Response Time to Stimuli in Division I Soccer Players

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Abstract

Spierer, DK, Petersen, RA, and Duffy, K. Response time to stimuli in Division I soccer players. *J Strength Cond Res* 24(X): 000–000, 2010—The purpose of this investigation was to examine the effect of auditory stimuli (AS) and visual stimuli (VS) on sprint time, sprint speed, and reaction time in National Collegiate Athletic Association Division I male soccer players. Fifteen healthy subjects (mean age 22.1 ± 1.6 years) volunteered for the study. This experiment was conducted on a regulation soccer field, using a wireless timing system. Subjects stood on a touch-and-release pad and were instructed a prompt (AS: "go" command via a microphone interface, VS: movement of a player located 10 m from the start) to run 20 m through the finish line timing gates without decelerating. After 3 submaximal sprint trials at 50%, conditions (AS and VS) were randomized and performed 3 times by each subject. The best sprint time, sprint speed, and reaction time were recorded. Paired *t*-tests were conducted on dependent variables to determine statistically significant differences. An alpha level was set at $p \leq 0.05$. Sprint time was reduced in response to VS as compared to AS (3.76 ± 0.16 seconds vs. 3.85 ± 0.15 seconds, $p = 0.001$). Sprint speed (distance covered) was greater in VS compared to AS (5.3 ± 0.21 $m{\cdot}s^{-1}$ vs. 5.1 ± 0.19 $m{\cdot}s^{-1}$, $p < 0.001$), and reaction time was reduced in VS compared to AS (0.53 ± 0.048 seconds vs. 0.61 ± 0.044 seconds, $p = 0.001$). These data show that VS rather than AS improve sprint response times in collegiate male soccer athletes. The data suggest that performance on the field may be improved if coaches and players strategize to integrate visual cues (e.g., gestures and signals) during practices and games.

Key Words sprint, auditory, performance, visual, coaching

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Introduction

Soccer requires quick reactions, rapid linear movement, and a temporal aspect that may necessitate abrupt changes in direction. Although typical coaching methods include communication through verbal commands and auditory stimuli (AS; e.g., warnings and short phrases), previous data demonstrate that the use of visual stimuli (VS; e.g., gestures and signals) may facilitate more awareness and result in improved performance in soccer athletes (25). Others concur and have reported by orienting attention to a spatial location, using peripheral vision enhances the efficiency of processing information and elicits improved attentionality to visual space and the task at hand (26).

Soccer performance can be attributed in large part to the methods players use to scan the field for information (25,28–31). Pesce et al. (25) examined the focus of visual attention in soccer players vs. age-matched controls, where subjects performed discriminative reaction time experiments at rest and after exercise cycling at 60% heart rate reserve. Visual attention was cued via spatial cues of different sizes, followed by compound stimuli with local (near) and global (far) targets on a PC-driven video screen.

The control group in Pesce et al.'s study was quicker to react to local targets on the screen, but the soccer players were faster at switching from local to global attention. This suggests that soccer players develop special skills to rapidly zoom out, and increase their visuospatial attention, thus being able to orient their attention to a larger field (25). Other studies support Pesce et al.'s findings and demonstrate that experienced soccer players respond quicker to visual cues, which suggest that without shifting gaze, a soccer athlete may be more capable of orienting one's visual space on the field, anticipating a developing play or the movement of the ball (30).

Other studies show that when athletic and nonathletic subjects used touch-sensitive pads, joysticks, or a touch-sensitive screens to choose discrete targets, response times to a VS was quicker than with an AS (4,5,7,10,15–17,23–25, 29,30). Differences have also been found in racecar drivers vs. age-matched controls where upper and lower extremity response times were measured in response to auditory and visual cues (5). In that study, racecar drivers demonstrated a significantly faster response time to visual cuing as compared to controls.

