalty Kick Save Responses*, meets the high academic standards for original scholarship and creative work established by the School of Kinesiology and the College of Health Professions. The work also conforms to the requirements and formatting guidelines of Marshall University. With our signatures, we approve the manuscript for publication.

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Abstract

Goalkeepers must perceive and analyze many different types of information in a short time to effectively move their bodies to make a save. Skilled goalkeepers enhance their actions by coupling them to information present in their environment. The information in their environment constantly changes, so the goalkeepers must adjust their strategies or positions to match the environmental demands. Goalkeepers use two types of perception and attentional strategies: stimulus-driven and goal-directed. Stimulus-driven perception is fast and compulsory, while goal-directed perception is slower and more methodical. Both visual search strategies direct the goalkeeper's attention to where it is most needed and can be trained to improve goalkeeping performance and efficiency. Therefore, this thesis aimed to investigate the effect of visual perception training strategies on improving goalkeeping actions. It was hypothesized that goalkeepers who underwent visual perceptual training and goal-directed visual perceptual strategies would show greater improvements between reaction times and movement towards the ball during a save of a penalty kick compared to those without training or goalkeepers who used stimulus-driven perceptual strategies.

This study was designed to be observational with a longitudinal, repeated-measures analysis. Nine experienced soccer goalkeepers gave consent and participated in this study, and they were separated into three groups: video-control, stimulus-driven, and goal-directed. The subjects underwent a pre-and post-test with a 10-day visual training intervention in between. Both pre-and post-tests had the subjects try and save 6 randomized penalty kicks from the same kicker, and after each kick, the subjects verbalized their thoughts to the researcher. The training had the goalkeepers watch a compilation of 20 penalty kick videos for 10 days. The data were collected using a video camera, pressure-sensing insoles, and an IMU. The data collected from

these devices were processed into discrete variables. Two-way, mixed-model ANOVA was conducted in SPSS to assess differences in the variables. A type I error rate was set at α=.01. A power analysis was conducted to determine the appropriate amount of people per group for statistical significance: a power of .8 and a Type I error rate of 10%. A qualitative analysis was used to investigate the participants' think-aloud responses to assess how they used perceptual training strategies and how they might have benefitted from the training.

The data set was checked for normality, and no significant 2-way interactions were present within the data. Reaction time increased from pre- to post-test for our training groups. The stimulus-driven group confidently accelerated in the correct direction, while the goal-directed confidently and the video-control groups nervously accelerated in the wrong direction. The stimulus-driven group also moved faster in the y-direction compared to the other two groups.

The first hypothesis was not supported because there were no positive differences from pre- to post-testing for any variable, and reaction time increased for all participants. The second hypothesis was not supported because we predicted the goal-directed group would show the most improvement when the stimulus-driven group became the most successful after training. There was human error because we employed human kickers instead of robots. Not all the shots went to the exact right place; sometimes, they were just close enough to count, or it took the kicker a few tries, which could have thrown the goalkeepers off their rhythm. We were unable to mediate subject training due to conflicting schedules, so not all subjects completed the full regime. Shifted equipment caused incomplete data in some trials. Our main finding of this study was that stimulus-driven training was better at improving goalkeeping performance.

Chapter 1: Introduction

When making a save, soccer goalkeepers analyze the pitch, their opponent, and the initial flight of the kicked ball to perceive the information they need to guide their body movements to intercept the shot. Goalkeepers rely on skillful visual perception to ensure that the appropriate action patterns are produced to make a save, an example of perception-action coupling (Bertenthl, Rose, & Bai, 1997; Huesmann, Loffing, Busch, Schroer, & Hagemann, 2021; Savelsbergh, Williams, van der Kamp, & Ward, 2002). Skilled goalkeepers enhance their interceptive actions by coupling them to information from their environment, i.e., the soccer field and opposing players (Stone, Maynard, North, Panchuk, & Davids, 2015). Goalkeepers need to have the ability to predict the trajectory of a kicked ball from an opponent's positioning of their trunk and foot, angle of running approach, ball direction, and ball speed (McMorris & Colenso, 1996; Hunter, Angilletta Jr., & Wilson, 2018; Savelsbergh et al., 2002; Shafizadeh & Platt, 2012). The goalkeepers' prediction must occur within an exceptionally short period of time because soccer is a fastball sport where the speed of play and velocity of the ball control when decisions have to be made (Savelsbergh et al., 2002). During a game, a goalkeeper constantly makes decisions regarding their position, defense strategy, and pose within the goal. Certain actions determine a goalkeeper's ability to position themselves appropriately about the position of opposing players, minimizing their displacement in goal before a shot takes place and choosing the best defensive strategy to block a shot (Lamas, Drezner, Otranto, & Barrera, 2018). Expert goalkeepers initiate their movements earlier than novices, which shows they can apply their improved perception-action coupling capacities to the distinctive visuomotor task of saving a shot (Mallek, Benguigui, Dicks, & Thouvarecq, 2017). Saving a shot requires optimal coordination between perception and action systems to intercept the kicked ball quickly.

Goalkeepers intake predictive information about the likely ball path and time-to-goal through a visual search that may be guided by a stimulus or directed by a goal. Visual information is brought in through the eyes and processed, organized, and interpreted within the brain to parameterize the saving action (Dinard & Thullier, 2004). Visual information may be perceived as stimulus-driven (bottom-up) or goal-driven (top-down). Bottom-up perception is a fast, compulsory, stimulus-driven mechanism (Parkhurst, Law, & Niebur, 2001), in this case, a reaction to the movement of the ball at the time of the kick. Stimulus-driven attention correlates the salience of stimulation at a location to visual fixation at those locations, i.e., the ball (Parkhurst et al., 2001). Top-down perception is a slower, more goal-directed mechanism (Parkhurst et al., 2001), such as searching for clues from the opponent's body positioning before the kick. Here, goalkeepers will pay attention to the angle of approach and looking direction of the opposing player to dictate their interceptive actions (Furley, Dicks, Stendtke, & Memmert, 2012). Expert goalkeepers tend to fixate their gaze on both kicking and non-kicking legs instead of the other parts of the body; however, novice goalkeepers tend to fixate more on the trunk, hips, and arms (Tedesqui & Orlick, 2015). Kinematic analyses have shown that the most reliable predictors of ball direction are the hips and kicking foot angle. Expert goalkeepers make fewer visual fixations for longer periods on the kicker compared to novice players (Causer, Smeeton, & Williams, 2017; Savelsbergh et al., 2002), and can better estimate the path of the ball, its speed, angle, and spin (Shafizadeh & Platt, 2012). Observers use a combination of stimulus-driven and goal-directed perceptions to perform tasks (Proulx, 2007). Parkhurst et al. (2001) suggested that, in general, the stimulus-driven, bottom-up mechanism is better because it affects the allocation of our attention to the more important matters, and our attention is naturally guided through this mechanism. Goal-directed attention strategies were found to lead to more frequent and longer fixations on items that did not always fit the task context. On the other hand, goal-directed perception was more useful when a set of task instructions needed to be completed (Parkhurst et al., 2001). Ultimately, both mechanisms must interact because the brain activity of each one is hard to dissociate from each other (Asplund, Todd, Synder, & Marois, 2010).

Both goal-directed and stimulus-driven visual search strategies can direct a goalkeeper's attention to where it is needed most, and both approaches can be trained to improve efficiency and relevance. Perceptual training effectively improves both predictive abilities and enhances performance (Murgia, Sors, Muroni, Santoro, Prpic, Galmonte, & Agonstini, 2014; Poulter, Wann, & Jackson, 2005). Training success is shown through improvements in outcomes of response time, speed, and response accuracy (Poulter et al., 2005). Perceptual skills also improve with experience (Murgia et al., 2014). A guided perceptual training program (goal-directed) allows the goalkeeper to anticipate the area of the goal better before the foot makes contact with the ball and improves their perceptual and tactical skills (Diaz, Fajen, & Phillips, 2012; Murgia et al., 2014; Nunez, Ona, Raya, & Bilbao, 2009; Rebelo-Goncalves, Figueriedo, Coelho-e-Silva, & Tessitor, 2016). After an extensive search, we found no literature that used or examined the success of stimulus-driven training. That stimulus-driven training is not widely used could be because stimulus-driven attention is considered people's default setting when it comes to attention. A comparison between the default and goal-directed would provide helpful information.

Goalkeepers who identify valid movement constraints from visual perception respond with faster limb and whole-body movements toward the future location of the ball. Goalkeeping actions are associative learning as a response to a stimulus. The strongest stimulation leads to the strongest association with that stimulus, eventually leading to the most common action (Plojac, van Schie, & Bekkering, 2009). For goalkeepers saving a shot on goal, their actions are short-term and explosive (Knoop, Fernandez-Fernandez, & Ferrauti, 2013; Hunter et al., 2018), so the most common action should be instinctive. Goalkeepers can consider themselves successful when they initiate a fast response time to move in the right direction toward the eventual location of the ball and make a save (Peiyong & Inomata, 2012). Small changes can make the difference between goalkeeping success and failure, so understanding the relative effectiveness of visual-perceptual training for a fast and correct response will help goalkeepers and coaches.

Purpose

The purpose of this thesis was to investigate the effect of visual perception training strategies on improving goalkeeping actions.

Research Question

What is the effect of goal-directed (top-down) versus stimulus-driven (bottom-up) visual perceptual training on the actions of goalkeepers as they make a save from a penalty kick?

Hypotheses

H1a: Goalkeepers who undergo visual perceptual training will show a pre- to post-training decrease in reaction time during a penalty kick save compared to those who do not train their visual perception.

H1b: Goalkeepers who undergo visual perceptual training will show a pre- to post-training increase in center of mass velocity during a penalty kick save compared to those who do not train their visual perception.

H1c: Goalkeepers who undergo visual perceptual training will show a pre- to post-training increase in center of mass acceleration during a penalty kick save compared to those who do not train their visual perception.

H1d: Goalkeepers who undergo visual perceptual training will show a pre- to post-training improvement in ground reaction force direction during a penalty kick compared to those who do not train their visual perception.

H2a: Goalkeepers who follow visual perceptual training with a goal-directed strategy will show a greater pre- to post-training decrease in reaction time during a penalty kick compared to goalkeepers who train with a stimulus-driven strategy.

H2b: Goalkeepers who follow visual perceptual training with a goal-directed strategy will show a greater pre- to post-training increase in center of mass velocity during a penalty kick save compared to goalkeepers who train with a stimulus-driven strategy.

H2c: Goalkeepers who follow visual perceptual training with a goal-directed strategy will show a greater pre- to post-training increase in center of mass acceleration during a penalty kick save compared to goalkeepers who train with a stimulus-driven strategy.

H2d: Goalkeepers who follow visual perceptual training with a goal-directed strategy will show a greater pre- to post-training improvement in ground reaction force direction during a penalty kick save compared to goalkeepers who train with a stimulus-driven strategy.

