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Learning to spike in volleyball with verbal and visually-enhanced feedback

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LEARNING TO SPIKE IN VOLLEYBALL WITH VERBAL AND VISUALLY-ENHANCED FEEDBACK

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ABSTRACT

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The relative effectiveness of verbal versus visually-enhanced feedback was compared for teaching spiking in volleyball. Factors that might produce a greater effect using visually-enhanced feedback were examined. In addition, the current study sought to explore thoughts that participants had while learning to spike. Two outcome measures were assessed to determine if the addition of visual feedback to verbal feedback (visually-enhanced feedback) was a superior way of coaching in comparison to verbal feedback alone.

Participants took part in an experimental cross-over design wherein they learned through two types of instruction (verbal and visually-enhanced feedback). Participants received one type of instruction for three sessions and then received the other type of instruction for three sessions. Three testing sessions took place: one at the beginning, one between instructional phases, and one at the end of the experiment. Two outcome measures were assessed: the height of contact when the participant hit the ball (measured using video footage in Dartfish) and the velocity of the ball produced by the hit (measured using a radar gun). A repeated-measures ANOVA was conducted for each outcome measure to evaluate differences between verbal and visually-enhanced feedback. Also, an ANCOVA was computed to see if participants' scores differed based on level of

experience or learning preference. After comparing participants' velocity and height of contact scores, no significant difference was found between verbal and visually-enhanced feedback. In addition, the level of experience and learning preference was not a significant covariate.

A qualitative analysis of participants' experiences while learning to spike was also undertaken. Participants' cognitions were assessed using a Think-Aloud Protocol in which participants verbalized what they were thinking about during each acquisition session. Athletes' preferences for learning were also evaluated using the Learning to Hit Interview.

Participants overwhelmingly preferred the visually-enhanced feedback. After assessing participants' thoughts while learning, six major themes emerged: cognitive processes, knowledge, environmental effects, self-efficacy, emotions, and visual appearance. These themes were similar to previous findings. However, the specific themes of cognitive processes and knowledge were findings that added to the body of literature on athletes' thoughts while learning with visual feedback.

This study not only contributed to the scientific understanding of how people learn with visual feedback, it also helped to inform practitioners about the viability of using visual feedback. Practitioners are cautioned that visual feedback might not help athletes learn motor skills more quickly than with verbal feedback alone. Future studies should examine this topic further while also giving attention to variables that might enhance visual feedback. The potential benefit of visual feedback should also be explored by examining participants' changes in technique rather than just looking at their outcome scores.

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CHAPTER I

INTRODUCTION

Coaches regularly seek increasingly effective methods to improve instruction and facilitate learning. They may demonstrate desired movements, offer more or fewer comments, or emphasize athletes' successes or failures. Many coaches are particularly thoughtful about the format of feedback they provide. One method of instruction that has received a great deal of interest is visual feedback. Although the majority of researchers who have studied the topic believe visual feedback to be a viable method, studies examining the effectiveness of this kind of feedback for teaching motor skills have shown mixed results (Rhoads, 2010a; Rothstein & Arnold, 1976).

The current investigation contributed to literature on visual feedback by comparing verbal and visual feedback in volleyball through a mixed-methods approach. Participants took part in an experimental cross-over design wherein they learned through one type of instruction and then switched to learning with another type of instruction. In one type of instruction, participants received traditional coaching via verbal feedback. In the other instructional model, participants received both verbal and visual feedback (visually-enhanced feedback).

Three acquisition sessions took place for both instructional phases. The type of instruction was randomly ordered. During the experiment, participants periodically described thoughts they were experiencing during the learning process in an audio-

recording. Testing sessions took place at the beginning of the experiment (pretest), between instructional phases, and at the end of the experiment (posttest). The height of contact when the participant hits the ball was measured using video footage in Dartfish. The velocity of the ball produced by the hit was measured using a radar gun.

After the experiment, participants completed a semi-structured interview about their experiences learning with and without visual feedback. The participants' responses during think-aloud sessions (Ram & McCullagh, 2003), during the experiment, and from the interviews after the experiment were coded and analyzed to compare preferences for the two types of instruction. In addition, the comments were analyzed to examine differences in thought processes about the two types of instruction. The cognitions while learning were also used to better understand the learning process and to derive implications for improved instructional practices.

Statement of Purpose

Superior methods of instruction are sought in volleyball to prevent injury and to allow athletes to participate for a lifetime. In addition, not all individuals learn the same and certain athletes may benefit more from different types of instruction. With these thoughts in mind, this investigation had two main objectives. First, this mixed-method study examined if differences existed in participants' ability to learn with verbal versus visually-enhanced feedback. Previous research has produced ambiguous findings about the superiority of visually-enhanced feedback. Also, no previous studies have looked at visually-enhanced feedback for teaching spiking in volleyball. This study focused on an athlete's performance at spiking as measured by the height of contact when the athlete hits the ball and the velocity after the athlete has hit the ball. Along with comparing

verbal to visually-enhanced feedback, participants' level of experience and learning preferences were examined as possible moderator variables for learning with visually-enhanced feedback.

The second objective of this investigation was to examine learners' cognitions while learning with the various feedback types. I conducted a qualitative analysis by interviewing the participants to see preferences for and experiences with the treatment types. A think-aloud protocol was also administered whereby participants spoke into an audio-recorder immediately after receiving feedback during each acquisition session. These sources of data allowed for a comparison of participants' thoughts while learning with verbal versus visually-enhanced feedback. Beyond examining differences in cognitions when learning with verbal versus visually-enhanced feedback, this study also focused on thoughts that aided in learning with visually-enhanced feedback. These thoughts were determined by examining categories of thoughts that occurred most often in learners who improved the most during the investigation.

Prior studies have evaluated the thought processes of participants when learning a motor skill. Four cognitive stages in learning with visual feedback have been identified (Hebert, Landin, & Menickelli, 1998): (a) getting used to seeing oneself on camera and making general observations, (b) detecting errors, (c) making connections and recognizing tendencies, and (d) correcting errors and reaching closure. Using a similar framework, Ram and McCullagh (2003) described themes that emerged using think-aloud procedures in motor learning. These categories included description of the sequence of movement, description of movement process, description of scenery, thoughts and affect, and shock and surprise. Due to the fact that many of the categories

identified by Hebert and colleagues (1998) are quite distinct from the categories described by Ram and McCullagh, this study sought to elaborate on the common themes that arose as participants described what they were thinking while learning.

Contributions of the Study

This study contributes to the literature by comparing verbal feedback with visually-enhanced feedback (verbal and visual feedback) in a domain that has not been studied previously (spiking in volleyball). This investigation sought to demonstrate that visual feedback is a superior method for coaching volleyball by using instant feedback. Most researchers hypothesize that instant feedback is better than delayed feedback. Brown (1973) found no significant difference between instant and delayed visual feedback; whereas, Zetou, Kourtesis, Getsiou, Michalapoulou, and Kioumourtzoglou (2009) found instant feedback to be a more effective method.