Although many investigations on response times to stimuli were conducted, the majority of studies have focused on nonathletic populations (7,8,14,19,26) and investigations in which athletes were tested are few in number (5,9,10,25,30). Even fewer of these studies have been conducted in soccer athletes (25,30) of which none have assessed response time during a sports-specific task. Thus, the current study strived to measure, in a one-time experiment, the inherent response of male National Collegiate Athletic Association (NCAA) Division I soccer players to VS and AS during a 20-m sprint.

Methods

Experimental Approach to the Problem

The study consisted of 3 experimental trials of each of the AS and VS stimulus. Subjects sprinted on a turf field and were randomly assigned to each stimulus by the flip of a coin. Data were acquired through the use a wireless timing system. We hypothesized that a VS would result in quicker sprint time, sprint speed, and reaction time as compared to an AS. This hypothesis is aligned with others who have studied sensory stimuli and the effect of AS and VS on athletic performance (5,10,25,27). The dependent variables in this investigation were chosen for the following reasons: (a) all 3 variables are relevant to the activity performed in soccer, (b) all 3 variables provide performance indices against which improvements and decrements can be measured, and (c) all 3 variables can be accurately recorded with the use of a wireless timing system.

Subjects

Fifteen subjects (mean age 22.1 ± 1.5 years) volunteered for this study from an NCAA Division I men's soccer team during their off-season and were familiarized with all experimental procedures. The protocol was modified from a previous study conducted in a laboratory setting with similar athletes (27). To ensure that subjects met inclusion criteria, an intake form was provided before testing to screen for personal or family history of cardiac, pulmonary, or neurological conditions that might preclude participation. Questionable subject histories were confirmed with the Long Island University head athletic trainer. Upon confirmation of a history of cardiac, pulmonary, or neurological dysfunction, subjects were excluded from participation. All subjects had normal to corrected-to-normal vision as determined by a preparticipation physical examination. Each subject was informed of the experimental risks and signed an informed consent document before the investigation. This study was approved by the Long Island University Institutional Review Board for use with human subjects. Subject characteristics are reported in Table 1.

Table 1. Subject characteristics. Results are reported in mean ± *SD*.

	n	Minimum	Maximum	Mean ± *SD*
Age (32)	15	19.0	25.0	22.1 ± 1.6
Weight (5)	15	68.2	102.3	80.3 ± 8.5
Height (1)	15	160.0	193.0	177.6 ± 8.4
Body mass index ($kg \cdot m^{-2}$)	15	22.5	32.8	25.5 ± 2.6

Procedures

Following well-established testing guidelines, subjects were instructed to refrain from maximal exercise, consumption of caffeine, and heavy meals 2–3 hours before testing (1). Subjects were habituated with the 2 conditions (AS and VS) (Figure 1) by performing 3 trials of running 20 m at 50% maximum speed without the addition of a stimulus. This acclimation protocol was implemented at a submaximal level so fatigue would not influence sprint performance during experimental trials. Before data acquisition, subjects were told they could ask questions and investigators were present to ensure each subject had a full understanding of the procedures. The order of conditions was randomized.