Delimitations

The delimitations for this study are as follows:

- Participants are healthy (no current injuries) soccer goalkeepers from local teams with at least five years of experience
- Participants will save live penalty kicks before and after 10 days of visual perceptual training
- Videos of soccer penalties from goalkeepers' point of view: used for visual perceptual training
- Sony RX10III camera: used to record videos of penalty kicks and attempted saves

- MetaWear IMU: used to measure goalkeepers' center of mass movements during attempted saves
- Arion Smart Insoles: used to measure goalkeepers' ground reaction forces during attempted saves
- Lapel microphone: used to record goalkeepers as they think aloud
- MatLab: used to synchronize data files and calculate movement timings and directions

Assumptions

The assumptions for this study are as follows:

- Participants completed the visual perceptual training as requested
- Participants gave full effort during the live penalty kick saves
- Participants completed the penalty saves in the same way as they would during a match

Operational Definitions

Bottom-up: Attention is paid to a visual stimulus driven by the stimulus being obvious and standing out from the environment (also stimulus-driven) (Parkhurst, Law, Niebur, 2001).

Goal-Directed: Attention paid to a visual stimulus driven by the stimulus being searched for consciously by the observer (also top-down) (Parkhurst et al., 2001).

Goalkeeper: An association football player whose role is to stop the opposition from scoring a goal by moving their body into the path of the ball (Ducksters, 2023).

Penalty: A single shot on goal against only the defending goalkeeper which is taken with the ball stationary from a mark 11 meters from the goal line and centered between the goal posts (The IFAB, 2023).

Perception-Action Coupling: Coordinated movement produced in response to and parameterized by the attention paid to environmental stimuli, particularly visual stimuli (Poljac et al, 2009; Huesmann et al., 2021).

Stimulus-Driven: Attention is paid to a visual stimulus driven by the stimulus being obvious and standing out from the environment (also bottom-up) (Parkhurst et al., 2001).

Think Aloud: Participants' verbal responses to open-ended, non-leading questions where participants describe their thought process as they complete a task (saving a penalty) (Ericsson & Simon, 1980).

Top-Down: Attention is paid to a visual stimulus driven by the stimulus being searched for consciously by the observer (also goal-directed) (Parkhurst et al., 2001).

Visual Perception: The ability to be aware of the environment and objects within it due to sensory information taken in by the eyes of location, structure, size, movement, shape, and pattern (APA Dictionary of Psychology, 2023).

Chapter 2: Literature Review

Goalkeepers

Soccer is one of the most recognizable, influential, and respected sports worldwide. Every member plays an important role in the team's success, but goalkeepers have one of the most important roles in the team. Goalkeepers are required to have fast, accurate response times based on a variety of visual cues exhibited by the opposing players, and their jobs rely on the actions of others. The purpose of this paper is to investigate how goalkeepers use different visual search strategies, what they perceive, and their resulting actions, as well as the benefits of different types of visual training. The topic of this thesis is important because there is little research investigating the different types of visual search strategies soccer players utilize during real-time events (Timmis, Turner, & van Paridon, 2014). Studying these strategies and their effects will ultimately give us further insight into how goalkeepers use them while performing. Since not much is known, we do not know which strategies are the most beneficial to goalkeeping success. The main themes present within these studies are the concept of perception-action coupling, the characteristics, and concepts of both perception and action, as well as the training and benefits of different visual search strategies.

Perception-Action Coupling

When making a save, soccer goalkeepers analyze the pitch, their opponent, and the initial flight of the kicked ball to perceive the information they need to guide their body movements to intercept the shot. Goalkeepers must rely on a specific type of skilled perception that precedes their action, leading to the important investigation of their use of perception-action coupling (Huesmann et al., 2021; Savelsbergh et al., 2002). Coupling perception and action is necessary to ensure that the appropriate action patterns are produced during specific environmental demands of the situation, in this case, a game or penalty kick (Bertenthl et al., 1997). The task determines functional perception-action coupling, and when performed well enough, it reveals an expertise effect (Mallek et al., 2017). The mapping between action observation and execution reflects the nature of the task goal instead of being obligatory or automatic like once thought, thus showing that it is more flexible than assumed (Poljac et al., 2009). Different degrees of perception-action coupling involve different neural mechanisms, including the ventral and dorsal streams, that process anticipation and action (Huesmann et al., 2021). The visual systems guide perception and action, and their natural coupling needs to be preserved to enhance the chances of unraveling the neural processes that underlie sports proficiency during real-world tasks (Huesmann et al., 2021). The ventral stream, also known as the vision for perception, processes characteristic information in the environment and identifies what action needs to be performed (Huesmann et al., 2021). The superior colliculus of the brain has a direct relationship with the enhancement of parietal lobe cells and the movement of the hands and eyes in the resulting environment (Posner, 1980). Further confirming that perception-action coupling occurs widely throughout the brain and visual systems. Goalkeepers can enhance their perception-action coupling systems through indeterminate interactions between them and their environment, i.e., the soccer field and opposing players (Stone et al., 2015). Skilled goalkeepers can regulate their interceptive actions by coupling them to different sources of information when it becomes available to them during their dynamic movements (Stone et al., 2015).

The goalkeepers need to have the visual ability to both judge and predict the trajectory of the ball, body angles, angle of approach, ball direction, the ball speed, and positioning of the opponent's trunk and foot at ball contact all within an exceptionally short period (McMorris & Colenso, 1996; Hunter et al., 2018; Shafizadeh & Platt, 2012). Goalkeepers also need to be able to use advanced postural cues to succeed in this sport (Savelsbergh et al., 2002). Since having been discovered that perception and action are coupled, we have come to realize that before a movement is made, anticipatory postural adjustments are made from the perceptual information sources given to the players so that interceptive actions can be made (Stone et al., 2015). Experts demonstrate more selective and refined visual search patterns and superior anticipation skills, and these search patterns are picked up continuously rather than discrete ones (Savelsbergh et al., 2002).

A fast-ball sport is when the speed of play and velocity of the ball control when the decisions must be made by players (Savelsbergh et al., 2002). In this situation, soccer would be considered one of those sports, and decisions must be made before the action occurs (Savelsbergh et al., 2002). The goalkeeper constantly makes decisions regarding their position, defense strategy, and pose within the goal. The actions of the goalkeeper are driven by their ability to position themselves accordingly regarding the position of the opposing player, minimizing their displacement in the goal before the shot, and correctly choosing the best defensive strategy to block the shot (Lamas et al., 2018). Expert goalkeepers initiate their movements to be adapted and regulated throughout the motion, thus showing that they can transfer their perception-action coupling capacities to this distinctive visuomotor task (Mallek et al., 2017). When an observer, like the goalkeeper, sees an opposing player's action, they produce an action that matches the observed one with a certain degree of precision (Bushnell, 2014). If the observed action changes, then the resulting action by the goalkeeper also changes accordingly, thus further cementing the idea of perception-action coupling (Bushnell, 2014).

In fast-ball sports, like soccer, success is determined when the athletes control the precisely timed visuomotor behaviors under tight spatiotemporal conditions (Mallek et al., 2017).

Not only does success require behavior control, but it also requires an optimal amount of coordination between both perception and action within a short time frame to intercept and return a projectile (Mallek et al., 2017). Long-term memory has also contributed to a potential theory of goalkeeper success (Huesmann et al., 2021). Advanced goalkeepers benefit from years of experience and exposure to any sport or task-specific situations because this knowledge is stored in long-term memory (Huesmann et al., 2021). When the goalkeepers are put back in their familiar experiences and demands, their memory can be accessed from the retrieval cues exhibited by the opposing player (Huesmann et al., 2021). Stress and fatigue affect memory by enhancing its formation around the stressors but impair memory retrieval and information acquisition (Vogel & Schwabe, 2016). Stress can lead to a misinformation effect during memory recall, and this effect occurs when misleading information is presented to the subject after the original event occurs and the memory is updated and reconsolidated when needed (Vogel & Schwabe, 2016). Stress shifts the balance of the memory systems from a more cognitive hippocampal learning strategy to a more rigid habit-like striatal strategy (Vogel & Schwabe,2016). If the subjects tried to recruit their hippocampal memory while stressed their task performance would be impaired (Vogel & Sschwabe, 2016). The most important mental skill for goalkeepers is the ability to maintain optimal focus, thus allowing them to achieve success and elevate their skill level (Tedesqui & Orlick, 2015).

Perception

Goalkeepers intake predictive information about the likely ball path and time-to-goal through a visual search that may be guided by a stimulus or directed by a goal. Perception is when sensory information is brought in through the eyes and processed and organized through the brain. Perception also functions as the interpretation of sensory information that results in an action (Dinard & Thullier, 2004). Our attention determines which available sensory information is processed so we become aware of where to look (Asplund et al., 2010). There are two types of perceptional attention: stimulus-driven (bottom-up) and goal-directed (top-down). Bottom-up attention is a fast, compulsory, stimulus-driven mechanism, while top-down attention is a slower, more goal-directed mechanism (Parkhurst et al., 2001). While different mechanisms stimulate both attentions, psychology has proven that the two have a complex dynamic relationship that determines what we are aware of from each moment (Connor, Egeth, Yantis, 2004). Both neural and psychophysical levels display that stimulus-driven attention occurs early in the process, and goal-directed takes over after about 100ms (Connor et al., 2004). In the stimulus-driven mechanism, the goalkeeper's attention is captured by different stimuli, which alerts them to different salient items in the environment (Parkhurst et al., 2001; Connor et al., 2004). Stimulus-driven mechanisms operate by using raw sensory input to shift attention rapidly and involuntarily to the important salient visual features in front of them, as well as generating subgoals and their answers asynchronously (Connor et al., 2004; Ramakrishnan, Srivastava, & Sudarshan, 1997). Whenever the goal-directed influences are the weakest, attention will become mostly stimulus-driven, contributing to their unique complex relationship (Parkhurst et al., 2001). In the goal-directed mechanism, the goalkeeper's attention is influenced by their expectations and intentions, and their attention regulates the stimulus-driven signals whenever they need to look for something specific in the environment (Parkhurst et al., 2001; Connor et al., 2004). Goal-directed mechanisms execute long-term cognitive strategies and synchronize the creation of subgoals and their answers (Connor et al., 2004; Ramakrishmnan et al., 1997). During stimulus-driven attention, a positive correlation exists between the fixation locations and the salience of stimulation at those locations (Parkhurst et al., 2001). The positive correlation between locations and salience leads to the selection of the first fixation location being determined by the properties of the stimulus (Parkhurst et al., 2001).

Goalkeepers perceive a few different things. First, the penalty taker exhibits enough kinematic information that it is sufficient to guide the perception of others, including the goalkeeper (Furley et al., 2012). One thing that catches a goalkeeper's attention in a penalty kick is a hastening and hiding behavior exhibited by the opposing player, including preparation speed and looking behavior (Furley et al., 2012). The types of behaviors exhibited by the opposing player lead a goalkeeper to think that the player is incompetent, anxious, and weak; thus, the goalkeeper becomes more confident that a save will be made (Furley et al., 2012). When kickers exhibit hastening behaviors, they risk putting themselves into a particular schema (Furley et al., 2012). When a player is sorted into a certain schema, it affects the goalkeeper, their competence, and performance (Furely et al., 2012). For instance, if the kicker has a longer preparation time and more confident-looking behavior, they are seen as more confident to the goalkeeper, and the odds of them scoring increases (Furely et al., 2012). Another example is when the kickers turn their back toward the goalkeepers while also rushing through their preparation routine (Furley et al., 2012). Small behaviors exhibited by the kickers increase the goalkeepers' confidence in saving the penalty kick (Furley et al., 2012). If the hastening and hiding behaviors are exhibited, they lead the goalkeeper to believe that it will be a less accurate kick, thus allowing them to move later as a response (Furley et al., 2012). During a penalty kick, they also pay attention to the angle of approach and looking direction of the opposing player to dictate their interceptive actions (Furley et al., 2012). Expert goalkeepers have been fixating their gaze on both kicking and non-kicking legs instead of the other parts of the body; however, novice goalkeepers have been fixating more on the trunk, hips, and arms (Causer et al., 2017; Savelsbergh et al., 2002).

