International Journal of Golf Sciences, 2015, 4, 1-14
http://dx.doi.org/10.1123/ijgs.2014-0011
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ARTICLE

Effect of Patch-Light Demonstration on Observational Learning of Golf Swing

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Video display of a model has been widely used as an observational learning tool; yet, the use of patch-light techniques that can highlight key features of motion has been seldom used. The purpose of this study was to determine the effectiveness of patch-light display for use in observational learning of the golf swing. Twenty-two novice golf participants were randomly assigned to three groups: video, patch-light, and control. Each participant performed 100 golf pitch shots, and 20 shots 24 hours later (retention). After each 10 shots, participants observed a recorded model perform 10 shots either in traditional video or patch-light format, or waited for a brief time period (control). Participants did not observe the model during retention. The patch-light group was neither more accurate nor more consistent than the video group or control. We believe that the familiarity of the task may have overridden any observational learning effect.

Keywords: point-light, modeling, relative motion, visual search

Visual demonstration is one of many popular methods of acquiring motor skills. Because performers rely strongly upon vision during an early stage of learning a motor skill, it is believed that demonstration is vital for novice performers (Fischman & Oxendine, 2001). Coaches and teachers in sport settings use demonstration quite frequently and students also acknowledge the importance of demonstration or modeling for effective learning (e.g., Linder, Lutz, & Clark, 2002). In a study examining attitudes about important features of a golf lesson, students reported that the ability to observe a demonstration was among the most important contributors

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to their feelings of success (Linder, Lutz, & Clark, 2002). In the motor learning literature, the provision of a visual demonstration and a learner's production of the movement displayed have been labeled *observational learning* or *modeling* (McCullagh, Weiss, & Ross, 1989).

Research concerning the processes of observational learning has often been directed by Bandura's (1986) social cognitive theory. Driven by Bandura's theory, much of the modeling literature has been focused on the question pertaining to how the demonstration should be given (e.g., skill level of model: Lirgg & Feltz, 1991), rather than what information should be given to the observer for effective learning (Scully & Newell, 1985). Ste-Marie, Law, Rymal, Jenny, Hall, and McCullagh (2012) argued that observational learning effects do not rely only on the motion to be perceived, and Scully and Newell (1985) argued that researchers should consider using an approach to the study of observational learning that is guided by perceptual considerations. According to Scully and Newell (1985), there is no need for a cognitive mediator between visual perception and motor action. During observational learning, these researchers argue that the observer perceives the relative motion of the movement pattern, rather than the actual movement being demonstrated, and that this perception is translated directly into action.

The relative motion can be highlighted through what is called "point-light or patch-light display." Point-light display is generated using either small, rounded markers while patch-light is generated by pieces of reflective tape that provides more information (e.g., contour) than just kinematics alone. While the studies that compared point-light and video demonstration used small and rounded markers (e.g., Horn, Williams, Scott, & Hodges, 2005), there are other perception studies that have used pieces of reflective tape in judging the hidden kinetic property (i.e., weight) from the perception of lifting motion (Runeson & Frykholm, 1981, 1983; Shim, Hecht, Lee, Yook, & Kim, 2009), recognizing walker's gender (Barclay, Cutting, & Kozlowski, 1978; Cutting, 1978; Kozlowski & Cutting, 1977), and identifying a friend's walking pattern (Cutting & Kozlowski, 1977) displayed in patch-light. The results of these studies indicate that the perception of relative motion allows direct retrieval of recognition memory for motor acts. Scully and Newell (1985) suggest; however, that an observer of a visual demonstration is able to use this information to constrain their own future motor action, thus allowing for the effects of observational learning.

Despite lack of the usual texture and color information, point- and patch-light display preserves the essential kinematic information in the observed movement. If point- and patch-light display indeed highlights relative motion and other important kinematic information, then one can expect the display can be a useful observational learning tool. Newell and Walter (1981) state that a complete model (as opposed to a point- or patch-light model) contains too much information and that this excessive information obscures or draws attention away from the most important features of the movement. This prediction was investigated among researchers by comparing the differences between a traditional video display of the full model versus a point- or patch-light display of the same model but they have found mixed results. Shim, Carlton, Chow, and Chae (2005) showed that tennis players were able to anticipate opponent player's shot more accurately when observing the opponent in live and video display than in patch-light. In observational learning, Horn, Williams, Scott, and Hodges (2005) showed that participants who observed the model in either point-light or video display showed similar immediate and enduring changes to imitating the model although the point-light group participants were more selective in their visual search strategy than the video group.