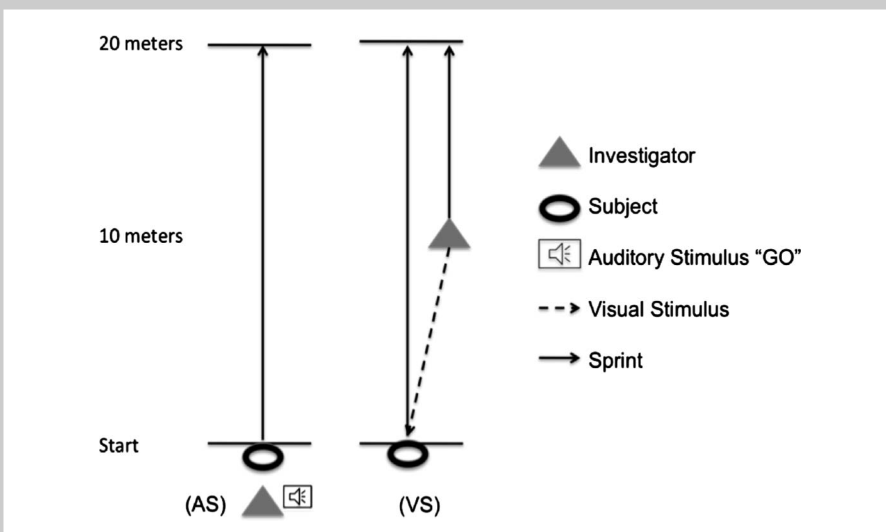

Figure 1. A detailed schematic of the auditory stimulus (AS) and visual stimulus (VS) protocols.

Experimental trials were conducted at each subject's relative maximum speed. After each trial, subjects passively recovered (walking around the test site) for 5 minutes before repeating the sprint.

The experiment was performed on the university's 400-m (40 × 10 m) in-filled turf (Fieldturf, Inc., Peachtree City, GA, USA), the same field used for practice and home games to ensure that subjects were being assessed on a surface where they regularly train and perform. Data were acquired with the use of a wireless Speed Trap II timing system (Brower Timing Systems, Draper, UT, USA). The Speed Trap II timing system minimizes human error by employing a digital readout emitted from 2 infrared electric eyes with built-in transmitters. The system is accurate to 1/100 of a second. The device allows for fully automatic calculation of speed and hands-free usage for self-timing.

Auditory Stimulus Protocol. Subjects were instructed to stand on a touch-and-release pad from which a start time was recorded. The AS was provided via a microphone interface synced with the start timer. The microphone is designed to relay a signal in response to a loud sound (e.g., starting gun, clap, or loud command). To begin the AS protocol, the primary investigator stood 1 m behind the subject and yelled "go" into the microphone to start the timer. Upon hearing the "go" command, subjects were instructed to sprint from the touch-and-release pad, through the timing gates at the finish line without braking (Figure 2).

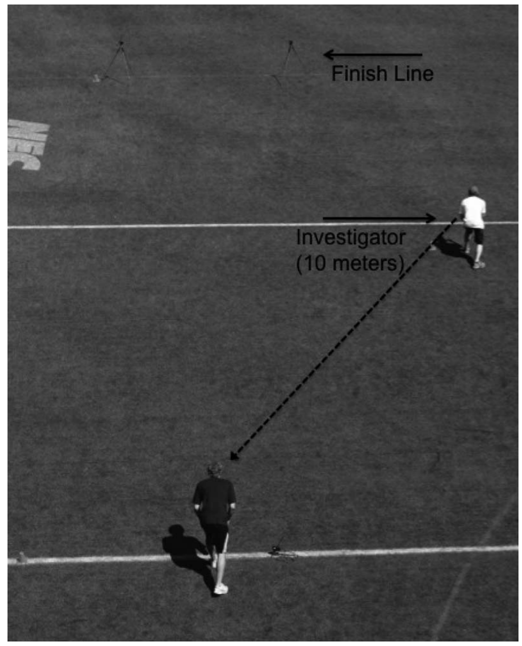

Figure 3. This figure corresponds to Figure 1 (visual stimulus [VS]). An athlete is at the bottom of the figure beginning the VS protocol from the start line. The timing gates (finish line) are at the top of the figure. The investigator is located 10 m from the start line and is depicted in the middle of the figure. The figure is not to scale of the actual 400-m testing area.