Kinematic analyses have shown that the most reliable predictors of ball direction are the angle of the hips and kicking foot (Causer et al., 2017; Savelsbergh et al., 2002). Expert goalkeepers make much fewer fixations for much longer periods on the kicker than novice players (Causer et al., 2017; Savelsbergh et al., 2002). During interviews, goalkeepers claim that looking at the run-up angle, the position of the kicking foot at ball contact, the position of the hip at foot contact, and their experience help them make their anticipatory movements (McMorris & Colenso, 1996). During a penalty kick, one goalkeeper reported focusing on the kicker's position before the run-up, and his focus allowed him to predict the corner being kicked to and respond accordingly (Tedesqui & Orlick, 2015). Compared to novices, expert goalkeepers spend a higher proportion of their time fixating on both legs instead of the hips (Causer et al., 2017). Compared to experts, novice goalkeepers spend their time fixating on the arm, trunk, and hips; however, kinematic analysis has demonstrated that the angle of the hips and kicking foot are reliable sources for predicting ball direction (Causer et al., 2017). To anticipate the height of the ball, the upper body, non-kicking foot, and initial ball flight are accurate predictors (Causer et al., 2017). To anticipate the side where the ball will be kicked, the angle of the kicker's run-up, the arc of the leg on approach to the ball, and angles of kicking foot and hips before ball contact have been accurate predictors (Causer & Williams, 2015). Postural cues related to height are more subtle and harder to find when comparing cues between height and side (Savelsbergh et al., 2002). There is a trade-off between early and late prediction when predicting the trajectory of the ball (Hunter et al., 2018). The early prediction allows more time to move, but the late prediction is more accurate (Hunter et al., 2018). As you can see, there are many sources of visual information about the ball's direction, speed, and time-to-contact; however, some of this information is only available after the ball is kicked, and sometimes it is too late for a goalkeeper to execute an accurate response (Diaz et al., 2012). While there is plenty of visual information, the penalty takers can use deceptive behaviors to try and throw off the goalkeepers. Expert goalkeepers can detect these deceptive behaviors better, and they can use them to their advantage because they have gained superior experience in perceiving and performing the actions (Wood, Vine, Parr, & Wilson, 2017). Sometimes, goalkeepers make a decision based on deceptive information exhibited by the kickers, which allows the kickers to have some breathing room and not have to demonstrate a high level of accuracy (Wood et al., 2017).

Our attention is required to focus our processing resources on specific areas of the environment to find what we are looking for, and the way it is allocated is determined by the visual information available in our environment (Boot, Becic, & Kramer, 2009). Goalkeepers, especially professional ones, use their memory and knowledge about the biological motion properties of the kicker to guide their actions, which fits well into embodied cognition (Sandini & Morasso, 2018). Embodied cognition has four elements: situated, time-pressured, the type of environment, and intrinsically action-oriented (Sandini & Morasso, 2018). A situated task is when we process task-relevant sensorimotor information, and the time-pressured element is when it is constrained to real-time interaction (Sandini & Morasso, 2018). The goalkeeper must focus most of his attention on the ball in open-play situations; however, penalty kicks are an externally paced and closed-play task (Tedesqui & Orlick, 2015; Furley et al., 2012). Goalkeepers must rely on the visual information the kicker exhibits and their body before the ball is kicked, especially during the run-up (Murgia et al., 2014; Diaz et al., 2012). During penalty kicks, the time and spatial constraints are reduced because the ball is stopped, allowing them to extract more relevant information from the environment to make an appropriate response (Tedesqui & Orlick, 2015). Goalkeepers use their vision to estimate the path of the ball, its speed, angle, and spin which are neededto have a successful game (Shafizadeh & Platt, 2012). Expert goalkeepers have reported that they use most of their attention to look at the angle of approach to the ball, the trunk position at contact, and the position of the kicking foot at contact instead of the non-kicking foot (Diaz et al., 2012). However, the angle of the non-kicking foot appeared to be the only reliable source of visual information and allowed the goalkeeper enough time to react properly (Diaz et al., 2012). However, we cannot assume that their anticipatory judgments are based on the non-kicking foot because the peripherals pick up additional motion information (Diaz et al., 2012). Goalkeepers have reported that they use their peripherals just as much as their normal visual field during penalty kicks, and they help them delay the movement response as much as possible to avoid giving any cues away from the opposing player (Tedesqui & Orlick, 2015). Expert goalkeepers can extract more task-relevant information from each important fixation located in the most information-dense area of their visual field (Tedesqui & Orlick, 2015). They can also reduce the amount of information that needs to be processed or use fewer fixations to create a coherent perceptual image (Savelsbergh et al., 2002). Within the visual field, there is a window, and within that window of attention, different objects compete for selection (Leber & Egeth, 2006). Competition in the visual field is based on salience, so the most salient object is awarded the most processing priority (Leber & Egeth, 2006). Researchers must understand how the goalkeepers perceive and respond to the kicker's angles, approaches, and shots because it is the key to optimizing penalty success and failure (Hunter et al., 2018). Whatever reaches our awareness and determines our behavior depends on the relationship between goal-directed and stimulus-driven attention (Asplund et al., 2010).

Given that there are two different approaches to perception and attention, they each seem to have their own effects. Both processes are defined as two different input types on the activation map of guided search (Proulx, 2007). There is strong evidence to suggest that the stimulus-driven bottom-up mechanism is better because it not only affects the allocation of our attention to the more important matters but also our attention is naturally guided through this mechanism (Parkhurst et al., 2001). Bottom-up processing guides our attention to unique salient objects in our visual field (Proulx, 2007). The salience of the objects gives bottom-up attention processing a more prominent role in attention guidance (Proulx, 2007). Since the ventral network controls bottom-up attention, the network limits our conscious perception, especially if the dorsal network or visual cortex is absent (Asplund et al., 2010)

On the other hand, goal-directed attention occurs more when task instructions must be completed (Parkhurst et al., 2001). Top-down goal-directed attention affects eye movements stemming from internal models (Parkhurst et al., 2001). However, it has been found that using goal-directed attention strategies will lead to more frequent and longer fixations on items that do not always fit with the context of the task (Parkhurst et al., 2001). It has been observed that there is greater variability of fixation locations when goal-directed attention strategies are used than compared to bottom-up stimulus-controlling attention (Parkhurst et al., 2001). Goal-directed search strategies are used when the target is comprised of different characteristics, and each location contains at least one characteristic of the target (Proulx, 2007). The goal-directed strategy provides strategic attentional control and guidance to the target because none of the characteristics are unique in the display (Proulx, 2007; Eimer & Kiss, 2010). Observers modify their goal-directed strategies based on the nature of tasks, thus guiding their attention to the target (Boot et al., 2009).

Although there is evidence of using both strategies separately, observers use a combination of the two strategies to perform the task (Proulx, 2007). Ultimately, stimulus-driven and goal-directed attention must interact because the brain mechanisms of stimulus-driven attention cannot be easily dissociated from the goal-directed behavior (Asplund et al., 2010). The allocation of attention is based on goal-directed and stimulus-driven factors, but goal-directed plays a more dominant role (Boot et al., 2009).

Visual Search Training

Perceptual training effectively develops predictive abilities and enhances performance (Murgia et al., 2014; Poulter et al., 2005). The success of perceptual training is shown through improvements in response time, speed, and response accuracy (Poulter et al., 2005). When vision is integrated with limb movement tasks, more practice and training result in a faster and more accurate decision-making process for participants (Shafizadeh & Platt, 2012). Perceptual skills have been proven to improve with experience and training, thus showing that our perceptual strategies can be refined (Murgia et al., 2014). Goalkeepers must have both motor and perceptual skills to succeed because they must quickly receive any important environmental information and react as quickly as possible to save the ball (Murgia et al., 2014). The goalkeepers' environment provides them with multiple visual cues, and goalkeepers are trained to use these advanced cues to become more successful (Shafizadh & Platt, 2012). Goalkeepers who practice using cues related to the placement of the non-kicking foot improve their ability to predict the shot direction (Shafizadeh & Platt, 2012). Visual cues specify the anticipation of motor function and the speed at which movement occurs (Nunez et al., 2009). The skills that require speed and precision to locate the stimulus are based on the performer anticipating the next location of the stimulus and not during its movement (Nunez et al., 2009). Guided perceptual training gives goalkeepers the appropriate cues and where to look for them during the critical kinematic points of the kick (Murgia et al., 2014). A long-term training program allows the goalkeeper to improve all physical, technical, perceptual, and tactical skills due to the appropriate muscle and perceptual-cognitive stimulus provided (Rebelo-Goncalves et al., 2016). Goalkeepers, who exhibit slower reaction times, can improve their ability to anticipate the direction of the ball by teaching them how to efficiently search for visual cues (Lidor, Ziv, & Gershon, 2012). Goalkeepers who undergo video-based training in penalty kicks can anticipate the goal area better before the foot makes contact with the ball (Diaz et al., 2012). Providing feedback on the most reliable sources of information will guide the observer and their attention toward those sources (Diaz et al., 2012).

After an extensive search, we found no literature examining and using stimulus-driven training. Stimulus-driven attention is considered people's default setting when it comes to attention, so no one has considered this a valuable research topic. While we did find some research on goal-directed approaches, there is still not a lot. Different visual search strategies studies say that how stimuli are prioritized is influenced by the observer's goals, thus incorporating goal-directed attentional control (Leber & Egeth, 2006). Unlike, stimulus-driven training, there is some evidence of goal-directed training being implemented. Participants tend to restrict attention to one target feature and search for additional targets that have similar features (Proulx, 2007). Participants also use a smaller grouping of targets and, in a goal-directed fashion, identify the target in that grouping (Proulx, 2007).

Action

Goalkeepers who identify valid movement constraints from visual perception respond with faster limb and whole-body movements toward the future location of the ball. A player is known to execute an action related to their list of action rules based on the condition (Lamas et al., 2018). Actions are based on associative learning, which responds to stimulation (Poljac et al., 2009). There is a close relationship between action observation and execution, and observing these executed actions stimulates the motor areas in the observer's brain (Poljac et al., 2009). The strongest stimulation leads to the strongest association with that stimulus eventually leading to action (Plojac et al., 2009). Like the ventral stream, the dorsal stream is the vision for action and is responsible for visual movement control (Huesmann et al., 2021). Since the dorsal stream aids in visual control, the goalkeeper ensures they are in the right place at the right time (Huesmann et al., 2021). During a penalty kick, it typically takes 600 ms for the ball to reach the goal, and goalkeepers have between 300 and 800 ms to react (Diaz et al., 2012; Timmis et al., 2014). Based on those times, sometimes the goalkeeper does not have enough time to properly initiate and complete the full-body movement required to save the shot (Diaz et al., 2012). Goalkeeper's actions are short-term, explosive, and demanding in response to the cues exhibited by the opposing players and the ball (Knoop et al., 2013; Hunter et al., 2018).