This investigation also sought to contribute to the knowledge of skill acquisition in volleyball by assessing the role of skill level and learning preference in an athlete's ability to learn with verbal and visually-enhanced feedback. Some researchers have proposed that a more accomplished athlete would be better able to learn from visual feedback (Green, 1970); whereas, others have found that novice athletes benefit more by seeing him or herself on film (Magill, 1994). I sought to show that athletes with more expertise and athletes who had a preference for visual stimuli benefitted more from visual feedback.

In addition, this study went into greater detail than previous investigations in answering what participants think about when learning a motor skill and what thoughts were most conducive to learning. The think-aloud procedure was used to reveal the

thought processes athletes go through when learning to spike. The think-aloud procedure sought to compare an athlete's thought processes when learning under two types of instruction. Responses from this procedure were also compared according to the athlete's relative level of improvement to see what thoughts were most conducive to learning. This information is intended to help future coaches teach spiking in volleyball.

Research Questions

Q1 Is visually-enhanced feedback more effective than verbal feedback?

Q2 Are athletes able to learn more from visually-enhanced feedback if they have more expertise?

Q3 Do athletes who have a visual learning preference learn better with visually-enhanced feedback?

Q4 How do athletes' cognitions differ when learning a complex motor skill with verbal versus visually-enhanced feedback?

Q5 How do thoughts about motor learning differ between relatively high improving and low improving learners?

Research Hypotheses

The major hypothesis of this study was that visually-enhanced feedback would be more effective than verbal feedback when learning to spike in volleyball. In addition, I predicted that participants with more playing experience would benefit more from visually-enhanced feedback because a more experienced athlete will have a better idea of what the skill should look like. Green (1970) found that advanced beginners benefitted more from visual feedback than did beginners with no experience. I also hypothesized that participants who preferred learning by seeing rather than hearing would benefit more from visually-enhanced feedback.

In studying participants' thoughts while learning, I expected to find many similar themes to those previously found. Moreover, I anticipated finding additional elements that have not been previously reported. In addition, I hypothesized that participants would have more sophisticated cognitions when learning with visually-enhanced feedback, which would enhance the learning process under this condition. Likewise, I anticipated that high-improving learners would have cognitions more conducive to learning than would be the case for low-improving learners.

Assumptions

A major assumption of my study was that participants would not influence one another in different ways by learning in small groups. When learning in groups, athletes often experience social facilitation and influence one another positively by cheering for one another. A review of studies has shown that groups can influence learning in three ways (Johnson & Johnson, 1985). First, the group context can enhance learning in a cooperative goal structure where learners benefit by helping one another. Second, learning can be deterred if there is a competitive goal structure and learners must compete to determine who will be successful. Third, no discernible influence occurs when people learn in an individualistic goal structure where the outcome of the situation is not dependent on others. According to a meta-analysis, higher achievement and more positive peer relationships were associated with cooperative rather than competitive or individualistic goal structures (Roseth, Johnson, & Johnson, 2008). I viewed my investigation as having occurred within a cooperative goal structure wherein participants were expected to be supporting and cheering for one another. I chose this design to maximize the learner's potential with the assumption that groups would influence one

another in a similar fashion so that differences between groups would not be statistically significant. This assumption was examined as a between-subjects effect in the repeated-measures ANOVA.

Limitations of the Study

There were several limitations of this study. One of the major limitations was a small sample size for quantitative analysis. The threat of external validity is an artifact of this small size. Based on a preliminary power analysis, a sample size of 19 participants was found to be feasible in detecting statistically significant effects. This sample size was deemed acceptable due to the intensive demands of data collection and my role as the only coach conducting the lessons. Ultimately, I was able to achieve a sample size of 26 participants.

Another limitation of my study was that participants learned in small groups of two to six. This created a difficulty because the influence of the group needed to be tested using a nested factor. However, learning in groups is ecologically valid as volleyball players regularly practice as a team in groups of six or more. The limitation of group dynamics was also counteracted by data sources in this investigation focusing on the individual learner and the thought processes that occurred when learning to spike.

A third limitation of my experiment was experimenter bias, which may have been apparent to participants since I was both the researcher and the coach. Because I was the coach administering both treatments and had an expectation that the combined treatment would be more effective, it is possible that I was perceived to be more enthusiastic in the combined treatment condition or that I inadvertently affected the outcomes of the study in some other way. I addressed this source of bias by asking participants in their interview

if they experienced differences in the verbal feedback when I was coaching under different feedback conditions (see Appendix A). In addition, outside observers evaluated an acquisition session under each type of treatment condition. The observers completed a behavior checklist rating my level of enthusiasm, amount of verbal feedback, and quality of feedback in relation to the participant's performance (see Appendix B).

A fourth limitation of my study was the lack of diversity in the sample. Participants were randomly selected among athletes from three volleyball clubs in Colorado. These clubs and the resulting sample of athletes who participated in this investigation were presumably representative of competitive volleyball players within Colorado. However, differences in learning might exist based on diverse backgrounds, which will need to be addressed in a future study.

A fifth limitation of the investigation was that participants were all female. It was assumed that males and females responded in the same manner to visually-enhanced feedback. However, a gender effect has been reported in learning with visual feedback (Barbarich, 1980). Therefore, generalizations about how males learn with visually-enhanced feedback cannot be made based on this investigation.

In addition, the comparison between a combination of verbal and visual feedback with verbal feedback alone has the advantage of comparing a prevalent format of coaching (verbal guidance) with a hypothetically more robust combination of verbal guidance and visual information. Yet the results of this comparison are open to alternative explanations; for example, the combined feedback was richer in information and therefore more instructive, rather than being more educational due to the precise array of feedback provided. Of course, the superiority of visually-enhanced feedback has

yet to be demonstrated definitively; thus, it is possible that visual feedback is not instructive or provides too much information for the learner to handle.

The results were also subject to additional threats to validity. One of these threats to validity was the carry-over effect (Kuehl, 2000). Because I conducted a randomized cross-over design, the participants experienced both types of treatments and the learning that occurred in the first period could have crossed over into the second period. To address this threat to validity, I implemented three procedures. I recorded baseline observations before each treatment period, balanced the number of treatment sessions, and established a washout period (a one-week period in which the participants did not receive any training; Kuehl, 2000).

A second potential threat to validity was diffusion of treatment. Many of the participants knew each other since they were part of the same club or same school. This threat was minimized by implementing a cross-over design where all participants received all forms of instruction.

A third threat to validity was fatigue whereby participants might not perform at their peak after a large number of repetitions. I minimized this problem by having testing sessions on separate days as acquisition sessions.

A fourth threat to validity was testing effects. Participants might learn the focus of the early testing sessions and this experience might affect their later performance. This threat to validity was examined by conducting a time-series analysis of the data, whereby learning over several sessions could be tracked.