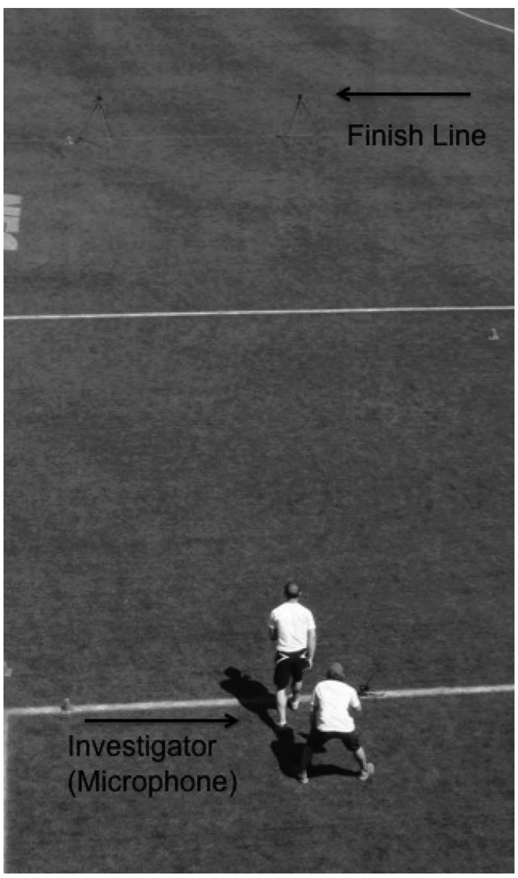

Figure 2. This figure corresponds to Figure 1 (auditory stimulus [AS]). An athlete is at the bottom of the figure, beginning the AS protocol from the start line. The timing gates (finish line) are located at the top of the figure, and the microphone interface and investigator are at the bottom of the figure. The figure is not to scale of the actual 400-m testing area.

Table 2. Results in response to auditory stimuli (AS) and visual stimuli (VS) in all subjects. Results are reported in mean ± *SD*.

	AS	VS	*p* Value
Transit time (s)	3.85 ± 0.15	3.76 ± 0.16	0.001
Transit speed ($m \cdot s^{-1}$)	5.1 ± 0.19	5.3 ± 0.21	<0.001
Reaction time (s)	0.61 ± 0.44	0.53 ± 0.048	0.001

Table 3. Definitions of dependent variables.

Measurements	Auditory stimulus	Visual stimulus
Sprint time (s)	Difference between departure point from touch-and-release pad in response to auditory command to the initial break of the electronic timing gates at the finish line.	Difference between the point of departure from touch-and-release pad to the initial break of the electronic timing gates at the finish line *and* the point of departure from an initial visual stimulus (movement of second player 10 m from start) via stopwatch to the initial break of the electronic timing gates at the finish line.
Sprint speed ($m \cdot s^{-1}$)	Difference in distance traveled from touch-and-release pad in response to the auditory command to the initial break of the electronic timing gates at the finish line.	Difference in distance traveled from touch-and-release pad to the initial break of the electronic timing gates at the finish line *and* the point of departure from an initial visual stimulus (movement of the second player 10 m from the start) via stopwatch to the initial break of the electronic timing gates at the finish line.
Reaction time (s)	Difference between the point of departure from the touch-and-release pad in response to the auditory command to the initial break of the electronic timing gates at the finish line.	Difference between the point of departure from touch-and-release pad to the initial break of the electronic timing gates at the finish line *and* the point of departure from an initial visual stimulus (movement of the second player 10 m from the start) via stopwatch to the initial break of the electronic timing gates at the finish line.

Visual Stimulus Protocol. Subjects were instructed to stand on the touch-and-release pad, 10 m from which a second player was located. The second player, when ready, began running toward the finish line. Subjects were instructed to begin their sprint when they visualized first movement of the second player (visual cue). A handheld stopwatch was used to record the time from when the second player moved to the time the subject crossed the finish line (Figure 3).