Within Scully and Newell's (1985) motor learning framework, acquiring a new coordination pattern is considered the primary goal in the early learning stage, and during observational motor learning, a new relative motion pattern is observed and learned to be copied while scaling of the motor action to meet the task demands come from physical practice. However, research shows that observers can gain scaling-related information from a model's action (e.g., Shim, Carlton, & Kim, 2004) and Hayes, Hodges, Scott, Horn, and Williams (2006) showed that the scaling of model's action can be reproduced through observational learning. Therefore, observation of a model can assist learning not only the important relative motion patterns as Scully and Newell (1985) suggest but also the control-related scaling features of the movement.

The purpose of the study was to determine if patch-light display can highlight kinematics and other movement features that would allow observers to imitate the model in regards to the motor coordination (e.g., arm vs. club) and motor scaling (e.g., shoulder angle and club angle in the end of the backswing). The tape wrapped around the joint would provide more information than just kinematics and perhaps accentuate the essential relative motion pattern necessary for participants to learn in the early stage as Scully and Newell (1985) suggest. With the use of patch-light display as opposed to point-light, we hope to increase the likelihood of showing a difference between video and patch-light interventions. We also hypothesized that both patch-light and video display will enhance observational learning of golf pitch shot especially in the early stage of learning as was found in Horn, Williams, Hayes, Hodges, and Scott (2007) and in Hayes et al. (2006).

Method

Participants

Twenty-one (10 males and 11 females, age = 22.1 ± 4.5 yrs) novice golfers who had played less than 4 rounds of golf in their lives participated. The twenty-one participants were randomly assigned to one of 3 groups while controlling for similar number of males and females in each group [video (4 male and 3 female), patch-light (3 male and 4 female), control (3 male and 4 female)]. An expert male golfer (0 handicap) who played golf at the intercollegiate level served as the model. All participants signed an informed consent form approved by the university institutional review board.

Demonstration Recording Procedure

Pieces of 5 cm wide white tape were attached on or near the major joints and head of the model. Pieces of tape were attached around and covered the elbows, wrists, knees, and ankles. Five 15 cm long pieces of tape were attached near the shoulders, hips, and forehead (Figure 1). On a flat artificial turf mat, the model performed

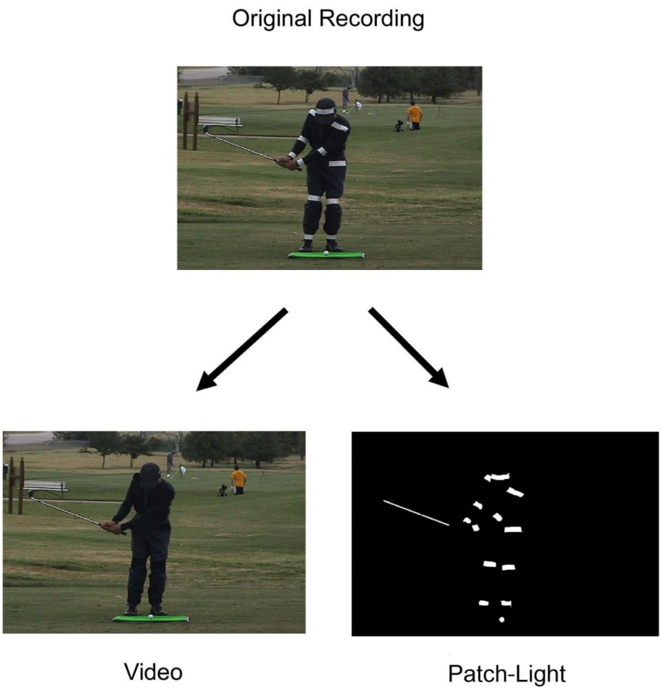

Figure 1 — Video and patch-light display produced from an identical recording.