A fifth threat to validity was differential attrition. A major difficulty of my pilot study was attrition. I addressed this by creating a schedule of participation sessions

before the study so participants knew in advance when the experiment was taking place. In this manner, participants who knew beforehand that they could not attend all of the sessions did not participate in the study.

Instrumentation was a final threat to validity. The setting machine used in this study was incorporated with the intention of delivering a precise set to the hitter. However, quantitative and qualitative evidence indicated that the setting machine was somewhat unreliable and affected the accuracy of outcome measurements.

Definition of Terms

Augmented feedback. Information that is provided about a task that supplements the intrinsic cues a performer receives while performing (e.g., knowledge of results, knowledge of performance, verbal feedback, and visual feedback; Schmidt & Lee, 2005).

Cognitive representations. Actions that are encoded by their sensory consequences in the brain with a memory structure capable of controlling the action's performance (Hommel, 1996).

Jump serving. In volleyball, the act of initiating a rally by throwing the ball in the air and then jumping and hitting the ball into the opponents' court (Kiraly, 1996).

Knowledge of performance. Post-movement information about the nature of the movement pattern (Schmidt & Lee, 2005).

Knowledge of results. Post-movement information about the outcome of the movement (Schmidt & Lee, 2005).

Motor cognition. Thought processes related to movement that allow us to achieve a greater understanding of ourselves, others, or the world (Fuentes & Bastian, 2007).

Motor skill. A reasonably complex motor performance (Sanders, 1969).

Passing. In volleyball, the act of contacting a ball with one's forearms so as to direct the ball to the setter (Kiraly, 1996). Also referred to as the "forearm pass" or "the bump."

Randomized cross-over design. Experimental manipulation of randomly assigning participants to one type of treatment or another and then switching treatments half-way through the experiment (Corr, Phillips, & Walker, 2004; Kuehl, 2000).

Serving. In volleyball, the act of initiating a rally by hitting the ball and sending it into the opponents' side of the court (Kiraly, 1996).

Setting. In volleyball, the act of contacting the ball with two hands above one's head to send the ball in flight through the air to set up a teammate to spike it (Kiraly, 1996).

Spiking. In volleyball, the act of jumping and contacting the ball with one's hand with the intent to propel the ball down onto the opponent's side of the court (Kiraly, 1996). Also referred to as "attacking" or "hitting."

Traditional instruction. The method of teaching a motor skill that utilizes verbal explanation, demonstration, practice, instructor analysis, and correction (Sanders, 1969).

Triangulation design. A mixed-methods procedure where quantitative and qualitative data are collected simultaneously and each source of data is given equal priority (Creswell, 2005).

Verbal feedback. A procedure used by a coach to provide verbal feedback about the skill just performed (Kountouris & Laios, 2007).

Video feedback. The use of video replay as a source of feedback (Sanders, 1969).

Visual feedback. The use of visual aids such as videos (Zetou et al., 2009), pictures (Hawthorne, 1964), or mirrors (Lynch, Chalmers, Knutzen, & Martin, 2009) by the coach to provide feedback to the athlete about a motor skill.

Visually-enhanced feedback. The use of visual feedback to augment verbal feedback.

CHAPTER II

LITERATURE REVIEW

This literature review is organized into five sections. The first section introduces research on traditional coaching techniques including instruction, verbal feedback, and observational learning. The second section presents the history of visual feedback, examining visual feedback in motor skills, visual feedback in sports, and specifically visual feedback in volleyball. In the third section, theoretical perspectives pertinent to visually-enhanced feedback are reviewed and research on learning styles and motor cognition is examined. The fourth section describes my preliminary investigation into visual feedback where participants learned the jump-serve in volleyball with different combinations of verbal feedback, visual feedback, and observational learning. Finally, the fifth section presents the rationale for my research questions.

Traditional Coaching Techniques

Coaching is highly competitive and coaches always seek ways of attaining an added advantage over the competition. Getting an advantage over an opposing team can come in a variety of ways: through improved practice, better drills, enhanced communication with players, and instruction in improved techniques. Numerous studies have examined variations in these coaching practices. Early studies examined traditional approaches to coaching whereby verbal instruction was provided followed by verbal feedback. The research on using verbal cues as a way to direct learning overwhelmingly

shows this to be an effective method of instruction (Kountouris & Laios, 2007; Landin, 1994; Magill, 1993). Often, a demonstration is also provided as a means to facilitate learning. Studies on observational learning show it to be a highly effective manner with which to teach motor skills (Feltz, 1982; Magill, 1993).

Instruction

As is the case in the academic classroom, instruction is a critical component of knowledge and skill acquisition in motor learning. Early work in sport pedagogy found that verbal instruction is among the most common teaching behaviors (Landin, 1994). Research has shown that motor learning can be facilitated with verbal instructions (Magill, 2004). However, when delivering verbal instructions, the teacher must be cognizant of the amount of information being presented since the learner can only attend to a certain amount of information. Verbal instruction is effective to the degree that it focuses the learner's attention on what the movement should look like and how to accomplish the action (Magill, 2004).

The most relevant example of verbal instruction when learning to spike in volleyball tested participants' ability to spike to a particular area using verbal cues (Kountouris & Laios, 2007). The verbal cue to hit one of three zones in the opponents' back court was administered to the participants by loud-speaker after the ball was set in the air by a setting machine. The participants were divided into four groups: control, auditory, variable-auditory, and visual. The control group received no instruction; whereas, the auditory group received verbal instruction regarding the location to hit. The variable-auditory group also received verbal instruction, but not every time. Last, the visual group saw the target area light up as they were spiking. It was found that

participants learned best when they practiced with variable-auditory cues (Kountouris & Laios, 2007).

Verbal Feedback

Although instruction can be highly effective in teaching motor skills, verbal feedback is the predominant mode of intervention in teaching motor skills (Knudson & Morrison, 2002). Movement feedback serves three major functions: it provides the learner with information, reinforcement, and motivation. Information from feedback allows the performer to correct movement errors. Feedback is also reinforcing. It can either increase the behavior (positive reinforcement) or decrease the behavior (punishment). Also, feedback can be motivating when the instructor gives positive feedback and is encouraging (Knudson & Morrison, 2002).

Verbal feedback often comes in the form of verbal cues, which are short and concise phrases that direct the learner's attention to critical components of the task at hand or prompt key movement patterns (Landin, 1994). Research indicates that verbal cues can be effective when they come from the teacher or when the learner cues him or herself (Cutton & Landin, 2007). The theoretical explanation for the effectiveness of verbal cues is that they help the athlete to focus attention. It has been reported that paying attention is one of the most important tasks when learning and performing in sports (Landin, 1994).