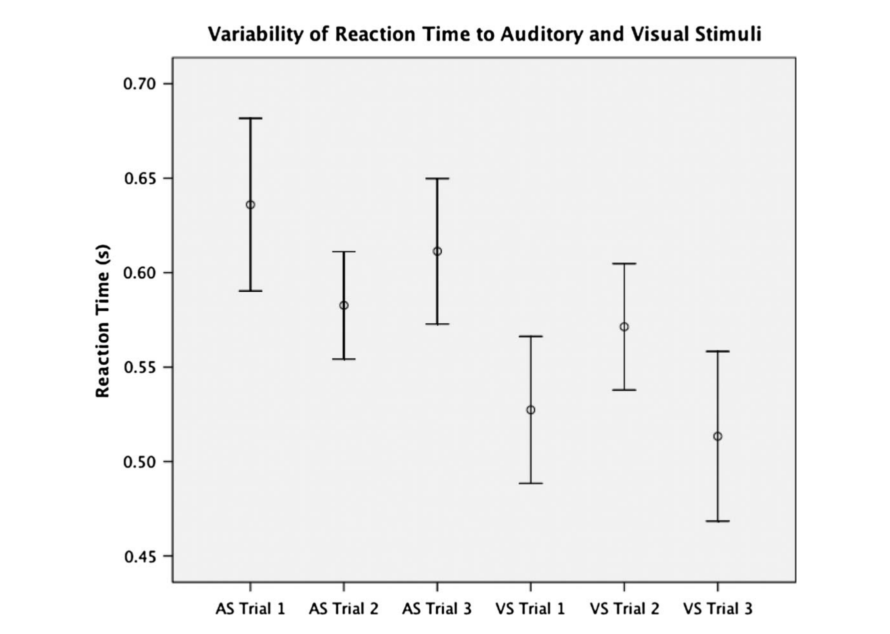

Figure 4. Reaction time variability by trial for each condition. The circles represent mean values and error bars represent a 95% confidence interval.

Statistical Analyses

Data were processed using a statistical analysis software package (SPSS version 16.0; SPSS, Inc., Chicago, IL, USA). Paired *t*-tests (AS vs. VS) were employed to compare results of sprint time, sprint speed, and reaction time. Mean values of the 3 trials were used for analysis. Values are expressed as mean ± *SD* and are shown in Table 2. Measurements are defined in Table 3.

Results

Intraclass correlation coefficients were conducted to determine test-retest reliability. Statistical significance was set at an alpha level of $p \leq 0.05$.

A reduction in sprint time was demonstrated in the VS condition as compared to the AS condition in all subjects (3.76 ± 0.16 seconds vs. 3.85 ± 0.15 seconds, $p = 0.001$; Figure 5A). The range of data for total time across all subjects for the VS condition was 3.55–4.06 seconds, and in response to the AS condition, the range was 3.62–4.10 seconds.

Sprint speed in the VS condition as compared to the AS condition was greater in all subjects (5.3 ± 0.21 $m \cdot s^{-1}$ vs. 5.1 ± 0.19 $m \cdot s^{-1}$, $p < 0.001$; Figure 5B) and was not influenced by player position. The range of data across all subjects for sprint speed was 4.92–5.63 $m \cdot s^{-1}$ and 4.88–5.53 $m \cdot s^{-1}$ for the VS and AS conditions, respectively.

Significant differences were noted in response to the VS condition as compared to the AS condition (0.53 ± 0.048 seconds vs. 0.61 ± 0.044 seconds, $p = 0.001$; Figure 5C). The range of data for reaction time across all subjects was 0.44–0.62 seconds and 0.51–0.67 seconds for VS and AS conditions, respectively. No significant differences were found based on player position.

Intraclass correlation coefficients were conducted to determine test-retest reliability during the 3 trials of each condition (Figure 4)–auditory condition: AS sprint time 0.968, $p < 0.001$; AS sprint time 0.968, $p < 0.001$; and AS reaction time 0.275, nonsignificant–visual condition: VS sprint time 0.959, $p < 0.001$; VS sprint speed 0.959, $p < 0.001$; and VS reaction time 0.350, nonsignificant. A power calculation was conducted to determine a medium effect size. A mean difference of 0.5 seconds between the average speed for 20-m sprint time and that of the subjects in the current study indicated that no less than 15 subjects would be sufficient to find significant differences ($p < 0.05$).

