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PEDAGOGY

Influence of Cueing Strategies on Gaze Behavior During Observational Learning

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Abstract

This study examined the degree to which cueing strategies were attended when participants viewed a video model using eye tracking technology. It also examined whether visual cues highlighting body movement versus the intended effect of the movement would be attended to equally. Participants (N = 55) were randomly assigned to one of five experimental groups according to the nature of the cueing strategy provided: (a) No cue (Control), (b) Visual cue focused on the arm (Internal), (c) Visual cue focused on the racket (External), (d) Arm visual cue plus verbal directive (internal + VC), and (e) Racket visual cue plus verbal directive (external + VC). Under the impression that their technique would be later assessed, all groups viewed a video model of a tennis forehand groundstroke four times while eye movements were recorded. Mean percentage time that gaze was fixated on the assigned visual cue was determined. All groups with the exception of the external + VC condition attended to the arm LookZone (LZ) significantly more than the racket LZ. Both internal groups also viewed their assigned cue a greater percentage of time than their corresponding external groups did but not more than the control condition did. These data suggest that observers of a model have a tendency to focus their visual attention on the final body segment that carries out the desired action regardless of cueing.

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Human movement practitioners have long used demonstrations to not only provide learners with a general idea of how a movement is performed but also highlight the critical features of a skill. Considerable research supports this practice (for reviews, see McCullagh, Law, & Ste-Marie, 2012; Ste-Marie et al., 2012) and has identified numerous variables that influence the effectiveness of observational learning, including the use of attention directing cues.

The social cognitive theory of observational learning (Bandura, 1986) suggests that learners create a cognitive representation of a skill by abstracting critical features of the movement modeled. This representation serves to guide subsequent movement attempts. Bandura (1986) also noted, however, that unless learners attend to the relevant aspects of the modeled performance, observational learning would be ineffective. The use of verbal cues to focus learners' attention to critical elements of a demonstration has since been investigated and shown to lead to greater learning than the viewing of a visual model alone. For example, Roach and Burwitz (1986) found that verbal cues in conjunction with modeling led to better performance than modeling alone on the development of form and accuracy in cricket batting. Weiss and Klint (1987) reported that children were able to better perform a sequencing task when verbal rehearsal strategies were combined with modeling. They concluded that in addition to a visual model, "verbal rehearsal strategies are also needed to help children selectively attend to relevant task components and remember the specific order in which skills should be executed" (Weiss & Klint, 1987, p. 240). Similar findings were reported by McCullagh, Stiehl, and Weiss (1990), who showed that greater improvements in movement form were achieved when observational learning was combined with verbal cues.

Janelle, Champenoy, Coombes, and Mousseau (2003) extended previous research to include a novel cueing strategy whereby attention-directing visual cues were superimposed on the video of a soccer pass highlighting key areas of interest. Their results indicated that video modeling in conjunction with both visual and verbal cues led to increased kicking proficiency in terms of accuracy, consistency, and movement form compared with other groups who received alternative modeling modalities.

A limitation of their study, acknowledged by Janelle et al. (2003), is that “mere inferences can be made concerning whether the cued model attributes were those in fact attended to” (p. 836). Although the assumption is that cueing strategies constrain learners’ selective attention to the critical features of the modeled movement, no direct evidence demonstrates that this is indeed the case. As such, Janelle et al. recommended that future studies incorporate eye tracking technology to examine visual search behaviors while participants view modeled actions. Ste-Marie et al. (2012) concurred, indicating in their review of the literature that the use of eye-movement recording to examine gaze behavior would have been useful in the Janelle et al. “experimentation to determine whether these benefits occurred due to increased focus on the relevant cues in the display” (p. 158). Consequently, the primary purpose of this study was to examine the degree to which cueing strategies were attended when participants viewed a video model using eye tracking technology.