A goalkeeper has a small amount of time to organize and execute an effective response, and if the goalkeeper executes it successfully, they demonstrate proficiency in a complex task (Sandini & Morasso, 2018). The goalkeeper's complex task includes perceptual, motor, cognitive, and affective assessments (Sandini & Morasso, 2018). There is a behavioral loop between the kicker and the goalkeeper, and the timing of the goalkeeper's actions is influenced by the visual information presented by the kicker (Furley et al., 2012). Goalkeepers use the kinetic and visual information from the kicker during the run-up to anticipate the kick direction (Furley et al., 2012). A downside is that if the goalkeeper initiates a movement too early, compared to the kicker, it will lead to an unsuccessful performance (Furley et al., 2012). Soccer has a high spatiotemporal pressure environment, and in sports like that, the players are forced to anticipate their opponent's next move (Huesmann et al., 2021). Based on the speed of the ball, the goalkeeper decides when they need to initiate their movement; if it is very fast, they consider moving earlier and anticipate where the ball might go so they can be there to stop it (Hunter et al., 2018). A slower shot results in a longer flight time, allowing the goalkeeper to wait longer before initiating movement, thus choosing the accuracy of their movement over timing (Hunter et al., 2018). Expert goalkeepers have quicker overall response times due to their accurate decision-making and anticipation (Tedesqui & Orlick, 2015). Goalkeepers must have a different visual perceptual ability that allows them to coordinate their movements and defend the goal in the process, and their actions can include punching a ball out, saving the shot, and intercepting the ball (Shafizadeh & Platt, 2012). Goalkeepers' skill level is determined and enhanced if they understand tactics, placement, perception, and anticipation (Knoop et al., 2013). To help make a successful save, goalkeepers must anticipate height and side, which could be given to them through different postural cues from the kicker (Causer & Williams, 2015). Goalkeepers can increase their chances of making a save by trying to throw off the kicker's fuel (Masters, van der Kamp, & Jackson, 2007). Goalkeepers can achieve this by standing ever so slightly to one side of the goal, thus throwing them off and making them kick to the larger side of the goal (Masters et al., 2007). Anticipation is key to performance, and the goalkeepers can use one of two strategies. The first strategy prioritizes timing over direction (Noel, van der Kamp, & Memmert, 2015). During the first strategy, the goalkeeper anticipates the kicker's intention and moves before the kicker's foot makes contact with the ball (Noel et al., 2015). The second strategy prioritizes direction over timing which is where they move after the ball is kicked to ensure they travel to the correct side, trying to increase their chances (Noel et al., 2015).

Visual cues are only displayed when the kicker wants to display them, directly affecting the goalkeeper's actions (Causer et al., 2017). The timing of when these cues become available to the goalkeeper directly affects their perceptual strategy and the accuracy of their choices (Causer et al., 2017). The timing of the goalkeeper's actions is influenced by the preperformance behaviors of the penalty takers (Furley et al., 2012). The pre-performance behaviors exhibited by the penalty takers, including hastening and hiding behaviors, show the goalkeeper that they are less likely to execute a successful kick, resulting in the goalkeepers initiating a later movement response (Furley et al., 2012). The kinematic information displayed by the penalty taker's run-up to the ball allows more skilled goalkeepers to utilize all that information appropriately to anticipate the direction of the ball before contact is made with the ball (Furley et al., 2012). Goalkeepers control their behavior based on the increased exposure to the amount of situated information given to them by the opposing player (Furley et al., 2012). Goalkeepers should be prepared to anticipate the ball and produce an effective response based on the visual information provided to them by the kicker, and their ultimate goal is to decrease their movement time as much as possible (Rebelo-Goncalves et al., 2016). There are biomechanical trade-offs between speed and accuracy during penalty kicks (Hunter et al., 2018). Speed-accuracy tradeoff means that if a shot is taken quicker, the goalkeeper has less time to respond and in turn, defend less appropriately (Hunter et al., 2018). When the shot is taken slower, it gives the goalkeepers more time to prepare a response and increase their accuracy to save the shot (Hunter et al., 2018). Goalkeepers have been known to adapt their movements to help minimize the effects of spin on the ball (Dessing & Craig, 2010). For example, if the ball was kicked, the goalkeepers can choose to wait longer before initiating their movement, to observe the ball's trajectory, allowing them to improve their ability to detect the curve on the ball (Dessing & Craig, 2010). Even if the save is not successful, the goalkeeper must go through a few different actions or decisions to get to that point.

The goalkeeper must first position themselves about the ball and the opposing player, they should stop their movement and displacement right before the shot is taken, and finally, they must choose the most appropriate defensive action to stop the ball from going into the net (Lamas et al., 2018). These sequences of decisions that the goalkeeper makes constant updates during the preparation of the kick, so they can properly protect the goal, and their success depends on those decisions (Lamas et al., 2018). For example, during diving saves, the goalkeeper's performance is determined by acceleration, deceleration, jumping, changes in directions, and diving motion (Rebelo-Goncalves et al., 2016). All these components are a combination of physiological, metabolic, biomechanical, and morphological characteristics (Rebelo-Goncalves et al., 2016). Goalkeepers can also consider themselves successful movement when they use advanced visual cue utilization to initiate a fast response time and accurate decision-making to move in the right direction (Peiyong & Inomata, 2012). Expert goalkeepers are more accurate in predicting the direction of the ball because they wait slightly longer before moving, have fewer corrective adjustments, and have elite search patterns (Peiyong & Inomata, 2012).

Summary

The literature review detailed a bit of information about perception-action coupling, perception, visual training, and action. Perception-action coupling is a necessary skill to master due to its effect on the environmental demands that ultimately control the resulting actions. To make anticipatory actions during a kick, goalkeepers need to use advanced postural cues exhibited by the opposing player, such as body angles, angle of approach, and ball direction. To perceive these types of cues, goalkeepers must either stimulus-driven, goal-directed, or both attentional processes. Expert goalkeepers have been known to extract more task-relevant information from each fixation in their overall visual field. Visual and perceptual training effectively improves both predictive abilities and enhances performance through response time, speed, and accuracy. There is no evidence of stimulus-driven training being used or very little evidence of goal-directed training. In goal-directed training, participants focus their attention on one target feature and look for other targets with the same feature. The strongest association drives goalkeepers' actions to a stimulus. Pre-performance behaviors exhibited by penalty takers show the goalkeeper all the information they need to know, good and bad. Depending on how skilled the goalkeeper is, all that information can be extremely useful. Due to this cue utilization and accurate decision-making, goalkeepers can consider themselves successful when they move in the right direction, even if a save cannot be made.

Chapter 3: Methods

Design

The purpose of this thesis was to investigate the effect of visual perception training strategies on improving goalkeeping actions. An observational study with a longitudinal, repeated-measures design was employed to determine this effect. The population was experienced, soccer goalkeepers, the intervention was visual search training, and the activity for testing was a set of penalty saves. The independent variable was the visual perception training group to which the participant was assigned three levels: video-control watching, stimulus-driven training, and goal-directed training. The dependent variables were reaction time, center of mass velocity, center of mass acceleration, and direction of ground reaction force (GRF). A qualitative analysis of participants' think-aloud responses was completed to assess the degree to which the participants followed the principles of their assigned visual perceptual training.

Participants

All participants for this study were recruited from a Division I college campus and the surrounding community. Nine goalkeepers participated in this study (age 21 years, experience 11 years, 6 males and 3 females). The inclusion criteria were to have played or be currently playing the position of a soccer goalkeeper with at least two years of experience, be recreationally active for at least two sessions a week for at least two hours per session, and have no current injury. Participants were excluded if they had less than two years of goalkeeping experience or had not played within the past three months, were not active for a least two sessions a week for at least two hours per session, were currently injured or had an injury requiring surgery within the past year, or were pregnant. The participants gave consent, and the study was been approved by the Marshall University IRB.

Protocol

Participants answered background questions (Appendix B) before beginning the study. Participants came to a recreation soccer field for a pre-test where they attempted to save six live penalty kicks. The same kicker was used for all subjects and trials, and his years of soccer experience as a field player were similar to those of the subjects. The kicker was given a list of randomized ball placements into one of the four corners for each trial, with the third trial having the same ball placement for every participant. Between each trial, the subjects were approached by the researcher and asked for their feedback and thoughts about how the trial went. After the pre-test, the participants were assigned at random to one of three training groups: Video-Control, where the participant watched soccer goalkeeping highlights every day for 10 days; Stimulus-Driven, where the participant watched a compilation of 20 penalty kick videos recorded from the point of view of the goalkeeper every day for 10 days, and with the instruction to watch where the ball is kicked and where it goes as they watched; Goal-Directed, where the participant watched a compilation of 20 penalty kick videos recorded from the point of view of the goalkeeper every day for 10 days, and with the instruction to look at the kicker and pay attention to how they move and to try to predict where they will kick the ball as they watched. The participants watched a compilation of 100 penalty kick videos split up over 5 days and repeated (20 videos a day) during the training period. The videos were emailed to the participants along with a survey, where they answered questions (Appendix B) to prove that they watched the compilation video. After the training period ended, the participant returned for a post-test and followed the same procedures as the pre-test. Participants came to a recreation soccer field where they attempted to save six live randomized penalty kicks from the same kicker used in the pre-test.

Data Collection

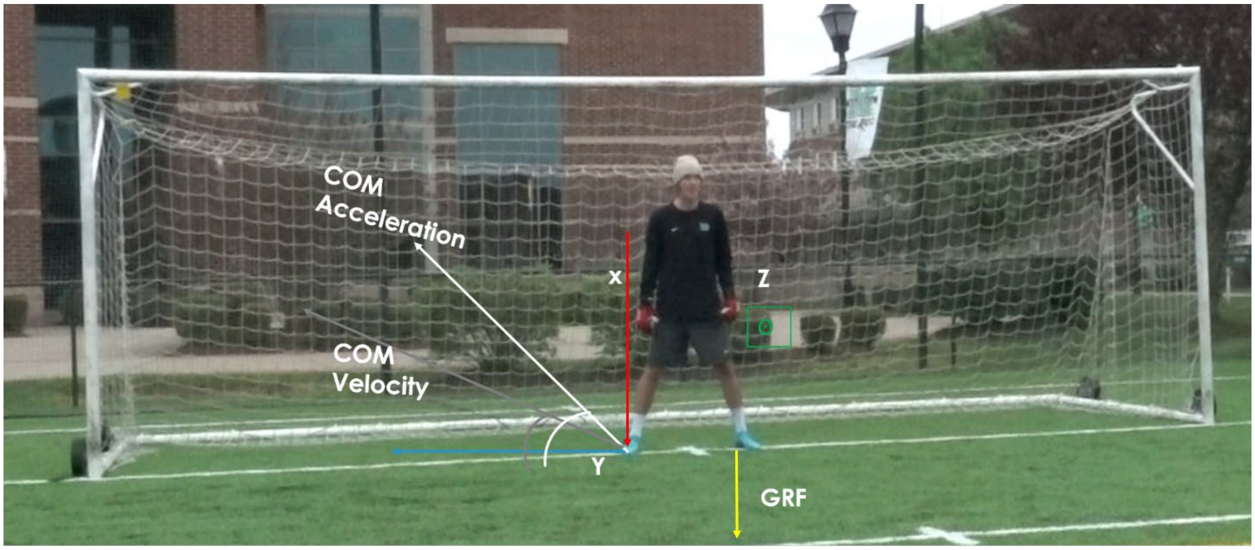
A video camera (RX10iii, Sony, New York, NY) was placed on a tripod behind and to the left of the kicker and was used to record the moment of contact with the ball and the movement of the goalkeeper. Pressure-sensing insoles (Arion, ATO-Gear, Groningen, Netherlands) were placed inside the participant's cleats and recorded the normal ground reaction force. An inertial measurement unit (IMU) (MetaWear, MBIENTLAB Inc., San Jose) was placed on the participant's sacrum and recorded the linear and rotational accelerations of the goalkeeper's trunk. After each penalty kick and attempted save, the participants followed a think-aloud protocol where they answered the open-ended question: "What did you do to try to save that penalty?" We followed the accepted think-aloud protocol as stated by Ericsson and Simon in their 1980 study (Ericsson & Simon, 1980). Their responses were recorded as they talked about what they were doing and what they were seeing during the pre-and post-test.