Building on research showing the utility of verbal cues when teaching athletes, researchers have proposed that self-cueing could be beneficial for athletes to regulate their attentional focus while performing. The positive effect of attentional-shift training (where an athlete learns how to focus his or her attention) has been demonstrated in sport

performance (Ziegler, 2002). Studies of athletes' awareness of cognitive processes are important in developing improved instructional practices and raising performance in athletics.

One influential investigation was designed to test the effects of verbal feedback on skill learning (Magill, 1993). In addition, the study sought to compare the relative effectiveness of verbal feedback compared to having a model demonstrate the skill. Participants learned a rhythmic gymnastics skill by viewing a model demonstrate it or by receiving verbal feedback. Although the study found verbal feedback to be helpful in learning the gymnastics skill, it was shown that observing a model was significantly better for learning it (Magill, 1993). With the finding that skill demonstration can be more effective in the learning process, a number of studies examined observational learning.

Observational Learning

Observational learning is the ability to learn an act by watching another individual. Observational learning was first observed in the classic "bobo doll" studies (Bandura, Ross, & Ross, 1963). These studies showed that children learned to be violent and aggressive after having observed an adult model these behaviors. Although these experiments highlight negative forms of behavior that can be elicited with observational learning, modeling has many beneficial applications. Numerous investigations have shown observational learning to be an effective method for teaching motor skills (Feltz, 1982; Magill, 1993).

One of the earliest studies on observational learning of motor skills was conducted by Martens, Burwitz, and Zuckerman (1976). These investigators sought to

demonstrate the modeling effect in motor learning. They designed experiments examining the influence of observing a correct model, observing a learning sequence model, and observing an incorrect model on participants' performance on two motor tasks. The motor tasks included rolling a ball up an inclined board to a target area ("roll up") and manipulating two inclined rods to roll a steel ball up an incline ("shoot the moon"). The results demonstrated the modeling effect for motor learning and showed no difference in performance between a live model and a filmed model demonstrating the tasks correctly (Martens et al., 1976).

A later study compared the benefits of knowledge of results versus knowledge of performance when learning the tennis forehand (Little & McCullagh, 1989). The participants were put into two instructional groups: knowledge of results and knowledge of performance. The participants observed a model demonstrate the tennis forehand. After observing the model, participants attempted the skill while receiving either information about the results of their performance or information about their form and technique. The researchers measured the outcome and the form of the participants' learning trials, allowing them to assess changes in performance. Upon analyzing the data with a discriminant analysis, the researchers found that scores on the form of participants' learning were more affected than the outcome scores. In addition, the knowledge of performance group significantly outperformed the knowledge of results group in scores on their form (Little & McCullagh, 1989). Other studies have further supported the modeling effect in motor skill acquisition while demonstrating the key role of cognitive representational development in observational learning (Carroll & Bandura, 1987, 1990).

Due to the fact that studies have shown modeling to facilitate performance in the cognitive phase of motor skill acquisition, it has been important to determine the particular factors that are involved. For instance, the effects of age and number of demonstrations have been evaluated in observational learning (Feltz, 1982). To examine age differences, Feltz compared groups of college women to a group of elementary school-age girls. The number of modeling demonstrations was examined by having four modeling conditions including no, 4, 8, and 12 demonstrations. The form and performance of the participants were measured. The modeling effect was found in the form but not in the performance ratings. It was hypothesized that older participants would require fewer observations of the model; however, this effect was not supported by the data. Also, the modeling effect was only found with 12 demonstrations. It was concluded that the number of observations that yielded a modeling effect was task-specific and also depended on the length of the practice period (Feltz, 1982).

Adding to research examining important variables involved in visual feedback, other scholars have endeavored to understand how motor learning occurs. Although little disagreement exists among researchers concerning what motor skill learning entails, determining what information is specifically used in the learning process is a major challenge for researchers. Magill (1993) stated that “motor skill learning is an action problem-solving situation where limbs must be coordinated and controlled to act according to the constraints imposed by time and space in order to accomplish the goal of a skill” (p. 358). How this problem is actually solved was studied in the skill acquisition of slalom skiers. The learning process was studied by examining visual demonstration and verbal feedback. Each day before practicing a skiing simulation, participants

observed a skilled model perform the skiing slalom simulation. It was shown that observing a skilled model could facilitate the acquisition of a motor skill. This result would imply that the visual system plays a major role in motor learning. Through the observation of another person's limbs and body movements, the observer is able to transform the visual cues into movement of his or her own body (Magill, 1993).

In a subsequent study (Magill & Schoenfelder-Zohdi, 1996), gymnasts were compared in their ability to learn a rhythmic rope skill used in competitions. The researchers sought to examine the differences between visual modeling of an expert compared to knowledge of performance (KP; e.g., information about how the skill was performed). To guide the learning process in the knowledge of performance condition, a script of statements was created for coaches to use. Participants were randomly assigned to one of four experimental groups: one group observed a model and received KP, one group observed a model without KP, one group did not observe a model but received KP, and the final group did not observe a model and did not receive KP (Magill & Schoenfelder-Zohdi, 1996).

The results of this intervention identified feedback that was more critical to beginners compared to learners who had already acquired some of the skills. It was shown that beginners required *prescriptive* knowledge of performance feedback; whereas, *descriptive* knowledge of performance sufficed for intermediate learners. Prescriptive feedback tells the learner what is needed to be done to correct a performance error; whereas, descriptive feedback simply tells the learner what the error was. Descriptive knowledge of performance is satisfactory for intermediate learners because

they have enough experience to understand how to correct the performance without further elaboration (Magill & Schoenfelder-Zohdi, 1996).

The results of this analysis indicated that knowledge of performance combined with modeling contained a lot of redundancies in information. Redundancy in information received from observation and KP was evident in that the group receiving both conditions did not show greater learning than did groups receiving only observation of a model or KP. It was recommended that future studies examine which aspects of observing a model might offer distinct information from KP and vice versa (Magill & Schoenfelder-Zohdi, 1996). Elaborating on these findings, a subsequent study reported that interference might occur if knowledge of results was provided after knowledge of performance (Zubiar, Oña, & Delgado, 1999). Although all of the aforementioned studies demonstrated the benefit of observational learning, they did not examine the possible benefits of self-observation.

Summary of Research on Traditional Coaching Techniques

In conclusion, a great deal of research has been aimed at improving instructional practice by coaches. Studies have reported the effectiveness of instruction, verbal feedback, and observational learning. Numerous investigations have found observational learning to be more effective than verbal feedback (Magill, 1993); whereas, others have reported beneficial additive effects of observational learning in conjunction with verbal instruction (Turpin, 1977). In addition, it is important to consider the developmental level of the learner because augmented feedback must be appropriate for the skill being learned, the person learning the skill, and the learning situation (Magill, 1994).