A secondary question of interest was whether attention-directing cues highlighting body movement versus the intended effect of the movement (e.g., on an implement) would be attended to equally. Two visual cue conditions corresponding to an internal (body movement) versus external (movement effect) attentional focus were examined. The first highlighted the action of the arm (internal), while the second highlighted the movement of the racket (external). Research over the past 15 years has demonstrated advantages for instructing learners to adopt an external focus of attention for both learning and performance (see Wulf, 2013, for a review). Yet common practice is to provide information related to specific body movements throughout the learning process. This was illustrated by Porter, Wu, and Partridge (2010), who found 84.6% of elite track and field athletes reported receiving instructions related to body and limb movements from their coaches. Similarly, Durham, Van Vliet, Badger, and Sackley (2009) reported that 95.5% of feedback statements given by physical therapists to stroke patients during treatment referenced body movements.

Initial skill acquisition requires learners to develop an understanding of the basic movement pattern. As such, there is a tendency to allocate conscious attention to the movement(s) of the body. Where a learner directs his or her attention to a model may also reflect this belief. Conceivably, learners may sometimes abandon attention-focusing cues in exchange for their own strategies or preferences. In fact, Marchant, Clough, and Crawshaw (2007) reported a 77% compliance rate when participants estimated the amount of instructions they used when learning a dart throwing task. Marchant et al. contended that "even with specific instructional direction, participants will inevitably use their own strategies from time to time" (p. 300). It was therefore hypothesized that the percentage of time spent looking at the visual cue highlighting the action of the arm (internal) would be greater than that highlighting the movement of the racket (external) regardless of group.

Method

Participants

Fifty-five undergraduate students (23 males, 32 females; M_{age} = 23.79 years) were randomly assigned to one of five experimental groups according to the nature of the cueing strategy provided: a control group ($N = 10$), an internal group (visual cue only; $N = 12$), an external group (visual cue only; $N = 12$), an internal + VC group (visual cue + verbal directive; $N = 10$), and an external + VC group (visual cue + verbal directive; $N = 11$). Participants had no or limited tennis experience. Written informed consent was obtained prior to testing, and the study was approved by the university's institutional reviewboard.

Video and Apparatus

All groups were shown the same 3-min video of two male and two female models executing a tennis forehand groundstroke from both a front and a side view (8 views total). The video differed by the nature of the visual cue provided according to group assignment. The video viewed by the control group was not enhanced and contained no visual cue. For both internal groups, the arm of the performer was superimposed with a pink highlight. The racket of the performer was superimposed with a pink highlight in the videos viewed by both external groups. Six separate videos (2 for each condition) were created to counterbalance the order of model gender viewed by participants, and each clip was separated by a gray screen for 2 seconds. All groups viewed their respective video four times.

While watching the video, eye movements were recorded via the Eye-Gaze Response Interface Computer Aid (ERICA; Eye Response Technologies, Inc., Charlottesville, VA) to determine participants' gaze behaviors. The system tracks eye movement through a table-mounted camera that when individually calibrated monitors features on the eye (glint and bright eye) at a sampling frequency of 30 Hz and translates this to a gaze position.

Procedures

Participants were instructed that they would be viewing several video demonstrations of the tennis forehand groundstroke. To simulate a performance environment and encourage typical observational learning behavior, they were further informed that following the video demonstrations, they would be asked to perform five forehand groundstrokes and that their technique would be assessed for correctness. No additional information was provided to the control, internal, and external groups. Participants in the internal + VC and external + VC groups were, however, verbally directed to focus their attention on the highlighted area of their corresponding video (arm or racket according to group), and it was emphasized that the most pertinent information for the successful reproduction of the skill was located in this area.

Participants were seated in front of a 17-in. computer monitor and their right eye was calibrated with the eye tracking system. They were then shown three sample videos and provided an opportunity to ask questions. Following the completion of the video viewing, participants were informed that they would not perform the skill and were debriefed.