pitch shots 14 m away from the target area. The size of the target area was the same as the actual size (10.8 cm in diameter) of the hole on a green. A digital camera (Panasonic AG-DVC15P, 60 Hz) was used to record the frontal view of the model. The pitching motions of the model were recorded until the ball landed on the green and stopped on the target area. That one pitching trial was selected as the demonstration. As shown in Figure 1, from this one recording, two separate displays (video and patch-light) were produced using video editing software (e.g., Adobe Premiere, Adobe After Effects, and Commotion). We used a technique developed by Thomas and Jordan (2001) in their work on the perception of facial movement. The captured stimulus clip of the model's golf swing was modified using Adobe After Effects and Commotion video processing software. To generate patch-light, first a white line was drawn across the shaft of the club using the drawing tool. Then, by using color-changing filters, all unwanted colors within the video clip were extracted leaving only the white pixels on the club and on the pieces of tape that were attached to the model. Eye-dropper tool was used to select precise pixel-accurate choice of color. The hue, saturation, and lightness of the selected colors were then reduced and changed to black. Once these color-changing filters were selected, they were automatically applied to the entire clip, not requiring frame-by-frame editing. To generate video display, white pixels on the pieces of tape were replaced with pixels cloned from the immediate surrounding region. Each of the two displays was duplicated 10 times and transferred to a videotape. In addition, the model giving a basic instruction on the grip was recorded.

Experimental Procedure

Participants were randomly assigned to three groups: video, patch-light, and control. Each participant verbally received the goal of the task and received a basic video instruction on the grip. Then, each performed 100 (10 pretest, 80 acquisition, and 10 posttest) golf pitch shots the first day and 20 shots (10 early retention and 10 late retention) 24 hours later. During acquisition trials, participants observed a recorded model perform 10 shots either in video or patch-light, or waited for a time (1 min) necessary to observe the demonstrations (control). The observation was followed by the actual performance of 10 shots and this procedure was repeated 9 times. The participants observed the frontal view of the model perpendicular to the ball as shown in Figure 1. They observed the model's swing and the initial ball flight on a 20 inch screen monitor. Participants did not observe the model during retention which occurred 24 hours later. The goal was to hit each shot 14 m to a 10.8 cm diameter target, attempting to stop the ball as close to the target as possible while trying to replicate the model's swing. As no vision was occluded, the participants had intrinsic visual feedback available.

Data Analysis

After each shot, the distance between the ball and target was measured and the angle formed from the target line to a line connecting the target and ball was measured in counterclockwise direction to calculate radial error and variable error. Radial error represents absolute distance from the target and variable error is the amount of standard deviation from the absolute error. Pretest 1–10, acquisition 1–10, 41–50, posttest 1–10, and retention 1–20 trials were recorded and kinematic analysis was performed on the model's demonstration shot and each participant's pretest 1, acquisition 1 and 41, posttest 1, and retention 1 and 20 using Ariel Dynamics system. We selected pretest 1 and retention 1 and 20 to observe the performance without an immediate effect of receiving a demonstration and selected trials acquisition 1, 41, and posttest 1 to observe the participant's performance immediately after receiving a demonstration in the beginning of acquisition, middle of acquisition, and posttest, respectively. On a basis of a survey from five highly experienced golf instructors and a biomechanical study conducted by Kim, Chung, and Woo (2012), the following kinematic parameters were selected for measurement: forearm and club angle, ball impact velocity, ball projection angle, and backswing and downswing time. Absolute forearm angle was measured from horizontal at wrist in a counterclockwise direction and absolute club angle was measured from horizontal at wrist in a clockwise direction.

Relative motion plots were performed on the arm and club angle where the greatest range of motion occurred. Cross-correlation of recognition coefficient (Sparrow, Donovan, van Emmerik, & Barry, 1987) between the relative motion plots of the beginner and the model was computed to quantitatively determine the degree of similarity. This correlation technique modified the chain-encoding method which was developed by Whiting and Zernicke (1982). The cross-correlation value ranges from -1–1, with the value approaching -1 or 1 indicating similarity and the value approaching zero indicating dissimilarity. For each participant, two relative motion plots were performed and therefore two cross correlations were computed.