Data Processing

Video, IMU, and GRF data were time-synchronized using the Unix time code stamped into the IMU and GRF output data files and frame rate of the video camera. Reaction time was calculated as the time difference between the frame in which contact was made between the ball and the kicker's foot from the video camera and the start of a continual acceleration slope from the IMU. The center of mass acceleration was calculated as the resultant acceleration vector from the IMU during a continual acceleration slope. The center of mass velocity was calculated as the integral of the resultant acceleration vector from the IMU during a continual acceleration slope. The direction of the GRF was calculated from the location of the center of pressure and the orientation of the GRF vector from the pressure-sensing insoles. (Figure 1) The visual cues and perception strategy used were gauged from the participants' answers to the think-aloud question.

Figure 1

Study Variables



The X-axis is denoted by the letter X with a red arrow pointing downwards. The Y-axis is denoted by the letter Y with a blue arrow pointing to the goalkeeper's right. The Z-axis is denoted with the letter Z with a green Cyrillic capital symbol. Ground Reaction Force is denoted as GRF and the yellow arrow points down into the ground. The center of mass acceleration is denoted with the white arrow positioned diagonally between the X/Y axes. The center of mass velocity is denoted with the gray arrow positioned diagonally between the Y axis and the COM acceleration vector.

Statistical Analyses

A two-way, mixed-model ANOVA was conducted in SPSS version 29 (IBM Corp., Armonk, NY) to assess within and between participant differences in reaction time, center of mass velocity, center of mass acceleration, and GRF among training group (video-control, stimulus-driven, goal-directed) and across time (pre and post). Type I error rate was set a priori at $\alpha = 0.1$. A power analysis was conducted to determine the appropriate amount of people per group for statistical significance. With a power of 0.8 and a Type I error rate of 0.1, based on pilot data estimates of effect sizes we needed 2.7 to 8.3 people per group.

Chapter 4: Results

The data set was checked for normality and the presence of outliers. Age, height, weight, and experience were all similar among groups (Table 1). For the dependent variables of reaction time, velocity, acceleration, and GRF, Levene's tests ($p = 0.393$, $p = 0.297$, $p = 0.400$, $p = 0.211$) and Box's M tests ($p = 0.111$, $p = 0.379$, $p = 0.356$, $p = 0.637$) were not significant, indicating that there was homogeneity of variances and covariances among the groups. There were no outliers in the data, as assessed by inspection of boxplots. From these results, we concluded that the data were normally distributed and met the assumptions to proceed with an ANOVA.

Table 1

Participant Demographics

Demographics	Video-Control Group	Stimulus-Driven Group	Goal-Directed Group	Overall
Age (yrs)	21.33 ± 4.61	18.33 ± 2.51	23.33 ± 2.88	20.99 ± 3.33
Experience (yrs)	12.66 ± 4.16	8.83 ± 3.88	11.66 ± 6.11	11.05 ± 4.71
Height (m)	1.76 ± 0.04	1.84 ± 0.10	1.74 ± 0.06	1.78 ± 0.06
Weight (kg)	90.86 ± 24.47	82.88 ± 5.06	77.10 ± 8.17	83.61 ± 12.56

Table 1 includes the demographic averages of the three groups individually and the overall averages in the four demographic areas: age, experience, height, and weight.

Two-way ANOVAs were conducted to examine the main and interaction effects of the training group and time on reaction time, velocity, and acceleration. There were no statistically significant interactions between training group and time for reaction time ($F_{2,6} = 2.534$, $p = 0.159$, $\eta^2 = 0.458$), velocity ($F_{2,6} = 0.043$, $p = 0.958$, $\eta^2 = 0.017$), acceleration ($F_{2,6} = 1.053$, $p =$

0.406, η^2 =0.260), or GRF ($F_{2,6}$ = 0.333, p = 0.667, η^2 =0.250). Since there were no statistically significant interactions, the main effects for between- and within-subjects factors were calculated.

The main effect of time was statistically significant for reaction time ($F_{1,6}$ = 4.467, p = 0.079, η^2 = 0.427) and showed an increase from the pre- to the post-test (0.212 s vs 0.370 s, Figure 2). The main effect of time was not statistically significant for speed ($F_{1,6}$ = 0.102, p = 0.760, η^2 = 0.017), acceleration ($F_{1,6}$ = 0.808, p = 0.403, η^2 = 0.119), or GRF ($F_{1,6}$ = 1.186, p = 0.417, η^2 = 0.442).

The main effect of the training groups was statistically significant for speed ($F_{2,6}$ = 5.939, p = 0.038, η^2 = 0.664). The stimulus group moved faster in the correct direction than the video group (1.36 m/s vs -0.02 m/s, p = 0.021) and the goal group (1.36 m/s vs 0.11 m/s, p = 0.030), whereas the video and goal groups moved with similar speeds (-0.02 m/s vs 0.11 m/s, p = 0.779) (Figure 3). The main effect of the training groups was statistically significant for acceleration ($F_{2,6}$ = 7.064, p = 0.079, η^2 = 0.541). The stimulus group accelerated faster in the correct direction than the video group (10.3 m/s^2 vs -1.4 m/s^2, p = 0.027), and the goal group (10.3 m/s^2 vs -10.0 m/s^2, p = 0.008), whereas the video and goal groups accelerated with similar magnitudes in the wrong direction (-1.4 m/s^2 vs -10.0 m/s^2, p = 0.0.349) (Figure 4). The main effect of the training group was not statistically significant for reaction time ($F_{2,6}$ = 1.426, p = 0.300, η^2 = 0.322)), or GRF ($F_{2,6}$ = 0.255, p = 0.790, η^2 = 0.145).

Figure 2

Reaction Time

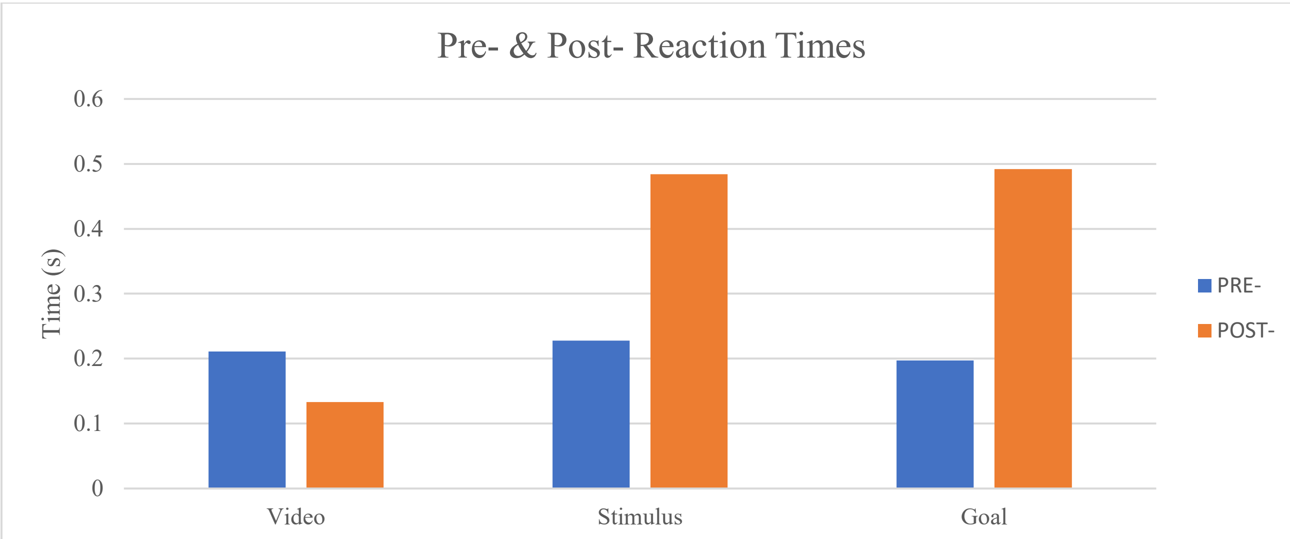


Figure 2 describes the relationship between the pre-and post-test reaction times for all three groups. Pre-test values are in blue and post-test values are in orange and denoted in the legend on the right. The video-control group pre-test value is 0.211 s and post-test value is 0.133 s. The stimulus-driven group pre-test value is 0.228 s and the post-test value is 0.484 s. The goal-directed group pre-test value is 0.197 s and the post-test value is 0.492 s.

Figure 3

Velocity

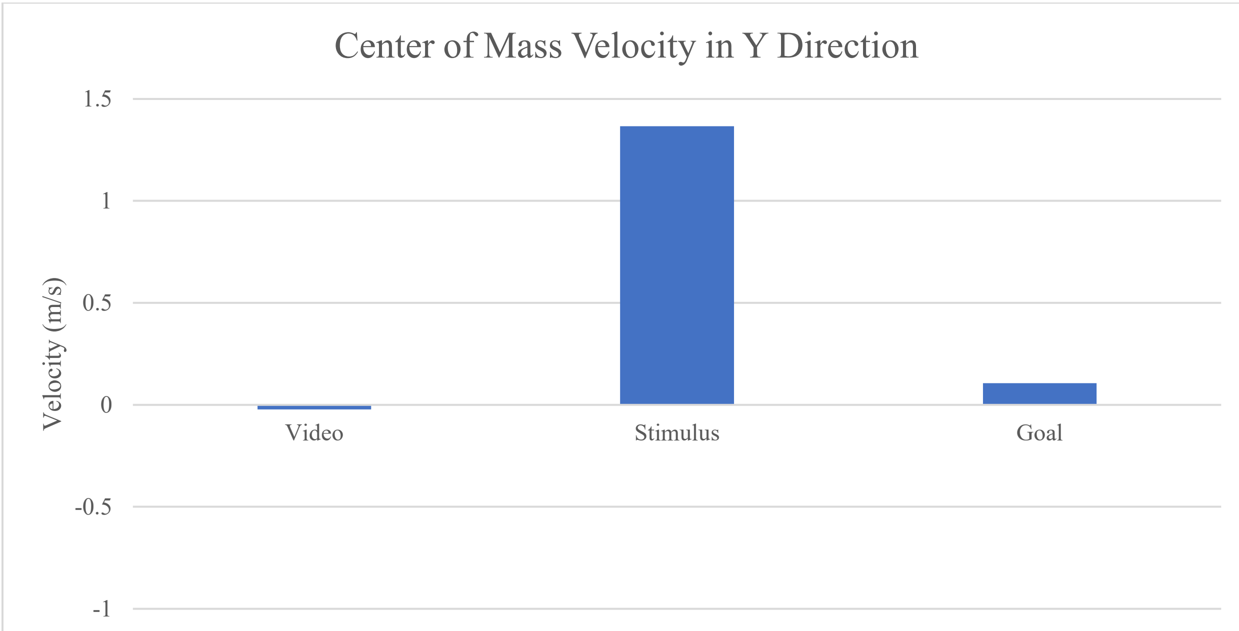


Figure 3 describes the relationship of the center of mass velocity measured in the Y direction for all three groups. The video control group had an average velocity of -0.02 m/s. The stimulus-driven group had an average velocity of 1.36 m/s. The goal-directed group had an average velocity of 0.11 m/s.