Data Analysis

Two regions of interest, called LookZones (LZ), were created using GazeTracker software (Eye Response Technologies, Inc., Charlottesville, VA) by outlining each visual cue area (arm and racket) to extrapolate gaze behavior. The variable of interest was the mean percentage time that participants' gaze was positioned in the corresponding LZ (visual cue assigned). Mean percentage of time gaze fixations occurred in the opposite LZ was also determined for all groups. A 5 (Group) × 2 (LZ) MANOVA examined the extent to which participants' visual attention was directed to each LZ. A critical alpha level was set at $p < .05$.

Results

Table 1 shows the means and standard deviations for each condition. A significant main effect for LZ, $F(1, 50) = 55.53$, $p < .05$, was revealed, indicating that visual attention was allocated a greater percentage of time to the arm LZ (M = 24.08%) than the racket LZ (M = 13.6%). A significant Group × LZ interaction was also revealed, $F(4, 50) = 4.19$, $p < .05$. Post hoc analyses indicated that of all groups, with the exception of the external + VC condition, attended to the arm LZ significantly more than the racket LZ (see Figure 1).

Table 1
Means and Standard Deviations for All Conditions

	Arm LZ		Racket LZ	
Group	***M***	***SD***	***M***	***SD***
Control	22.30	7.77	13.08	3.98
Internal	24.81	13.40	11.12	4.53
External	24.88	10.24	13.29	7.11
Internal + VC	28.34	11.06	10.56	4.35
External + VC	20.17	12.97	19.85	8.87

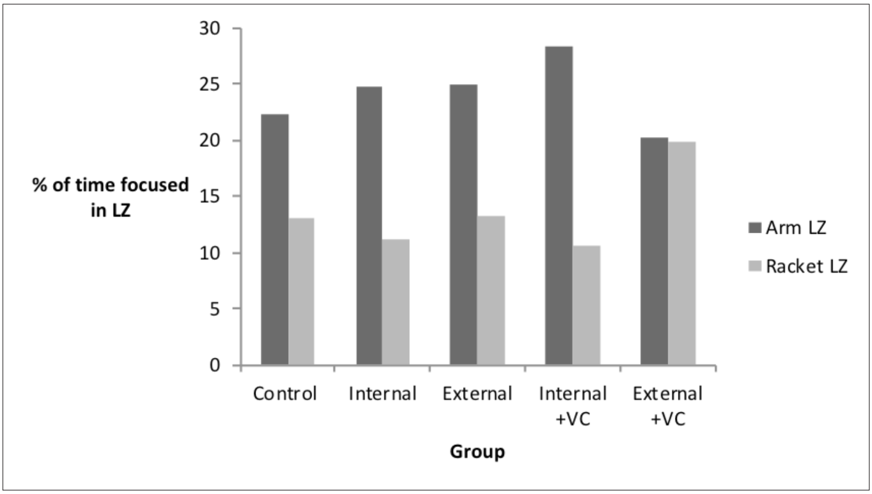

Figure 1. Mean percentage of time gaze was focused in each LZ.

For the cued conditions, the internal group fixated their gaze on the visual cue a significantly greater percentage of time (*M* = 24.81%) than the external (*M* = 13.29%) group. Further, gaze fixations were directed at the visual cue a significantly greater percentage of time for the internal + VC group (*M* = 28.34%) than both the external group (*M* = 13.29%) and the external + VC group (*M* = 19.85%; see Figure 2).