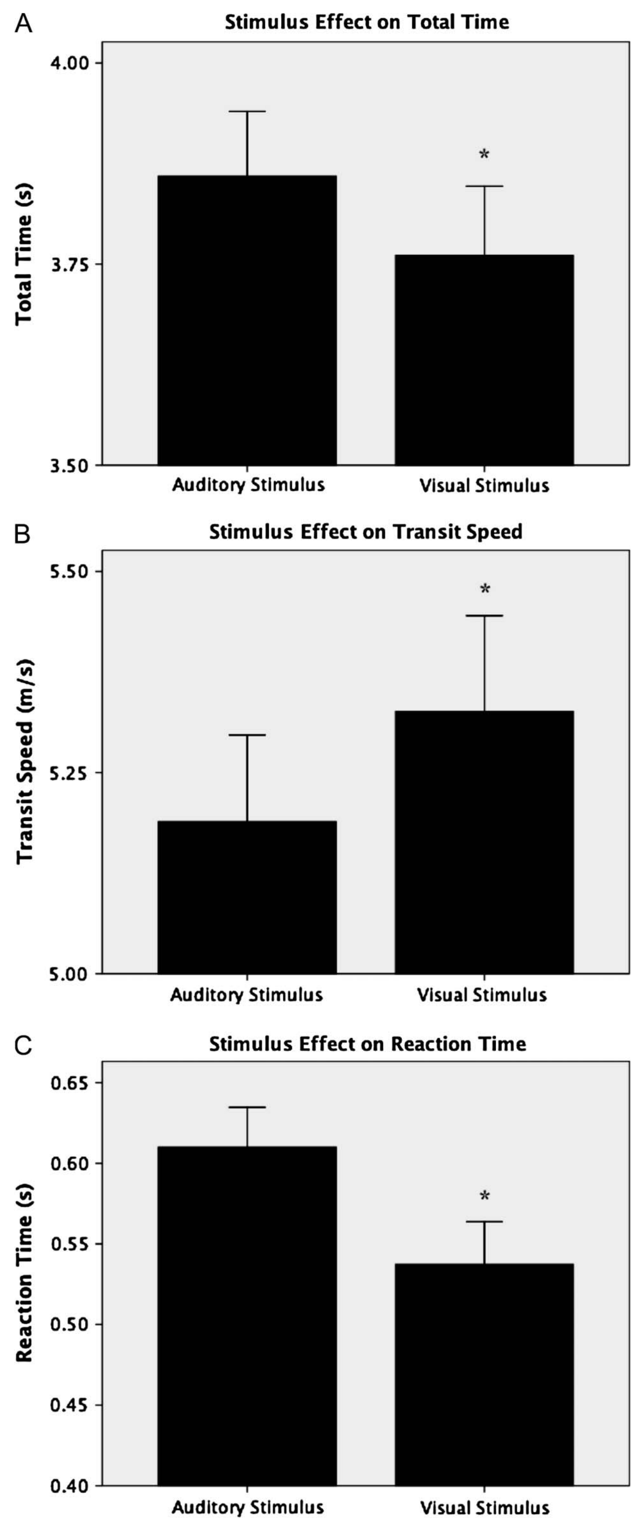

Figure 5. (A) Sprint time (seconds) was reduced for all subjects under the visual stimulus condition as compared to the auditory stimulus condition (*$p = 0.001$). (B) Sprint speed ($m \cdot s^{-1}$) was greater in response to visual stimuli in all subjects (*$p < 0.001$). (C) Reaction time (s) was reduced in response to visual stimuli in all subjects (*$p = 0.001$).

Discussion

The purpose of this study was to examine the effects of AS and VS on 20-m sprint performance and reaction time in NCAA Division I men's soccer players. The major findings suggest that VS elicits decreased sprint times, increased sprint speed, and improved reaction times in the athletes tested. This investigation is a follow-up to a laboratory-based study of short-distance (3 m) response times to AS and VS in NCAA Division I men's soccer players and women's lacrosse players (27).