Visual Feedback

Drawing on evidence from observational learning, along with the idea that viewing oneself perform might be a useful feedback mechanism, many researchers began examining forms of augmented feedback (Cutton & Landin, 2007; Magill, 1994; Markland & Martinek, 1988). Augmented feedback is information that is provided about a task that supplements the intrinsic cues the performer experiences while enacting the skill (Schmidt & Lee, 2005). Visual feedback in particular has received a great deal of attention (Rhoads, 2010a; Rothstein & Arnold, 1976). Visual feedback is the use of visual aids such as videos by the coach to provide feedback to the athlete about a motor skill (Zetou et al., 2009).

It has been argued that visual presentation is preferred over verbal instruction because language is not equally proficient as vision at specifying precise aspects of human movement (Martens, 1975). Many studies have shown visual feedback to be a valuable method for providing feedback (Mache, 2005; Zetou et al., 2009); whereas, other interventions have shown it to have negligible, or even disadvantageous, effects (Carmichael, 1969; Kernodle, Johnson, & Arnold, 2001). In addition, a number of pertinent variables have been highlighted including immediacy of feedback, skill level of the participants, and type of skill being learned (Rhoads, 2010a).

Visual Feedback in Motor Learning

The examination of visual feedback as a potential aid in the acquisition of motor skills has a long history with inconclusive findings. Research on the viability of visual feedback dates back almost to the time filming was first available. Although there has been consistent interest in the topic, a definitive answer regarding visual feedback's

utility remains unclear. The earliest known research on visual feedback dates back to 1948 when a moderate level of effectiveness was reported in teaching gymnastics (Brown & Messersmith, 1948). The early existence of this study is quite remarkable considering video cameras for home use were not available until 1946 when Radio Corporation of America first began production of image orthicon video cameras for civilian use (Abramson, 2003). Subsequent work has produced ambiguous findings; some studies showed high effectiveness and others showed little advantage or even distraction from visual feedback.

One of the early investigations examining the effectiveness of visual feedback in motor skills examined four sport-type motor skills (Jackson, 1973): volleying a volleyball against a wall, throwing and catching a tennis ball while lying on one’s back, bouncing a volleyball on the end of a softball bat, and shooting a free throw shot in basketball. Three classes of physical education students were randomly assigned to one of three groups: a visual feedback experimental group, a visual and auditory feedback group, and a control group. A six-week period was allotted for skill acquisition and skill retention. It was tentatively concluded that visual feedback positively affected the acquisition of sport-type motor skills.

One of the earliest studies on concurrent visual feedback examined participants’ ability to imitate modeled action patterns of a paddle, arm, and wrist (Carroll & Bandura, 1982). Concurrent feedback was provided by allowing participants to observe themselves in a video monitor while performing. Results of the study found that when an action pattern lay outside the individual’s visual field, concurrent visual feedback could markedly accelerate learning. The experiment also demonstrated that if the participant

had not developed an adequate conceptual representation of the skill, then visual feedback was of minimal use for error detection and correction (Carroll & Bandura, 1982).

To expand on Bandura's (1977) theory of observational learning, Erbaugh (1985) examined primary-grade children and their ability to learn a jumping task using visual feedback. In the experimental condition, participants periodically viewed a videotape of their own performance while learning to balance on a stabilometer and jump on a horizontally rotating bar. The results showed that children who viewed their own performance on video were able to make corrections to their movement while children in the control group were unable to do so. It was concluded that children can effectively learn a motor task using self-observation (Erbaugh, 1985).

Visual feedback has been used to study participants' ability to lower a weight using the front and back thigh muscles (Lukasiewicz, 1997). Both men and women served as participants with all individuals receiving all treatment methods in a randomized order. Participants received visual feedback, verbal encouragement, both visual feedback and verbal encouragement, or no instruction. The results indicated that visual feedback and visual feedback with verbal encouragement were the most beneficial treatments. Verbal encouragement alone was not found to be helpful in increasing performance (Lukasiewicz, 1997).

In a similar investigation, the power output of athletes performing the leg press based on types of feedback was examined (Hopper, Axel Berg, Anderson, & Madan, 2003). Sixteen female field hockey players were randomly assigned to a cross-over design where they received either visual feedback or no visual feedback first and then

received the other manipulation second. Visual feedback was presented to the participant on a computer monitor showing the power output of her leg press. The researchers showed that visual feedback significantly improved performance during the explosive leg press maneuver. The researchers suggested that visual feedback should be utilized whenever training or measuring power on the leg press as a tool for maximizing performance (Hopper et al., 2003).

The utility of biofeedback has also been examined in learning how to improve the vertical jump (Mache, 2005). Individuals in a control group were told they could improve on their prior jump while those in an experimental group saw their performance on video and were instructed on the optimal knee angle for a maximal vertical jump. The experimental group received visual and verbal feedback; whereas, the control group received neither type of feedback. Compared to the control group, the experimental group made significant changes by reducing the depth of descent, decreasing time of propulsion, and increasing jump height. Thus, the authors obtained support for the effective use of verbal and visual feedback in improving the process and product of the vertical jump (Mache, 2005).

Visual Feedback and Sports

The first study of visual feedback in sports was conducted in 1948 and was an analysis of potential benefits of motion pictures in teaching tumbling (Brown & Messersmith, 1948). The authors showed the experimental group movies of exemplary tumblers in action. In addition, members of the experimental group were filmed while tumbling and shown videos of their own performance. Two classes were taught by the same instructor with one class serving as the control group and the other class as the

experimental group. The experimental group viewed performance in four classes after it had been filmed. It was concluded that the experimental group made slightly more progress in learning tumbling skills but not at a statistically significant level. The authors concluded that motion pictures were highly motivating for the students. On the other hand, the authors noted that class time might have been put to better use in actual practice rather than observing past performances (Brown & Messersmith, 1948).

Another early investigation determined the relative effectiveness of videotape feedback for women learning a lacrosse skill (Brown, 1973). This study also examined whether immediate or delayed feedback (24 hours) was preferable. Seventy-five undergraduate students participated in the study and were individually assigned to one of three groups: a control group, an experimental group receiving videotape feedback immediately following performance, and an experimental group receiving delayed feedback. No significant differences were found among any of the groups. It was suggested that many factors other than videotape feedback and the length of post-feedback delay affected the learning of this gross motor skill. The author offered the following recommendations: extend the number of testing days, conduct the study with other motor tasks and with different skill levels, and examine the effect of various intervals of feedback delay (Brown, 1973).

A subsequent study examined the use of visual feedback for learning the standing broad jump in high school girls (Zebas, 1974). Visual feedback took the form of a videotape picture. This feedback was delayed and not presented until the second session. It was reported that visual feedback did not affect the distance jumped or the mechanical efficiency of the performer executing the standing broad jump. Although mechanical

efficiency was not shown to improve at a statistically significant level when using visual feedback, the author viewed this technique as having potential instructional value and warranting further investigation (Zebas, 1974).