Dependent variables for each performance outcome were error (radial and variable), cross-correlation, ball outcome (impact velocity and projection angle), time (back swing and down swing), and angles in the end of back swing (arm and club). Improvement of the dependent measures were investigated in 6 stages including pretest, beginning of acquisition, middle of acquisition, posttest, early retention, and late retention. For all dependent measures, 3 × 6 (Group × Stage) ANOVAs with stage as the repeated-measures factor were performed. On all significant main effects, follow-up multiple comparison post hoc analyses (Bonferroni) were conducted.

Results

Ball-Target Error Score

The performance improvement occurred rapidly in the beginning of acquisition and was retained 24 hours later (Figure 2). For 3 × 6 (Group × Stage) ANOVA on radial error, there was a significant stage effect, $F(5, 95) = 12.91$, $\eta_p^2 = .40$, $p < .01$, though the group main effect did not reach significance, $F(2, 19) = .83$, $p = .45$ and there was no interaction, $F(10, 95) = 0.44$, $p = .92$. Examining follow-up comparisons for stage (Bonferroni), pretest radial error was significantly higher than the radial error of all other stages. Similar results were found on variable error. There was a significant stage effect, $F(5, 95) = 4.65$, $\eta_p^2 = .20$, $p < .01$, but the

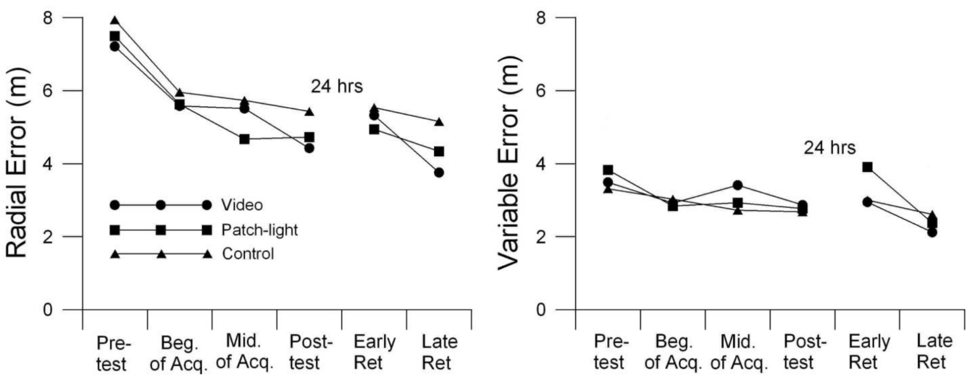

Figure 2 — Radial and variable error of the three groups during acquisition and retention. Radial error in pretest was significantly greater than the error in all other stages. Variable error in pretest was significantly greater than late retention only ($p < .05$).

group main effect did not reach significance, $F(2, 19) = .48$, $p = .63$ and there was no interaction, $F(10, 95) = 1.26$, $p = .27$. Variable errors in pretest were significantly higher than late retention only.

Relative Motion Pattern

The participants in all groups, including the control group, were able to mimic the model's relative motion pattern of the arm and club even before observing the model in the pretest. A 3 × 6 (Group × Stage) ANOVA performed on cross-correlation between relative motion plots of the forearm and club angle of the model and participant did not show any effect for group, $F(2, 19) = .17$, $p = .85$ and interaction, $F(10, 95) = 1.59$, $p = .12$, but did show an effect for stage, $F(5, 95) = 3.29$, $\eta_p^2 = .16$, $p < .01$. The cross-correlation between pretest and midacquisition was significantly different.

As shown in Figure 3, the changes in the forearm and club angle were both almost linear for the model, and participants were largely able to mimic this movement pattern. Participants, however, exhibited differences in their range of motion of the forearm and club angle. A decrease in degrees indicates a greater range of motion and a negative value of club angle indicates that the club is positioned above horizontal. In the end of backswing, the model's forearm angle and club angle were approximately 30 degrees and -25 degrees, respectively. In the pretest, the three groups maintained a similar forearm angle of 30 degrees as the model but with a smaller club angle of near -10 degrees which would indicate that they did not, in golf terms, cock the wrist as much as the model. However, in the retention, both forearm and club angles decreased compared with the angles in the pretest which would indicate that all three groups produced a greater backswing. In the first retention, the participants' forearm swing was noticeably greater than that of the model (Figure 3).