An essential component of athletic performance in soccer is the player's awareness of local (near) stimuli and global (far) stimuli. The game is influenced by several external factors, including environmental variability, temporal constraints, and movement of an opponent where quick decision making and movements are constantly required (11). Unlike auditory commands that are more frequently heard on the field during games and practices, VS (e.g., the movement of a ball or the shifting of an opponent) may provide players with more flexible search strategies and an ability to scan the field for information. The effectiveness of these strategies may differ depending upon how many players are on the field or whether the play is emphasizing offense or defense (30,31). Nevertheless, the ability of the players to scan or search is borne out of their visuospatial attention (a visual awareness of surroundings) and is either controlled automatically or voluntarily (13).

Automatic control takes place in the peripheral field of view, where attention is elicited by the abrupt onset of a cue, independent of the task at hand. Conversely, voluntary control describes focused attention to the task at hand rather than attention paid to the periphery. Findings in the current study suggest that during the VS, an abrupt cue (movement of the second player located 10-m from the start; Figures 1 and 3) elicited an automatic mode of control (6). Others have similarly described automatic control in testing athletes in response to AS and VS (20,24,25,30). Automatic control has been found in experienced basketball players where search strategies were less affected by local stimuli than those that were in the global field of vision (20). Similarly, this technique has been shown by high-level volleyball players when anticipating movement of teammates, opponents, and the ball (24).

The quicker response to VS in the current investigation suggests that a VS may improve a player's ability to anticipate movement. This may be attributable to a more rapid extraction of relevant information. For example, during the auditory protocol, although there is a split second when the player is waiting to hear "go," the ability to anticipate movement is more difficult because no relevant information is presented until the sound is uttered. However, during the visual condition, players may have quickly responded because they were extracting relevant information presented as movement.

The rapid response to the visual condition in this study may be because of a learning effect during the practice and experimental trials. Data demonstrate that a quicker response time may be achieved by specific and nonspecific training because it relates to the visual task. Arito and Oguri (4) found that training protocols are associated with an improved ability to anticipate after a VS is presented in simple and discriminative tasks on a computer monitor. Similarly, Hascelik et al. (10) demonstrated that 10 weeks of weight training elicits a quicker response time to both AS and VS in volleyball players. The current protocol consisted of 3 experimental trials with 3 practice trials, and even though the data suggest variability in reaction times between trials (Figure 4), the brief number of trials most likely did not elicit a learning effect; however, this may have been the case if the number of trials were increased.

In addition to training, gender may have also played a role in the variance of reaction times seen in the current study, and although female players were not tested in this investigation, data suggest that men possess a quicker processing speed in response to VS than AS (2). Outside of athletic performance, some suggest that response time differences are a function of the type of stimuli presented (e.g., visual or auditory) (3,8). Tasks that present a semantic verbal stimulus or AS (e.g., numbers, letters, or spoken words) are more favorable to women, whereas responses that are more of a spatial or visual nature (e.g., a flashing light on a screen) exhibit a male advantage (21). Men' superiority in visual and spatial abilities is sometimes attributed to differences in cognitive strategies (5,12,14,22); however, others believe that the response differences are associated more with innate processing of verbal and spatial tasks (3,8,15,23,24).

The majority of evidence in this area is isolated to response times represented by fine motor control (e.g., pressing of keys or joystick manipulation) (2,19,23,29,30) not total body movements such as sprinting. Additionally, at the time of this study, there was minimal research specifically related to visual and auditory response times in soccer players (25,30). The results of the current study can be directly applied to soccer and may help temper the anticipation a player experiences when presented with an external stimulus. Unlike previous work, the protocols in this study were conducted on the field to ensure that the assessment of sprint performance was commensurate with the elements of play and running surface on which the soccer athlete performs.

To our knowledge, this is the second study to investigate response times to AS and VS using activities that employ sprinting, and it is the first study to be conducted in collegiate male soccer players. The current study only assessed soccer players, which may limit the results' application to other sports and activities. Also, subjects' eyesight and hearing were not measured with an eye examination or an audiogram before conducting the sprint trials. To protect against this limitation, all subjects had reported, through medical forms, normal to corrected-to-normal vision and were cleared to participate in soccer by the team physician. In addition, the subject pool was small. Although many attempts were made to recruit additional subjects, conflicts of scheduling and injuries left a small pool of subjects.