Figure 4

Acceleration

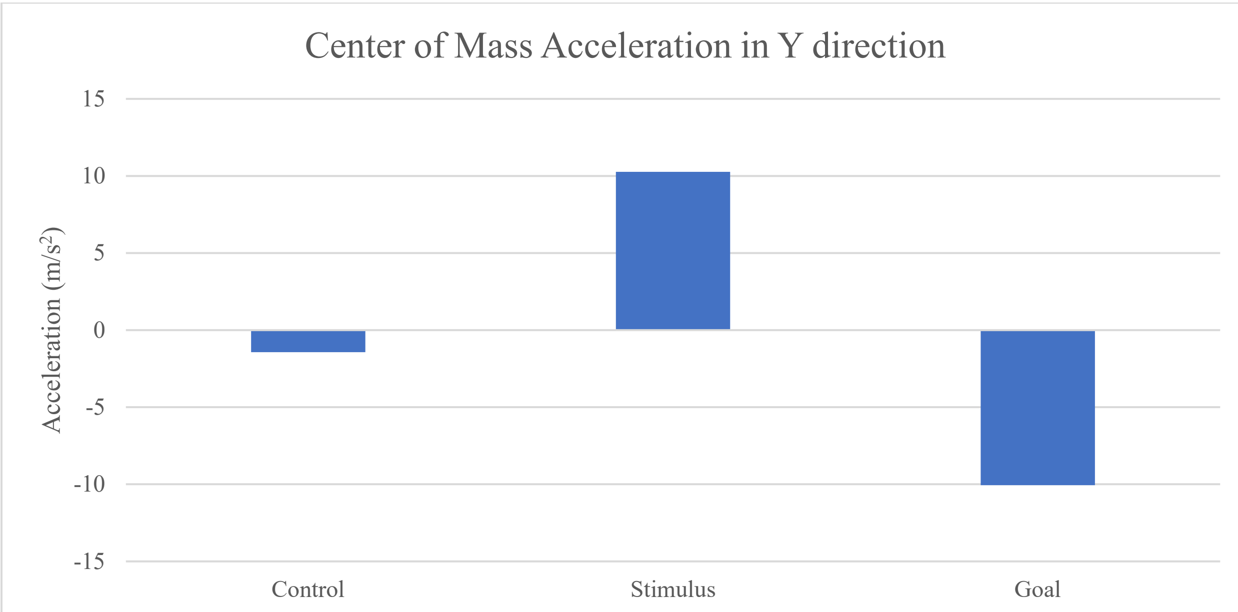


Figure 4 describes the relationship of the center of mass acceleration measured in the Y direction for all three groups. The video-control group had an average acceleration of -1.42 m/s^2*. The stimulus-driven group had an average acceleration of 10.26* m/s^2*. The goal-directed group had an average acceleration of -10.05* m/s^2*.*

Chapter 5: Discussion

In this study, we investigated the effectiveness of visual perceptual training in improving goalkeeping penalty kick performance. We predicted that goalkeepers who underwent visual perceptual training would have decreased reaction time and increased velocities, accelerations, and ground reaction forces compared to those who did not. We further predicted that goalkeepers who followed stimulus-driven training would improve more than goalkeepers who followed goal-directed training. Our first hypothesis was not supported. There were no positive differences from pre- to post-testing for any variable, and reaction time increased for all training group participants. Our second hypothesis was not supported either. We predicted the goal-directed group would be more successful than the other two groups. Following that, the stimulus-driven group would be more successful than the video-control group. However, after further investigation, we found that the stimulus-driven group was the most successful, followed by the goal-directed group and then the video-control group. The stimulus-driven group was more confident, moved quicker, and accelerated faster to their target than the other two.

Reaction time for all groups went the opposite of how we predicted. The average reaction time was 0.158 seconds slower in the post-test than the pre-test, and the average reaction time for the goal-directed group was 0.342 seconds, the stimulus-driven group was 0.356 seconds, and the video-control group was 0.172 seconds. Based on these numbers, the goal-directed did not have the fastest time the control group did; however, just because the reaction time is slower, it does not mean it is bad. During the subject's pre-tests, we let them do whatever felt natural to them by giving them very few instructions, hence faster averages. When they returned for their post-tests, their types of training forced them to rethink their original strategies, lengthen their processing time, and consider new strategies or points of attention, eliciting slower reaction time averages. There is an individual-differences approach that appears within an experimental design that Mueller et al., 2017 discovered is important to fully understand the underlying control mechanism in both performance and learning (Mueller, Gurisik, Hecimovich, Harbaugh, & Vallence, 2017). Mueller et al.'s study found that during a learning stage, individual skilled goalkeepers explored the speed and accuracy of their movements in a nonlinear fashion across their time scale (Mueller et al., 2017). They found that some individuals benefited their response accuracy by responding earlier, while others benefited their response accuracy by responding later (Mueller et al., 2017). Through our training, we forced the subjects to think differently than what they were used to, and depending on their group, we reconditioned them to pay attention to the many different cues available. Thus, giving them more visual information to search and decipher before making the appropriate movements.

Visual information processing can be compromised if any processing stages are inefficient (Lev, Ludwig, Gilaie-Dotan, Voss, Sterzer, Hesselmann, & Polat, 2014). Visual processing stages can include noisy retinal input, crowding, masking, and slow neural processing (Lev et al., 2014). Additionally, reaction time can be affected by arousal, age, fatigue, practice, errors, exercise, stress, distractions, type of vision (peripheral, etc.), and type of stimuli (Kosinski, 2013; Vaillancourt & Christou, 2013). The fastest reaction time occurs when there is an intermediate level of arousal, which slows down when the subject is too relaxed or tense (Kosinski, 2013). Kosinski (2013) also states that reaction times are less consistent whenever subjects have experienced an adequate amount of practice at a new reaction time task. However, once a subject makes an error, all the subsequent reaction times are slower because the subject is more cautious (Kosinski, 2013). Multiple studies, like Trimmel and Poelzl (2006), found that distractions increase reaction time, because background noise lengthens reaction time by inhibiting parts of the cerebral cortex (Kosinski, 2013). Our study was conducted outside, downtown, in the middle of campus, so it is possible that the goalkeepers were distracted by several things, visually or audibly. Regarding visual stimuli, different eye portions can cause different reaction times. If the stimulus is picked up by the cones (center of eye), that is when the fastest reaction times will occur, as opposed to if the stimulus was picked up by the rods (edge of eye), where slower reaction times will occur (Kosinski, 2013). During their post-tests, several subjects thought the training was helpful because they got to observe some strategies from professionals, as well as, being offered new visual cues to consider during penalty kicks. Goalkeepers gaining new perspectives or strategies could have played a part in the reduction of their reaction times. Reaction time decreases could be due to the goalkeepers eliciting more complex responses trying to retrieve that stored information, thus taking longer to perform the desired action (Kosinski, 2013).

Skilled performers, in this case, our goalkeepers, can regulate their inceptive actions by coupling them to the different sources of information that become partially available to them at different times during the movement (Stone et al., 2015). Perception-action coupling is an important concept linking together our visual processing capabilities and the resulting motor actions. Perception and action must be coupled so that proper action movements are produced from specific environmental demands of the task at hand (Bertenthl et al., 1997). We know that the mapping between action observation and execution is flexible because it depends on the nature of the task goal (Poljac et al., 2009). In this case, we trained our goalkeepers to divert their attention to the ball and specific points on the kicker, and their attention to these points gave them enough information to form their decisions and resulting movements. Our goalkeepers perceived the ball or kicker, processed any information exhibited by them, and coupled that information to the movements they made moments after the ball was kicked. Perception-action coupling and decision-making are critical elements in developing the ability to express speed and agility capabilities under certain conditions (Horicka, Hianik, & Simonek, 2014). Some of the goalkeepers were more successful than others.

The center of mass velocity was investigated as a measure of movement toward the ball to make a save. The video-control group had a speed of -0.023 m/s, the stimulus-driven group was 1.36 m/s, and the goal-directed group was 0.10 m/s. With the stimulus group being faster, this suggests the second part of our hypothesis was not correct. The stimulus group being faster meant that our subjects in the stimulus-driven group moved faster to their intended target and were also correct in their decision. At times, speed can be compromised to become more accurate. There is a phenomenon that occurs at a certain level of stimulus discriminability, where if the subject makes a faster response, they are more likely to commit more errors, and vice versa (Liu & Watnabe, 2011). The phenomenon is called the speed-accuracy tradeoff. When learning a new skill, we tend to take as long as we need to ensure we perform the most accurate response possible. The more comfortable we become performing the task, the faster we accomplish it and the less we think about it. When a time constraint is added to the task, we sacrifice accuracy just to ensure speed takes precedence. Most tasks contain both speed and accuracy requirements, and typically the best way to approach these situations is to move as fast as you can while still maintaining the desired accuracy (Fairbrother, 2010). Liu & Watnabe, 2011 have shown that training has led to a faster and more accurate response, as well as, improved performance across a range of stimulus levels. An observer was put under three different conditions in two alternative forced-choice tasks, and as a result, the observer responded faster but made more errors in condition A than in condition B (Liu & Watnabe, 2011). Assuming stimulus discriminability was the same in both conditions, any differences in reaction time and accuracy were due to the speed-accuracy tradeoff (Liu & Watnabe, 2011). However, if stimulus discriminability was higher in either condition than the other, then the observer's performance in condition C was as accurate as the one with the lower stimulus discrimination and had a faster mean reaction time (Liu & Watnabe, 2011). The faster reaction time in condition C could be because of the higher stimulus discriminability or because of nondecision factors, such as faster motor response times, unrelated to stimulus discrimination (Liu & Watnabe, 2011).

The diffusion model accounts for the speed-accuracy tradeoff, stimulus discriminability, and drift rate (Liu & Watnabe, 2011). The diffusion model has three important parameters: drift rate, non-decision time, and boundary separation (Liu & Watnabe, 2011). When there is an increase in stimulus strength, a larger drift rate is produced, which then leads to faster and more accurate responses (Liu & Watnabe, 2011). When the boundary separation decreases, the observer can produce faster but less accurate responses and vice versa (Liu & Watnabe, 2011). Drift rates can be improved with practice, and drift rates during perceptual tasks measure the quality of the sensory input to the decision process (Petrov, Van Horn, & Ratcliff, 2011). Perceptual learning helps predict a drift rate increase that affects accuracy, reaction time, speed, and, the variability attributable to the speed-accuracy tradeoff (Petrov et al., 2011). Traditional perceptual training interventions have improved decision speed, accuracy, response accuracy, and overall speed (Jackson & Farrow, 2005). Observing the subjects in the present study, made it easy to see the speed-accuracy tradeoff in use. For example, in subject 3's post-test, she made the right decision to go right, but she was not quite fast enough to make the save. Maybe if she was able to come to her decision quicker, she could have been where she needed to be to make the save. Our goalkeepers use the basic Newtonian principles to keep still, prepared, and moving throughout the task. Newton's first law keeps our goalkeepers at rest or in preparatory movements because all forces on the goalkeeper and vice versa are balanced. Thus, keeping them upright and prepared for any situation. Speed-accuracy tradeoff can be witnessed in real-time when the subject videos are played back. There are certain kicks where the goalkeepers make the right decision but do not arrive at the spot quick enough to save the ball. In those specific trials, the subjects chose accuracy over speed. In other trials, the subjects were fast enough but did not always pick the right direction. In these trials, the subjects chose speed over accuracy. Finally, in some trials, the subjects traveled at the right speed and made the correct assumptions to save the ball, even if sometimes it was just "luck."