Kinematic Performance Parameters

Most of the kinematic performance parameters showed an effect only in stage. As summarized in Table 1, no effects were found for ball impact velocity but ball projection angle showed an effect for stage, $F(5, 95) = 5.51$, $\eta_p^2 = .30$, $p < .01$. Post hoc comparisons showed a significant increase in the ball projection angle from pretest to posttest and from pretest to late retention. The ball projection angle gradually improved and reached higher close to the model's ball projection angle (31.5 degrees). When the participants in all groups returned for the retention trials, ball projection angle of their first trial was small (25 degrees) but by the last 20th retention trial, the projection angle improved (34 degrees).

Temporal parameters such as the backswing time and downswing time did not show any effect with an exception of effect on downswing time for stage, $F(5, 95) = 4.12$, $\eta_p^2 = .19$, $p < .01$. The downswing time in middle of acquisition, posttest, and early retention were greater than the time in the pretest. The forearm angle in the end of backswing showed an effect only on stage, $F(5, 95) = 3.10$, $\eta_p^2 = .15$, $p < .05$. The forearm angle significantly increased from the beginning of acquisition to the middle of acquisition (Table 1).

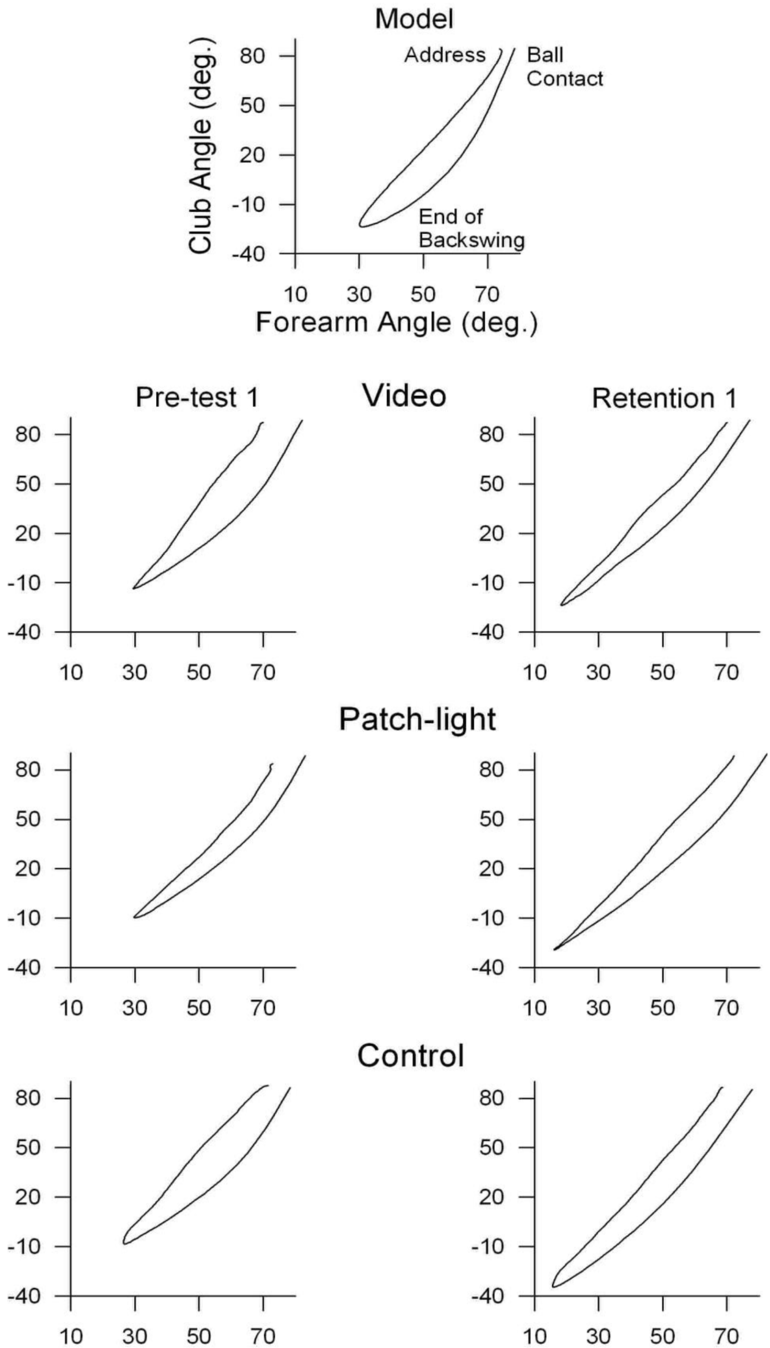

Figure 3 — Club angle plotted against forearm angle for first acquisition and first retention trial.

Table 1 Change of Kinematic Parameters During 6 Stages of Learning

	Stage					
Group	**Pretest**	**Beginning of Acquisition**	**Middle of Acquisition**	**Posttest**	**Early Retention**	**Late Retention**
Ball impact velocity (Model = 10.4 m/s)						
Video	10.0	10.5	11.1	9.4	8.2	9.9
Patch-light	14.3	12.1	11.4	11.1	14.1	15.6
Control	9.4	8.6	9.6	9.5	10.9	10.8
Ball projection angle (Model = 31.5 degrees)						
	*#			*		#
Video	24.6	22.3	26.2	35.2	22.0	30.1
Patch-light	13.5	21.5	33.7	36.6	27.2	41.7
Control	21.2	29.4	30.3	27.0	25.5	29.9
Cross-correlation of arm and club angle compared with model						
	*		*			
Video	.52	.77	.84	.72	.73	.72
Patch-light	.76	.71	.74	.70	.68	.58
Control	.48	.72	.74	.70	.74	.66