Numerous studies have demonstrated a small effect when augmenting feedback with visual information. Many of these studies have shown that visual feedback may not add a lot of information beyond what is already available through verbal means. One such investigation examined the benefits of self-modeling on gymnasts' balance beam performance (Winfrey & Weeks, 1993). One group of intermediate-level female gymnasts served as the experimental group. Gymnasts in this group watched a videotape of themselves three times per week during a six-week period (self-modeling group). Another group of gymnasts served as a control group and underwent the normal practice regimen of practicing the balance beam with verbal feedback. After the six-week period, differences in performance and self-efficacy were compared between groups. Results failed to show differences in skill acquisition or self-efficacy between the self-modeling and control groups. However, the self-modeling group was more accurate in assessing performance based on correlational scores between performance and self-efficacy (r = .92). The control group showed a much lower correspondence between performance and self-efficacy scores (r = .02). The authors stated that self-modeling was likely to increase athletes' accurate assessment of their skill level. A major limitation to this study was participants watched the same videotape of themselves, which was recorded prior to the study. Watching a poor performance repeatedly prior to practice probably decreased the participants' levels of motivation and self-efficacy. The authors noted the potential

benefits of augmented self-modeling feedback from videotapes (Winfrey & Weeks, 1993).

The lack of beneficial effects using visual feedback was also reported in a study of women learning the overhand throw with a tennis ball using their non-dominant hand (Kernodle et al., 2001). Two groups of women were provided either verbal instruction on how to improve their throwing motion or the same verbal instruction along with a videotape replay of their performance. An interesting manipulation within this study was the researchers slowly withdrew the frequency of feedback opportunities as the sessions progressed. Thus, for the first two sessions, feedback was provided after every second trial. Eventually by the fifth and sixth sessions, feedback was provided after every fifth trial. This technique (referred to as the fade format) was implemented to enhance retention scores. The reason for this arrangement was that the learner was forced to problem-solve and process the information more deeply (Kernodle et al., 2001).

This study did not show the instruction method with visual feedback to be superior to the verbal instruction by itself (Kernodle et al., 2001). It was interpreted that this result was due to information overload, i.e., the participants did not improve with visual feedback because it provided more information than they could process. It was also suggested that visual feedback provided redundant information, similar to findings by Magill and Schoenfelder-Zohdi (1996). A possible limitation of this study was the fact that the fade format was implemented. This variation in feedback administration might have changed the results if the feedback had remained constant. Perhaps participants needed the same number of feedback repetitions throughout the experiment to gain the most from visual feedback.

To date, the most comprehensive literature review of visual feedback was conducted by Rothstein and Arnold (1976). Based on the available studies at that point, the investigators found the majority of relevant studies demonstrated non-significant findings when examining visual feedback. Of 52 studies, 33 showed non-significant results (Rothstein & Arnold, 1976). Similarly, the moderate effectiveness of visual feedback has also been shown in an unpublished meta-analysis of visual feedback (Rhoads, 2010a). After collecting means and standard deviations for experimental and control groups comparing visual feedback to auditory feedback, it was found that visual feedback provided some additional benefits beyond coaching or traditional verbal feedback. A weighted mean effect size of 0.28 was reported (Cohen's *d*). An effect size of 0.30 is considered small, 0.50 is a medium effect, while 0.80 and above is considered a large effect size when comparing independent means (Cohen, 1992). Therefore, it appeared that visual feedback had a modest effect.

However, the non-significant findings of many of these studies defy most people's assumptions about the beneficial effects of visual feedback. Many computer programs have been developed to augment feedback. Numerous sports teams use video as a way to train and improve skill proficiency (Hurd, 1991). Therefore, a closer inspection of existing interventions is required. There are a few possible ways of explaining the weak evidence for visual feedback to date. First, visual feedback may actually provide little additional benefit beyond verbal instruction. Second, the majority of studies so far conducted may be of poor quality and unable to assess the beneficial effects of visual feedback. Third, the necessary research methods needed to appropriately assess the utility of visual feedback for learning motor skills have not yet been

implemented. Fourth, visual feedback may only be beneficial for people who have a preference for visual learning and so the beneficial effects of visual feedback are diminished when results are averaged for all participants.

I do not adhere to the notion that visual feedback is not more beneficial than verbal feedback alone. Nor do I think the majority of prior studies were poorly conducted. I believe visual feedback has shown minimal advantageous effects in part because technology was not available to deliver instantaneous feedback in the manner that products such as Dartfish are capable of doing. In addition, the major factor that has diluted findings in support of visual feedback is individual differences in learning. Some athletes prefer receiving feedback verbally; whereas, other athletes can benefit from visually-enhanced feedback.

Visual Feedback in Volleyball

A number of investigations examining visual feedback for teaching volleyball have also been conducted. The earliest study of visual feedback in volleyball assessed the act of setting (Sanders, 1969). Participants were instructed to strike the volleyball to a target using the “two-hand overhand volley” (setting). The instructor verbally critiqued each person’s performance and demonstrated the skill if necessary. The experimental group received the same instructional method along with a visual critique immediately following the participant’s performance. Although the study found the effectiveness of visual feedback to be non-significant, the author felt that visual feedback might still have value for the physical education profession. The author recommended that a more difficult motor skill be examined as participants might have shown a ceiling effect in learning how to set (Sanders, 1969).

The first known study to assess visual feedback in teaching the forearm pass in volleyball was conducted by Barbarich (1980). The forearm pass is where the athlete puts two arms together and contacts the ball with their forearm. In this intervention, the control group received a conventional teaching method comprised of verbal instruction, demonstration, and teacher correction. The experimental group received this teaching method along with visual feedback. The participants were seventh and eighth graders from two schools who had no prior experience with the forearm pass. There were nine total sessions and participants were tested in their ability to pass a ball to a designated target. It was shown that visual feedback was helpful for men but not women in learning the volleyball forearm pass. In comparing the pretest and posttest performance scores for passing, both the control and experimental groups improved. In addition, no difference was found between treatment groups. Thus, visual feedback did not show additional benefits beyond traditional teaching methods (Barbarich, 1980).

A later study also measured the forearm pass in volleyball (Barzouka, Bergeles, & Hatzhiharistos, 2007). This study tested novice high school girls' ability to learn the pass with various types of visual feedback. The control group received verbal feedback regarding the proper technical skills. Experimental Group One received instruction through a video of an expert modeling the skill with verbal instructions that were recorded by a physical education teacher. Experimental Group Two received the same instruction along with viewing a self-modeled video of the participant's correct performance. The self-modeled video was shown in the next practice session. The results of the study showed that verbal instruction seemed to be the critical component

that allowed for skill acquisition and retention since all groups performed the same in learning the volleyball forearm pass (Barzouka et al., 2007).