Acceleration was also considered as the final piece of the kinematic puzzle. The video-control group recorded an acceleration of -1.42 m/s^2, the stimulus-driven group was 10.26 m/s^2, and the goal-directed group was -10.04 m/s^2. The negative numbers recorded in the video-control and goal-directed groups mean that the goalkeepers chose the wrong direction when it came to judging the direction of the penalty kicks. The goal-directed group's acceleration magnitude was just as high as the stimulus-driven group, thus demonstrating to us that both groups were confident in their decision. However, the stimulus-driven group chose the correct direction of the corresponding kick compared to the goal-directed group. Meanwhile, the video-control group was neither confident nor correct in their decision based on the magnitude of the data. In Newton's second law, the forces on and from the goalkeeper have now become unbalanced, thus causing the goalkeeper to accelerate from their position to where they decided to go within the goal. The goalkeepers create a net force from the ground that is much stronger than their constant mass, creating a faster acceleration and confidence in their decision to get to the desired spot. If the goalkeepers do not feel as confident, the net force they are creating to accelerate themselves is not as strong as before, and they do not get to the desired spot as quickly.

The stimulus group's success could be attributed to a couple of ideas: after-training effects, anticipation, speed-accuracy trade-off, or effective perception-action coupling. Based on how the training went, the stimulus group could have responded more effectively to the training thus improving their overall performance, as well as increasing their accuracy. Stimulus specificity is a significant property of perceptual learning and improvement to such stimuli must be the same ones used in training (Petrov et al., 2011). The stimulus-driven group was told to only pay attention to the ball, while the goal-directed was told to pay attention to the kicker's body and corresponding movements, and the video-control group was not given a specific area to look at. Based on what Petrov et al. (2011) said about stimulus specificity, the stimulus group, in this case, would have benefitted from the training the most, due to them having a consistent stimulus to divert all their attention to. Following this same concept, the other two groups would not have been this successful due to the varying attention of inconsistent stimuli. Goalkeepers can use anticipation as a strategy to try to give themselves an advantage in a situation they have little to no control over. Goalkeepers attempt to detect critical movement features made by their opponent at the beginning of a movement that helps them predict an outcome, and if done right, can give them an advantage during the play. (Helm, Resier, Munzet, 2016). Many anticipation training studies have included an in-situ test to assess anticipatory training interventions at different group levels (Mueller et al., 2017). Farrow and Abernethy (2002) compared explicit and implicit video-based temporal occlusion anticipation training of tennis serve returns, and they found that the implicit group was superior to the explicit group (Mueller et al., 2017). Their implicit group was taught to anticipate the speed of serve from video temporal occlusion, and their explicit group was taught to search for visual cues (Mueller et al., 2017). In our study, we found quite the opposite results. Our goalkeepers were taught and told to look for specific visual cues explicitly, and these cues helped them anticipate the direction of the kick. By telling our subjects what to look at they were more successful compared to our video-control group, whom we did not tell to look for visual cues, so they had to rely more on their implicit learning skills.

The three variables discussed in detail above are the only variables we chose where there were differences among groups and time. The remaining variables: angle, center of pressure, force, velocity, and acceleration in the x-direction, did not show any differences, but there are reasons for why. We did not see a change in the velocity and acceleration in the X-direction because the movement we were measuring was in the Y-direction. At the beginning of this experiment, we established our axes as the X-axis being up and down, the Y-axis being left and right, and the Z-axis being forward and backward in the goal. The penalty kick we used for data comparison was in the bottom right corner of the goal (from the goalkeeper's perspective), and the movement required to save those kicks calls for the goalkeeper to move more in the Y-direction than the X-. We did not see a change in the amount of force that was applied mostly because it was easier for the goalkeepers to push just against the ground for movement instead of transferring that energy from the force to a certain skill. Our bodies can transfer energy throughout our bodies for any movement or exercise. When the goalkeepers move, their joint and body segments within the chain affect one another. The lower body kinetic chain consists of the spinal column, pelvis, hips, thighs, knees, lower legs, ankles, feet, and toes. When the goalkeepers generate force and movement, it travels from the nerves in the spinal column down to the toes, thus producing the necessary movement required for the skill. All our goalkeepers generate their forces differently, but they all use that generated force to push off the unmovable ground. The force needed to move against the ground is relative to the goalkeepers who generate it. Angles generated by movement are similar to how force is, and the angle of movement is created by the direction and force that the person needs to travel to finish the desired movement. As mentioned earlier, the kick that we used for data comparison was in the bottom right corner of the goal, and for data comparison to work effectively, the position and condition need to remain the same. Since the condition needs to remain the same, our goalkeepers make the same movements to reach the final position. The movements made by the goalkeepers caused a similar angle to be created from the original position, and if the goalkeepers guessed correctly, they would be making similar angles to travel to the desired position.

The center of pressure is created by humans exerting a force on the ground and the ground exerting an equal force back (ground reaction force), thus producing a sense of balance and stability in our lives. The ground reaction force is concentrated in our feet and the point of concentration is the center of pressure of our bodies. The center of pressure is crucial for balance, stability, and postural control, and is linked to our center of mass. Center pressure displacement can occur when someone becomes off balance and falls or deliberately changes it due to the task at hand. Center of pressure displacement can be used to determine a wide variety of biomechanical variables, the force being one of them. When the subjects are moving back and forth, preparing themselves for kick, their center of pressure is constantly changing to keep them balanced. The center of pressure, in this case, is another relative variable that depends on the pressure displacement, which depends on the subject’s own weight and force distribution once the movement begins. Depending on the goalkeeper’s decision, whether right or wrong, the opposite foot will create the most force to help push them off the ground quickly and to the final position in the goal.

While we quantitatively measured all the other study variables mentioned in this study, there is one concept that we had to measure qualitatively to gauge the goalkeeper's perspectives. The way the study was set up, there was no accurate way to measure the goalkeeping perspective without compromising the methodology. Due to the lack of mobile eye-tracking equipment, we decided to utilize the concept of a think-aloud with the subjects. Think-aloud requires the subject to verbalize their thought process while continuously performing, and there is no evidence to suggest that these instructions would influence subject performance (Birch & Whitehead, 2019; Ericsson & Simon, 1980). There are currently three proposed think-aloud levels, first introduced by Ericsson & Simon (1980). Level 1 includes simple vocalizations of inner speech, with no effort from the subject to verbalize their thoughts (Birch & Whitehead, 2019; Ericsson & Simon, 1980). Level 2 involves verbal encoding and vocalization of an internal mental representation that was not originally verbally coded (i.e., visual stimuli, movements, etc.) (Birch & Whitehead, 2019; Ericsson & Simon, 1980). Level 3 involves explaining the subject's thoughts, ideas, motives, and hypotheses (Birch & Whitehead, 2019; Ericsson & Simon, 1980). Most researchers use level 2 think-aloud procedures and verbalizations due to its ability to capture the subject's ongoing cognition within their short-term memory (Birch & Whitehead, 2019). Think-aloud benefits the researcher because it allows thought processes to be captured in real-time reduces the risk of retrospective bias and memory decay, as well as, and identifies any differences in perceptual-cognitive processes between subjects of varying expertise (Birch & Whitehead, 2019).

Think-aloud also must be executed in a certain way so that it does not interfere with what the researcher needs. By requesting a certain type of information, it can hint to the subjects about what aspects of the task are important (Ericsson & Simon, 1980). From this, the subjects could alter their normal mode of procession to give the researcher the information needed to complete the trial or study (Ericsson & Simon, 1980). Now, whatever the subjects report is most likely to be less than the researcher needs to hear, and to help get the most information possible, researchers need to ask questions that contain contextual information (Ericsson & Simon, 1980). A way to counteract subjectivity during analysis is by providing the subjects with a fixed set of alternative responses (Ericsson & Samson, 1980). When subjects are given general instructions, they tend to tell everything they can remember or what they were thinking about while performing the specific task, and in most cases, the more information given with less bias added typically benefits the researchers (Ericsson & Simon, 1980). Researchers rarely use retrospective probing because the subject's memory and processes would be poor and lacking detail, as well as, researchers are more interested in the general characteristics of the thought process rather than episodic details of an individual trial (Ericsson & Simon, 1980). However, retrospective probing hopes to recover memory traces of the subject's thought processes by giving them appropriate instructions to recall their processes during certain trials (Ericsson & Simon, 1980). Information is stored in different memories with different capacities and characteristics: sensory stores of short duration, short-term memory with limited capacity and/or immediate duration, and long-term memory with large capacity and relatively permanent storage with slow fixation and access time (Ericsson & Simon, 1980). Short-term memory is believed to be extinguished over time or whenever it is replaced, and we can assume that any verbalization of the cognitive process would have to be based on the information available in our memories (Ericsson & Simon, 1980). Even our memories, especially short-term, can be affected by our attentional processes. Whenever there is a shift in attention, specifically caused by sudden movements in our peripheral vision, loud noises, and emotions through our reticular system, the information given around the shift could lead the subjects to give a relatively clear account of the interruption, thus giving the researcher a less complete report than one compared to a normal thought process induced from our short-term memory (Ericsson & Simon, 1980). Think-aloud can be used to retrieve information from long-term memory; however, it can slow the process and make the data seem less natural (Birch & Whitehead, 2019). The information that can be obtained from short-term memory is only briefly available during and after performing a task (Birch & Whitehead, 2019).

For our study, we asked our subjects a couple of questions after each trial. These questions included what they were looking at, and their thought processes or thoughts were about while the kick was happening. Immediately after each trial finished, I walked up to our subjects asking them these questions. Responses varied in length and information given from person to person, sometimes due to their varying levels of expertise. Our third subject (placed in goal-directed group) played as a goalkeeper for 17 years, and four of those were when she played at a university division II level. When I asked her these questions after the third pre-test trial, she mainly informed me that "the kicker set up with the ball differently and ran up to it straighter" than in his previous kicks. She was able to notice those minute details over all her trials and be more specific with her strategies due to her higher level of expertise. During this trial, she also told me that she directed most of her attention to the line the kicker made with his body and the ball and how she anticipated the line of the ball right before and immediately after it was kicked. When we reviewed this specific trial in her pre-test video, we can see that her processing all this information led her to favor her left side, anticipating that would be the correct side; however, by the time she realized her mistake, it was too late, and a goal was scored in the bottom right corner of the net. It is important to note that you can read her facial expression well enough to know that she knows she made a mistake.