Backswing time (Model = 800 msec)						
Video	940	770	780	750	780	810
Patch-light	700	710	760	770	740	760
Control	970	610	690	720	730	720

Table 1 ***(continued)***

Group	Stage					
	Pretest	Beginning of Acquisition	Middle of Acquisition	Posttest	Early Retention	Late Retention
	Downswing time (Model = 340 msec)					
	*#&		*	#	&	
Video	340	380	400	390	380	320
Patch-light	310	340	380	380	360	370
Control	300	290	330	350	340	320
	Forearm angle in the end of backswing (Model = 39 degrees)					
		*	*			
Video	42.0	44.3	47.6	47.6	45.9	48.1
Patch-light	41.4	48.8	58.9	58.2	54.1	54.6
Control	38.4	29.0	40.1	45.1	48.9	40.3
	Club angle in the end of backswing (Model = 114 degrees)					
Video	109.5	107.6	117.4	112.5	114.4	131.8
Patch-light	101.1	105.3	120.8	124.4	119.6	120.0
Control	102.8	81.6	104.0	114.8	126.5	108.2

Note. *, #, & = significant difference at 0.05 for all groups combined.

Discussion

Overall, performance or learning effects for all groups occurred when considering ball-target error scores, relative motion pattern, and kinematic performance parameters such as the downswing time, and the forearm and club angle in the end of backswing. However, the patch-light group did not show a clear indication of enhanced performance or learning than the video group. In addition, the demonstration groups did not show an enhanced performance or learning compared with control group that did not receive demonstration. Despite the golf swing being novel to the participants, it is possible that the participants have already learned a similar relative motion pattern of golf swing from other sports such as tennis swing or bat swing. This conjecture is based on the fact that all groups were able to somewhat mimic the model's golf swing during pretest before observing the model. Then, through practice alone, the participants were able to learn the proper coordination pattern quickly. The cross-correlation values of the control group ($r = .72$), showing how much the relative motion of arm and club angle matched the model, was just as high as the video ($r = .77$) or patch-light ($r = .71$) group after observing a first set of demonstrations.