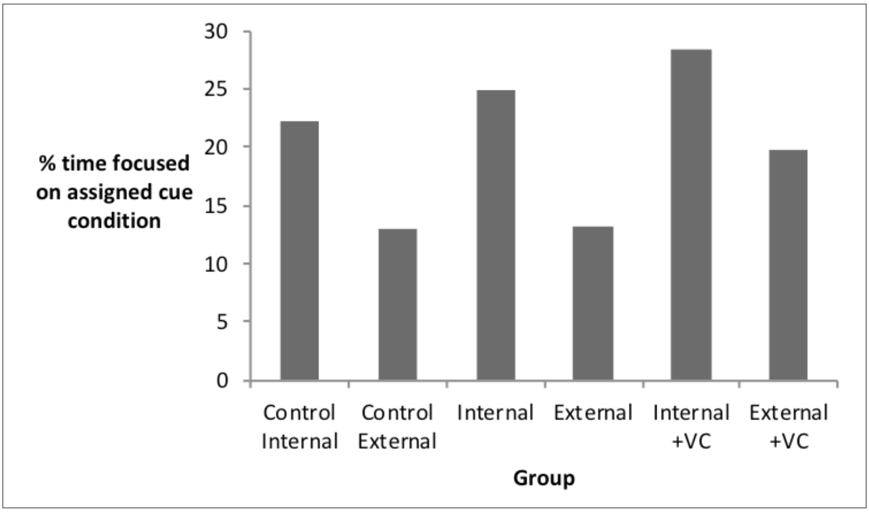

Figure 2. Mean percentage of time groups were focused on their assigned cued condition (mean percentage of time gaze was focused in each LZ displayed for control group).

Regarding visual search behaviors in the LZ opposite to that which was visually cued, both the internal (*M* = 11.19%) and internal + VC (*M* = 10.56%) groups spent less time viewing the opposite LZ than the external (*M* = 24.88%) and external + VC (*M* = 20.17%; see Figure 3) groups did.

Discussion

The purpose of this study was twofold: (a) to determine the degree to which visual cues were attended when participants viewed a video model and (b) to examine whether visual cues highlighting body movement versus the intended effect of the movement would be attended to equally. The results indicated that the addition of visual cues highlighting either the action of the arm or the movement

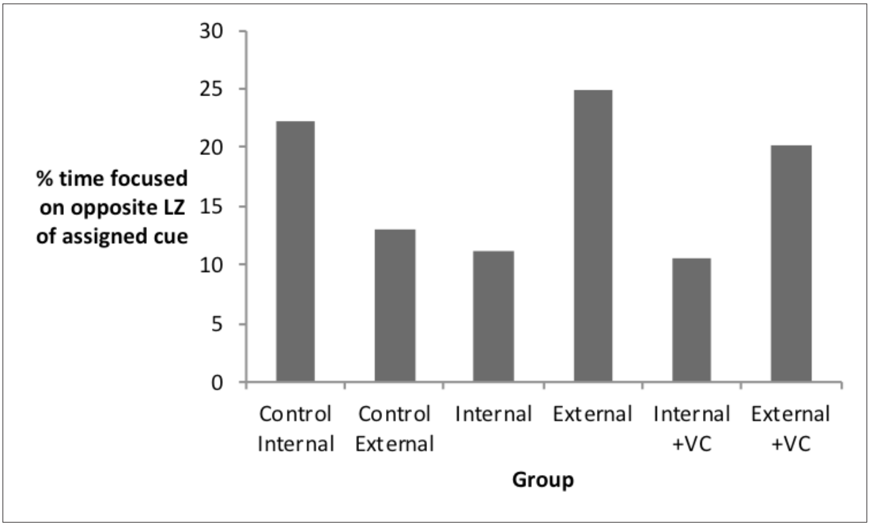

Figure 3. Mean percentage of time groups were focused on the opposite LZ from their assigned cued condition (mean percentage of time gaze was focused in each LZ displayed for control group).

of the racket had no effect, as the percentage of time the control group spent looking at each corresponding LZ was not significantly different from the matching visual cue condition (control internal vs. internal conditions and control external vs external condition). Further, no differences were found between the control group and both the internal + VC and external + VC conditions, although a large effect size was determined for the latter comparison, which also approached significance (d = .97, p = .09). In other words, with the exception of the external + VC condition, the addition of a visual cue superimposed on a video model, even when participants were given a verbal directive to attend it, did not influence visual search behaviors. A disparity therefore exists between the results of this study and the findings of Janelle et al. (2003) where the combination of a video model plus both verbal and visual cues led to greater proficiency in both kicking form and accuracy when compared to five other cueing strategies, including the that of a video model with visual cues directing participants to the critical aspects of the movement. Their results were attributed to the assumption that greater attention was directed to the cued model attributes. In the present study however, no significant differences were found between the internal and internal +VC groups. Similar findings were revealed for the external vs. external +VC groups, although effect size was determined to be large and the difference approached significance (d = .82, p = .088). In other words, the addition of a directive to focus on the visual cue and the emphasis that this area contained the information most pertinent to the reproduction of the skill did not influence the visual search strategies employed by participants for the internal + VC group but did make a practical difference for the external + VC group.