Another example is our fifth subject (placed in the stimulus-training group); he has played the position for 4 ½ years and was the starting goalkeeper at his high school. After his third post-test trial, he informed me that he was looking at the direction in which the kicker's body was leaning when he was approaching the ball, and he noticed that at the last second, the kicker swung and lowered his hips down, indicating to the subject that, to his knowledge, the kick would travel to his left in the bottom corner of the goal. The bottom left corner of the goal is where he ended up traveling; this was the wrong decision because he should have traveled to his bottom right instead. Subject five told me that he mostly paid attention to the kicker's body, and if he needed more information, he would glance at the kicker's face. Subject 5 was placed in the stimulus-training group, meaning his training only included the instructions of watching and paying attention to the ball, and not the kickers' features. It was not asked why he switched focus points because we did not want to interfere with his future performances and answers. It raises the question as to why he switched his focus points when he was assigned to a specific group with specific instructions. We can only speculate whether it was due to miscommunication between him and the researcher, unclear instructions, the trained strategy was not something he was using and the training was not long enough to make sure he used it more than his normal strategy, or the personal benefits of using his normal familiar strategy were greater than the new strategy that was unfamiliar to him.

A final example is our fourth subject (placed in the video-control group) who has played the position for 8 years and was one of the starting goalkeepers at his high school. When reviewing the notes and his third post-test trial video, he mentioned to me that he was "not looking anywhere specific" and that he "waited, took in a bunch of different cues and information, and reacted after the kicker made contact with the ball." While he was not looking anywhere or thinking about anything specifically, he mentioned that his gaze would return to the ball before it was kicked. As mentioned earlier, this subject decided to wait and gather all the information he could before making his decision, which is a common strategy for goalkeepers. He did travel in the correct direction (his bottom right), so he was in the correct position to possibly save the ball; however, the kicker's shot was on target, but it happened to miss the goal and travel past the other side of the goalpost. A common mistake made by kickers; even professionals miss the goal from time to time. Subject four likes to wait to initiate his response until he has enough reliable predictors present and/or processed to take this calculated risk. The specific process and how he approached every trial were noted and repeated throughout his tests. Where this subject was in the video-control group, he was given very few instructions on what cues to pay attention to, so during both pre- and post-tests, he utilized the strategies that he has formulated over the years to showcase and verbalize the best version of himself, his performance, and his visual processing capabilities.

Limitations

Our study had several limitations worth noting. By having a human kicker, we open ourselves to human error. We are not robots and we are not perfect; our kicker cannot always put the ball in the correct spot every single time. During data collection, our kicker messed up at least once a test, so certain kicks had to be redone until the ball was put in the right spot. Human error could have also occurred in setting up the equipment and keeping it connected. The goalkeepers were told to pretend this was a real-life situation and to act as normal as possible, including jumping, falling, and sliding. Intense movements could have knocked the accelerometer loose or disconnected the insoles, which led to incomplete data in some trials. Small ways to combat this for next time is keeping a closer eye on making sure all the equipment is still connected or using a different type of equipment that can withstand those types of movement, and unless we had access to a kicking robot, there was always going to be variability in the kicks made. There were some limitations present during the duration of the training. The subjects were tasked to watch an approximately 5-minute video emailed to them every day for ten days after their pretest. During the post-test, some subjects admitted to me that they did not watch the video the whole time, and excuses varied from forgetting to not having time to watch them. So, some subjects did not experience the full training regime, and this could have affected the data and their ability to learn and apply their training possibly. We were not able to mediate their training due to many conflicting schedules and it would be impracticable to make it happen how it is supposed to. These limitations can be fixed by altering the regime and bringing the subjects for a more active type of training, especially with experienced people who just have one job and one schedule to work off. The length of the training could have also become a limitation. Our training can be seen as too long, too short, or even too distracting at times. We chose 10 days because it was just long to see some improvements, but not too long to where it became a huge time commitment to the subjects and we could finish the study promptly. Optimal training improvement schedules can start at two weeks and go up to a couple of months. A way to fix this for next time to lengthen the training to find the right schedule for the study, subjects, and the proper improvements to be shown. One concept we did not explore in this study is investigating how the subjects are using their training to learn, something someone can investigate for future studies.

Conclusion

According to our results, we found that subjects who underwent training showed improvements in their goalkeeping abilities, as well as, the ones who were in the stimulus-driven training group. Our stimulus-driven training group was easier to train because they had a constant and consistent stimulus. Consistent stimulus allows the subjects to process information quicker, and ultimately make their decision quicker and move faster to save the ball. If they did not have a consistent stimulus, they would have to constantly shift their attention to different visual cues to finally find the right one that gives them the most information, and end up moving late and miss the kick because they were still processing the visual information given to them. In the end, stimulus-driven training was considered the best at improving the performance of our goalkeepers.

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Appendix A: IRB Approval Letter

MARSHALL UNIVERSITY
www.marshall.edu

Office of Research Integrity
Institutional Review Board
One John Marshall Drive
Huntington, WV 25755

FWA 00002704

IRB1 #00002205
IRB2 #00003206

November 11, 2019

Steven Leigh, PhD
School of Kinesiology, Marshall University

RE: IRBNet ID# 1502034-1

At: Marshall University Institutional Review Board #1 (Medical)

Dear Dr. Leigh:

Protocol Title:	[1502034-1] Assessing the effectiveness of goal-directed versus stimulus-driven visual search training at improving goalkeepers' penalty kick save responses

Site Location:	MU	
Submission Type:	New Project	APPROVED
Review Type:	Expedited Review	

In accordance with 45CFR46.110(a)(4) & (6), the above study was granted Expedited approval today by the Marshall University Institutional Review Board #1 (Medical) Chair. An annual update will be required on November 11, 2020 for administrative review and approval. The update must include the Annual Update Form and current educational certificates for all investigators involved in the study. All amendments must be submitted for approval by the IRB Chair prior to implementation and a closure request is required upon completion of the study.

This study is for student Annabelle Treacy.

If you have any questions, please contact the Marshall University Institutional Review Board #1 (Medical) Coordinator Margaret Hardy at (304) 696-2477 or hardyma@marshall.edu. Please include your study title and reference number in all correspondence with this office.

Sincerely,

Brett Williams

Brett Williams
Director, Office of Research Integrity

- 1 -

Generated on IRBNet

Appendix B: Questionnaire

- Background questions
    - How old are you?
    - How long have you played this position?
    - How tall are you?
    - How much do you weigh?
- Questions during trials
    - What was your thought process during the kick?
    - What were you looking at?
    - Questions about training process during post-test:
        - How do you feel the training went?
        - Do you think it helped?
        - Was the training load enough?
- Questions asked during training videos
    - For Group 1(Control):
        - List a few things the goalkeepers did.
    - For Groups 2 & 3(Stimulus & Goal):
        - Where did kick #5 go?
        - Where did kick #20 go?
        - Try to change numbers each day, but keep the same for every subject.
            - Day 1: 5, 15
            - Day 2: 5, 15
            - Day 3: 8, 16
            - Day 4: 8, 18
            - Day 5: 7, 12
            - Day 6: 3, 14
            - Day 7: 4, 13
            - Day 8: 4, 13
            - Day 9: 2, 11
            - Day 10: 2, 10
- Script of instructions for each training group that also included a Google Drive link to all the training videos
    - Training Group 1: Control
        - The attached video is your assignment over the course of your training. Watch the video and pay attention to the goalkeeper's movements, strategies, etc
            - The links that were attached to their videos were different goalkeeping highlight compilations from YouTube.
    - Training Group 2: Stimulus
        - The following video contains 20 penalty kicks. When you watch the video, focus on the ball and watch it all the way into the goal. Try and predict where in the goal the ball is going to go as early as you can by focusing on the ball and its movements. Make sure to take note of how many you guess correctly throughout the video
    - Training Group 3: Goal

- The following video contains 20 penalty kicks. When you watch the video, try and predict where in the goal the ball is going to go as early as you can by reading the movements of the player before the kick. You can look at any part of the player's body or the ball that you feel helps you predict where the ball is going to go once it is kicked. Make sure to take note of how many you guessed correctly throughout the video.

Curriculum Vitae

Annabelle Treacy

abmarie8@gmail.com

Education

Marshall University, Huntington WV

MS Biomechanics September 2024 (expected)

Thesis: *Assessing the Effectiveness of Goal-Directed versus Stimulus-Driven Visual Search Training at Improving Goalkeepers' Penalty Kick Save Responses*

The purpose of this study is to investigate the effect of visual perception training strategies on improving goalkeeping actions. There were no significant 2-way interactions, however, there were significant main effects. The subjects that underwent training improved their goalkeeping performance, and the stimulus-driven group improved and was more confident in their performance.

Classes:

- ESS 670- Research Methods in Kinesiology
- ESS 601- Advanced Exercise Testing
- ESS 636- Structural Kinesiology
- HS 650- Human Gait
- HS 615- Kinematic Analysis Application in Biomechanics
- HS 635- Kinetics Analysis Application in Biomechanics
- HS 610- Advanced Biomechanics
- HS 578- Biomechanics Research Practicum
- STA 518- Biostatistics

Marshall University, Huntington WV

BS Biomechanics May 2020

Capstone: *Perceptual and Movement Factors Predictive of Success in Soccer Goalkeepers*

The purpose of this paper was to identify the perceptual and movement factors that differentiate expert and experienced goalkeepers. There were no statistically significant differences in movement factors between expert and experienced goalkeepers; however, this suggests that perceptual strategies are the difference in goalkeeping success. The ability to make use of the kicker's body language cues with a prediction strategy for anticipatory saccades appears to be the most effective for goalkeeping success.

Classes:

- ESS 375- Fitness Assessment & Exercise Prescription
- ESS 442- Principles of Strength and Conditioning
- HS 369- Motor Learning
- HS 365- Functional Kinesiology
- HS 435- Biomechanical Instrumentation MatLab
- HS 465- Biomechanical Analytics of Movement
- HS 478- Research Practicum Biomechanics
- HS 464- Pathomechanics

HS 475- Trends in Biomechanics
HS 495- Trends in Biomechanics II
SFT 373- Principles of Ergonomics & Human Factors

Work Experience

Contractor for Sportsbox AI

Worked with digitizing software of baseball and golf swing videos; Skew Angle Accuracy projects; Golf Swing Annotations project

Affiliations

Member of ISBS

Publications

Treacy, Annabelle; Konz, Suzanne; and Leigh, Steven (2021) "INFLUENCE OF LANDING QUADRANT ON ELLIPTICAL ORBIT AND ITS REALTION TO RELEASE PARAMETERS OF THE HAMMER THROW," ISBS Proceedings Archive: Vol. 39 : Iss. 1 , Article 78.

Other Relations

Front desk receptionist Huntington Cabell Wayne Animal Shelter May 2024-present
Front desk assistant at Brown Dog Yoga Studio March 2024-present
Hostess at Le Bistro from July 2021-2022; Waitress from May 2022-May 2024
Graduate Assistant at Marshall University August 2020- May 2022
Donut maker at Peace Love and Little Donuts from September 2018-April 2021
Lifeguard for 6 years and Pool manager at local neighborhood pool for final 2 years from May 2013-September 2019
Floor safety supervisor for Pump up the Fun from September 2016-May 2019
Volunteer at various local businesses/non-profits/events for 15 years.
New Investigator Award nominee at ISBS 2020

References

Dr. Steven Leigh
Dr. Suzanne Konz
Nathaniel Ashton
Jane Zhang
Dakota Maddox