This study is the first to show the scientific applicability of VS in a field setting with collegiate male soccer players. The findings of this study suggest that during specific situations (i.e., sprinting), traditional audible commands may not be as effective as strategies that incorporate gestures, signals, and scanning techniques. Furthermore, these data suggest that VS could be used to a greater extent in team sports such as soccer. Future studies need to be conducted to address the effect of vision training, scanning techniques, and techniques of automatic control on the field and its effect on player performance.

In conclusion, the main finding of this study is that VS compared to AS elicit quicker sprint times, greater sprint speeds, and faster reaction times in male collegiate soccer players on the field. These findings may be attributable to search strategies, neurological processing speed, or a men's innate response to visual presentation. Although some of the methods of previous studies are different from those employed in the current study, a consistent finding is that VS improves response time with fine motor control or with sprinting. A further understanding of this phenomenon may be beneficial to the performance of the male soccer athlete where varied coaching strategies could be implemented.

Practical Applications

The current data demonstrate that NCAA Division I men's soccer players responded quicker during a 20-m sprint activity on the field when presented with a VS. The improvement of basic visual search strategies and their relation to visual attention represent significant factors to enhance athletes' perceptual skill. Pesce et al. (25) found that experienced soccer players show more flexible search strategies and players who are trained to increase their attention to a VS can rapidly shift their gaze to pick up information from several relevant sources (i.e., coaches, opponents, ball movement, and teammates) (30). This suggests that performance of the expert soccer player is attributable to scanning and responding to specific visual information.

Studies indicate that the experience (training) of the athlete is associated with efficient search strategies (10,25). Although the subjects in this study were not specifically trained to improve their visuospatial awareness, the response time differences in the favor of VS in the current study may portend an alternate or additional training technique for athletes participating in team sports. Previous data suggest that incorporating training experiences that couple submaximal physical exercise with complex attentional zooming tasks may be beneficial to the athlete (25). This would require athletes to rapidly shift between narrow and wide focus of attention while practicing.

For the coach, a structured training regimen that encourages visual searching strategies may provide a tool to enhance performance of the players on the field (18). These programs are focused to improve scanning, visual awareness, and performance; however, they do not represent traditional soccer coaching techniques. Specific skills training like "soccer freeze tag" is implemented to allow players to improve their ability to scan and react. In this exercise, half the players on the field are given a ball and the other players are without a ball. The object of the drill is for the players with the ball ("it") to tag or "freeze" those without the ball by touching them while dribbling the ball. Players who are tagged must stop and place their hands on their head. This gesture is the visual signal to attract other "unfrozen" players to release the "frozen" player. During the drill, players are instructed to position slightly behind the ball so they can continuously scan the field while dribbling. This drill is an example of an alternative method for players to develop their peripheral vision and to scan the field for relevant information (18).

The data in the current study do not indicate that traditional methods of coaching soccer should be disregarded and the authors are keenly aware that many traditional practice drills are necessary especially for those playing defense in which much of the action is occurring behind the player. However, during practices, if specific visual awareness exercises like the "tag" game are implemented, players may be able to sharpen their peripheral vision and thus their ability to switch between narrow (one opponent) and wide (whole field) focus. Nontraditional drills such as these can be implemented piecemeal into a very traditional practice setting, mixing audible commands and visual gestures depending upon the situation.

Using these drills, coaches may be able to identify players that possess a superior ability to scan or divert their attention from local to global stimuli. Once those players are identified, advanced training techniques and drills can be used to improve their ability to "see the field" while the other more auditory-minded players can use more rudimentary drills to hone their visual skills. The use of VS may be contrary to traditional methods of communication during practices and games, but the current data and other evidence demonstrate strong support for the use of gestures, signals, and other VS as a means of improving performance.

Acknowledgments

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