The efficacy of visual feedback has also been examined in an investigation focusing on the skills of *passing* and *setting* in volleyball (Zetou et al., 2009). Passing is where an athlete uses one's forearms to send the ball to the setter. Setting is where an athlete contacts the ball with two hands above his or her head to send the ball in flight through the air for a teammate to spike. This study was conducted with 32 novice girl beach-volleyball players with an average age of 12-years-old. The utility of self-modeling (where athletes view themselves after performing a skill) was tested on athletes' ability to learn the aforementioned volleyball skills. The self-modeling group was compared to a control group whose members received traditional feedback from a coach without receiving visual feedback. In addition to measuring skill acquisition, this study examined participants' levels of self-efficacy to see if visual feedback improved their confidence levels in their ability to perform volleyball skills.

To evaluate improvements in the volleyball skills, a rating system was devised based on the accuracy of athletes' passes or sets to a target. The accuracy of the trial was scored from 1 to 4 with 4 being the highest score. After 10 trials, a maximum of 40 points could be earned by each participant. In addition to the skill evaluation, passing and setting were also assessed through observations. Passing was assessed using American Alliance for Health, Physical Education, Recreation and Dance's (AAHPERD; 1984) test for passing in indoor volleyball. Setting was assessed using the North Carolina State University Volleyball Skills Test (Bartlett, Smith, Davis, & Peel, 1991). The test-retest reliability was high for each test: $r = .97$ for passing and $r = .94$ for setting (Zetou,

Giatsis, & Tzetzis, 2005). The results of this study showed that the self-modeling group had greater improvements in passing and setting than did the control group. In addition, the self-modeling group showed a greater increase in self-efficacy compared to the control group (Zetou et al., 2009).

In another investigation, the use of visual feedback was examined for teaching the skills of *setting* and *serving* in volleyball (Zetou, Tzetzis, Vernadakis, & Kioumourtzoglou, 2002). Setting is where an athlete contacts the ball with two hands above his or her head to send the ball in flight through the air for a teammate to spike. Serving is where an athlete initiates a rally by hitting the ball above one's head. An experiment was undertaken to investigate two different types of modeling and knowledge of performance on the acquisition and retention of these skills. The participants included 116 elementary school boys and girls with a mean age of 11.7 years. Participants were randomly assigned to one of two groups. One group observed a videotape of an expert model performing the skill (expert modeling group); whereas, the second group watched a videotape replay of their own performance (self-modeling group). Each group watched a videotape of a model or of their own performance for two minutes on two separate occasions during a 40-minute practice session.

The experiment measured the results of each participant's performance along with the technique of the skill. The skills of setting (contacting the ball overhead with one's hands and sending the ball to a hitter) and passing (contacting the ball with one's forearm and sending the ball to the setter) were measured based on the participant's ability to direct the ball to a target. For setting, a participant could score a maximum of five points per trial. For passing, a participant could score a maximum of four points per trial.

Performance techniques were assessed by two observers who rated the correct execution of seven elements of each skill. Based on a posttest and retention test, it was concluded that the expert modeling group performed better on the posttest and retention test compared to the self-modeling group. The authors suggested that future studies focus on different practice settings with both sexes. In addition, athletes with different levels of expertise should be studied while looking at a greater complexity of skills (Zetou et al., 2002).

Another study focused on the skill of serving in volleyball while measuring the effectiveness of self-modeling on performance and self-efficacy (Ram & McCullagh, 2003). Self-modeling was operationalized as being distinct from visual feedback since only the best clips of the participants' performance were shown. The investigators intentionally selected optimal movements to increase self-efficacy of the participants. Videotape replays were not shown after every trial but were compiled with highlights shown to the participant before the next session. This study implemented a multiple baseline, single-subject design, wherein each individual was compared to his or her own scores (Ram & McCullagh, 2003).

Upon analyzing the data, Ram and McCullagh (2003) found no significance in the performance scores or self-efficacy ratings of the participants. One interesting finding was that participants were often surprised at seeing themselves on camera. It took many participants some time to get used to this experience; the amount of think-aloud verbalizations decreased when describing their thoughts and feelings upon viewing themselves on film. The authors noted that learners might take awhile to familiarize themselves with experiences of self-modeling. In addition, although the intention of the

study was to test the benefits of self-modeling alone, it became clear to the researchers by the end of the study that some instruction from a coach was necessary to guide the participants in their learning (Ram & McCullagh, 2003).

Summary of Studies on Visual Feedback

Research on the effectiveness of visual feedback has been conducted in the context of improving motor skills, sport skills generally and volleyball skills specifically. Although studies have been conducted measuring participants' ability to learn to spike in volleyball, no known studies have examined the use of visual feedback for teaching spiking in volleyball. Spiking entails the act of jumping and contacting the ball with one's hand with the intent to propel the ball down onto the opponent's side of the court (Kiraly, 1996). Based on the mixed findings of visual feedback's utility, it is still undetermined whether visual feedback is effective as a means for augmenting instruction in sports. In addition, a number of variables influence the effectiveness of visual feedback as an instructional tool. Visual feedback may be more effective if it is applied with more immediacy (Zetou et al., 2009) and if it is provided along with verbal feedback (Lukasiewicz, 1997; Ram & McCullagh, 2003).

Theoretical Perspectives

Three theoretical perspectives are helpful in understanding the role visual feedback plays in aiding motor skill acquisition: motor cognition, developmental levels, and learning styles. Familiarity with how the brain processes information to control movement is a key element. In addition, knowledge of how the developmental level and learning style of athlete's impacts learning might prove to be helpful to practitioners interested in using visual feedback.

Motor Cognition

The study of motor action is based on the hypothesis that motor control emerges from the interaction between the nervous system (brain) and other physiological systems of the body (Gabbard, 2004). One of the popular approaches for studying the learning and execution of motor behavior is the information processing approach which compares human processing to basic computer functions (Gabbard, 2004). The term motor cognition refers to thought processes that guide movement. In distinguishing motor cognition from motor control, Creem-Regerh (2009) states,

> Motor control requires sensory-motor integration using both forward and inverse models so that actions are constantly corrected to allow for accurate execution. Motor cognition is more broadly defined as planning, imagery, gestures, knowledge about actions, and the generation of internal representations for action. (p. 167)

Motor cognition has also been described as the ability to understand our own movement and to learn about the world from our movement (Fuentes & Bastian, 2007).

Early research in motor cognition sought to test the social cognitive theory (Bandura, 1977) of observational learning. An experiment tested whether cognitive representation mediated action production and if visual guidance aided in the translation of conception into action (Carroll & Bandura, 1987). Modeled action patterns involving an individual’s paddle, arm, and wrist movements were used in accordance with a prior study (Carroll & Bandura, 1982). However, this study also examined the participants’ cognitive representations of the movements using the pictorial arrangement test. Photographs of accurate pattern movements were shown to the participants along with inaccurate patterns. The participants were asked to select the correct pattern movements. The results of the study revealed that observational learning greatly improved the

participants' ability to learn the task by visually coordinating their movements with the modeled actions or a retained conception of the action. In addition, an association was found between participants' ability to correctly identify pattern movements and the ability to perform the action. This demonstrated that participants must have an understanding of the movement before being able to perform it. This finding supported the hypothesis that cognitive representation mediates action production (Carroll & Bandura, 1987). Adding to these findings, a later study (Carroll & Bandura, 1990) showed that multiple exposures to the modeled action and verbal coding contributed to the accuracy of cognitive representation. Verbal coding is a depiction in words of what the model is doing behaviorally (Carroll & Bandura, 1990). Other researchers have similarly hypothesized that visual feedback is effective because it draws the learner's attention to errors in movement and allows him or her to modify subsequent performances (Menickelli, 2004).