Although our attempt to show a greater effect on observational learning for the patch-light condition was unsuccessful, it must be noted that few studies have demonstrated such an effect. Scully and Carnegie's (1998) results on target landing accuracy of a ballet movement sequence were favorable for the point-light group, but there were no statistical tests performed on these data. Observational learning studies that used a dart throwing task (Al-Abood et al., 2001) failed to document superior performance or learning for the point-light display condition compared with the traditional video condition. In studies using the racquet sports groundstroke anticipation tasks (Abernethy, Gill, Parks, & Packer, 2001; Shim, Carlton, Chow, & Chae, 2005; Ward, Williams, & Bennett, 2002), participants in the video group outperformed the patch-light group.

Our goal was to determine if extra contour information can perhaps accentuate the kinematics and show a stronger modeling effect, but based on the present results and the results of other studies, there does not appear to be a strong support for the hypothesis that patch-light display is superior to video display. Yet, it certainly appears that patch-light display is *similarly effective* as video display. Unexpectedly, however, the control group performed at the same level as the two display groups. In light of these results, it is important to consider what information is attended to when observing these types of displays. Kernodle and Carlton (1992) have suggested that video demonstration should be used with visual cues to get the learner's attention on a particular aspect of the visual information because too much information may be available in the video display. This seems to be the research rationale for point-light display procedures. However, while point-light demonstration may narrow the learners' attention to only movement kinematics they may still need a special instruction on where to attend. For example, it may be important to verbally instruct participants to attend to a certain feature of the movement.

Scully and Carnegie (1998) completed one of few studies that have documented an advantage of point-light over traditional displays in learning a dance move. While this advantage was not examined statistically, the results do appear compelling. Thus, it is important to compare how their experiment may have differed qualitatively from the present studies. Upon examination of their research, one procedural difference appears to be a possible source of difference. They presented participants with only three trials of a model performing a motion that lasted 5 seconds. In the present experiment, participants were shown 80 trials of a model performing a motion that lasted less than 1.7 seconds. It may be that Scully and Carnegie's dance task required participants to engage in a more difficult memorization process than the present task as their skill was of a longer duration. Of course, it may also be that the effects of point light are most obvious very early in learning, thus the effect may only be observed after a very limited number of trials. This would support Horn, Williams, and Scott's (2002) speculation that fewer point-light demonstrations enhance greater learning. However, examining Table 1 reveals no apparent trend for the patch-light group to more closely approximate the model's movement pattern than the video group after viewing only one set of 10 demonstrations. Yet, a more thorough examination of these two factors (time of movement and number of observational learning trials), as they may impact the effectiveness of patch-light observational learning, is probably warranted.

The findings in this study do not present a strong rationale for the use of patch-light display to enhance observational learning. To reiterate the shortcomings, this study involved a specific type of sport tasks that was novel but familiar due to similarities in motions to other tasks such as racquet swing and we regretfully did not ask their experience in other racquet sports. The participants had an intrinsic feedback of where the ball went. When the intrinsic visual knowledge of results was taken away in the study by Horn, et al. (2005), the video and point-light demonstration group showed immediate and enduring changes to more closely imitate the model than the control group. The participants in this study may have abandoned the strategy to emulate the model and focused more on performance knowing the outcome of the previous shot and because of the pressure to hit the ball. In summary, gathering the results of this and previous studies, the efficacy of demonstration (particularly patch- or point-light) may be maximized with a task of longer duration, fewer model observations, minimal task constraints, no knowledge of results, and specific instruction on where to focus.

This study is the first attempt of testing patch-light display in observational learning. In past studies, point-light display was generated by digitizing and capturing the locations of round reflective markers placed on the joints, leaving a room for possible error while capturing the joint positions. In addition, video display was generated from the same recording but with reflective markers still on the joints. Therefore, the video display may additionally include the highlight of the reflective markers. In this study, the reflective tape surrounding the joints were masked by cloning surrounding pixels and coloring the tape. The patch-light was generated to accentuate kinematics by using large tape wrapped around the joints rather than small and round reflective markers. Patch-light display was used in early studies of perception of lifted weight where the observers can identify the kinetic property (weight) from solely kinematics (lifting motion). Although, we were unsuccessful in showing a greater modeling effect of patch-light display, we show that the added information (e.g., contour) along with kinematics did not hinder the participants from observational learning. With a modest finding and a new technique to generate video and patch-light display from the same movement recording, we feel the study adds to extant literature and has a potential for further use in future perception research.

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