The action of the arm was selectively attended to significantly more than the movement of the racket LZ. In fact, the percentage of time spent looking in the arm LZ was almost twice that of the racket LZ. Evidently participants perceived that viewing the action of the arm would provide more critical information regarding the performance of the skill. This outcome may also provide insight as to why, as noted earlier, there exists a disconnect between research and practice regarding attentional focus, as well as perhaps some skepticism in the research community itself to the acceptance that an external attentional focus is beneficial for initial learning (Wulf, 2013). Wulf (2016) explained that focusing one's attention is related to the planning of the movement. Yet, through observation, learners seek information to assist their approximation attempts of the movement modeled. In other words, learners use information gleaned from the model to *plan* subsequent movement attempts. These data suggest that learners intuitively perceived the action of the arm in this task to provide more salient information than the movement of the racket. This would likely result in the observer imposing conscious control over the arm during successive movement attempts, which is in direct conflict with the attentional focus literature and perhaps the source of the "perpetuation of the notion that novices (should) show enhanced learning with internal focus instructions" (Wulf, 2013, p. 91).

The greater percentage of time that gaze was focused in the arm versus racket LZ also raises questions regarding the conclusions of Breslin, Hodges, and Williams (2009) that during the initial stages of skill acquisition, viewing "information from the end effector [or the final component of the system that carries out the desired action] is prioritized during observational learning" (p. 488). In their study, they manipulated the visual information available during the demonstration of a cricket bowling action and found that participants' visual attention was mainly focused on the action of the model's bowling arm. Breslin, Hodges, Williams, Curran, and Kremer (2005) also found that when viewing a full-body model of the bowling action, participants replicated only the model's bowling arm relative motion. In the present study, the end effector was an implement, the tennis racket, rather than a body segment. Also different is that the task observed, executing a tennis forehand groundstroke, is classified as an open skill, whereas a cricket bowling action would be categorized as a closed skill. Savelsbergh, Rivas and van der Kamp (2008) suggested that early in learning, participants initially freeze perceptual degrees of freedom, selectively attending "to one of multiple sources of information that will enable him to more or less successfully perform the task at hand" (p. 157). Accordingly, the movement of the arm in the present study rather than the end effector, the racket, may have been considered more task relevant. On the other hand, if participants interpreted the goal of viewing the model to be one of learning how to move the racket rather than how the racket moves to contact the ball, it could be argued that the arm may have been treated *as* the end effector. Additional studies are needed to fully understand how multiple sources of information are perceived and their relationship to visual search tendencies while participants view a demonstration.

One limitation of this study was that the eye recording equipment utilized could only acquire gaze behaviors that occurred in the created LZs. Given that the percentage of gaze fixations captured ranged from approximately 35–38%, a significant amount of visual search information was not available for analysis. As technologies that allow capture of all gaze behaviors develop, the influence of attention-directing cueing mechanisms will be better understood.

A limitation in previous studies examining cueing strategies and observational learning is the assumption that learners are attending to the cue provided based on physical performance measures. The findings of this study suggest that this may not be the case. Instead, according to eye-movement recordings, it appears that learners have a tendency to focus on the body segment that carries out the desired action regardless of the cue, with the exception of the verbal directive to attend to the racket. In this case, no significant difference was found between viewing times in the arm LZ (*M* = 20.17%) and racket LZ (*M* = 19.85%), implying that this cueing strategy was somewhat effective. Though additional research is needed, it is possible that for facilitation of observational learning to occur, cueing the final body segment that carries out the desired action during a demonstration may be unnecessary or occur initially, and attention should be drawn to other critical features of the movement as practice progresses.

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