Based on a review of literature on motor cognition, a new argument has been suggested to explain action understanding in humans (Gallese, Rochat, Cossu, & Sinigaglia, 2009). The previous conception maintained that actions are understood by representing mental states of another person's actions. The new conception holds that action understanding may occur with motor cognition. Evidence from studies on the mirror neuron system helps to explain an individual's ability to understand action by using the same brain areas involved in conducting the motor action (Gallese et al., 2009). Mirror neurons are brain areas that are active during production and observation of an action (Rizollati & Craighero, 2004).

The groundbreaking study (Rizollati, Fadiga, Gallese & Fogassi, 1996) that first provided evidence for the mirror neuron system (MNS) found that an area in the brain of macaque monkeys lit up both when the monkeys grasped food and when they observed the researcher grasp the food. The area of the brain that lit up both for the observation and performance of an action is known as the premotor cortex (F5). This finding is significant to the study of visual feedback since it is likely that the MNS is also involved when viewing oneself and others to learn a motor action.

With the discovery of the mirror neuron system, much attention has been given to how the meaning of movement might be understood with the same areas of the brain that produce movement. Areas of the brain that appear to be involved in the mirror neuron system include the ventral premotor cortex, Brodmann's area 44 (i.e., Broca's area), and the rostral inferior parietal cortex (Fuentes & Bastian, 2007). In addition, brain areas that play a key role in visually-based cognitive processing of human body movements include the ventral premotor cortex, extrastriate body area, and the middle temporal/visual area 5. These areas of the brain are involved in the production and representation of action (Piefke et al., 2009).

Based on observations showing that motor imagery and motor execution are highly associated in terms of neural substrates, Jeannerod (as cited by Kranczioch, Mathews, Dean, & Sterr, 2009) suggested the neural simulation theory. This theory maintains that motor execution is only different from motor imagery due to the fact that motor execution actually carries out the action. Thus, an overt action involves the preparation of an action. If the action is not carried out, the same process occurs except the action is merely simulated and not performed. To investigate this theory further,

Kranczioch et al. (2009) studied event-related potential data. They had participants perform simple or complex finger movements in a priming task and compared motor imagery (covert preparation) and motor execution (overt action) using electroencephalographic recordings. Their results supported the idea that motor imagery and execution share common functional networks. A later study (Miller et al., 2010) replicated this finding by showing that the same neocortical areas involved in motor imagery were also involved in the planning and execution of motor movements. These results lend further credence to the notion that motor simulation and action involve similar cognitive components as has been found in research on the mirror neuron system (Kranczioch et al., 2009).

Extending the findings that motor imagery and motor execution share common neural networks, a meta-analysis was conducted on the associations between the psychological states and anatomical activation of action processing (Grezes & Decety, 2001). It was found that action execution, simulation, observation, and verbalization all showed an overlap in activation sites. However, scattered foci for these aspects showed that a strict overlap did not exist. A question that remained unanswered is how we are able to distinguish our own actions from actions we observe in others (Grezes & Decety, 2001).

Research on motor cognition had implications for my study; it laid the groundwork for how motor learning occurs and how observing oneself is a viable method for error detection and correction. The mechanisms that allow for motor imitation to occur are explained through the research on the mirror neuron system whereby motor skill acquisition is mediated by observation. This process is made possible by cognitive

representations whereby movements are observed and encoded by the brain and memory retrieval initiates the performance of an action (Hommel, 1996).

Developmental Levels

As humans develop from infants with reflexive actions into adults with the ability to perform highly complex tasks, a number of changes occur due to the interaction of maturation and experience. In part, younger children are not able to generate, excite, or plan the appropriate movement patterns. Part of the challenge is that children must learn to balance the complex interaction of inhibitory and excitatory actions (Todor & Lazarus, 1986).

As children develop, move within their environment, and manipulate objects, their capacity for motor learning greatly increases. It has been recognized that there are periods of enhanced and reduced trainability in athletes (Hirtz & Starosta, 2002). Coaches of highly technical sports know that children typically learn the most important skills before the onset of puberty. A sensitive period between the ages of 7 and 23 years of age has been identified in which athletes are more adept at acquiring coordination. With the onset of puberty comes a decreased ability to acquire motor skills. As growth spurts occur, a corresponding lack of coordination is often seen in adolescents. Although it may be easier to gain coordination prior to puberty, the capacity for motor learning is retained throughout development due to lifelong plasticity (Hirtz & Starosta, 2002).

As performers move from adolescence into adulthood, they develop the potential to become experts in a given field. According to a number of investigations by experts from a variety of fields, expertise is the result of intense practice for a minimum of 10 years (Ericsson, Krampe, & Tesch-Römer, 1993). This finding was also replicated in a

study of expertise development in volleyball (Da Matta, 2004). Not only is a large amount of practice necessary to develop expertise, but it must be *deliberate practice*. This practice is very intense and focused on the task, often involving individualized instruction tailored to the performer's needs (Magill, 2004). Researchers have also identified three distinct stages of sport participation that athletes pass through on the way to attaining expert performance: the sampling years (5-12), the specializing years (13-15), and the investment years (16+; Baker, Côté, & Abernethy, 2003).

In conclusion, humans proceed through various developmental levels in acquiring motor skills. Initially, young children struggle to plan and generate appropriate movement patterns. As maturation occurs, children become more adept at acquiring motor coordination. With the onset of puberty comes a decreased ability to acquire motor skills. After puberty, adolescents return to a high level of motor skill acquisition. At this point, adolescents begin to specialize and invest in activities in which they excel.

Research on developmental levels and expertise development had implications for my study because prior research suggested that motor learning with visual feedback was moderated by level of experience. Some researchers hypothesized that learning with visual feedback is more effective for beginners (Magill, 1994) while others indicated that some level of experience was necessary to gain the most from visual feedback (Green, 1970). I hypothesized that intermediate athletes, such as those individuals who participated in my investigation, were the most receptive to visual feedback because they had enough experience and training to know what the skill should look like and how to perform it but had not yet mastered the task.

Learning Styles

Learning styles are distinct approaches individual learners take when learning something new. An individual's learning style is composed of three main behaviors: cognitive, affective, and psychological (Keefe & Monk, 1986, as cited by De Bello, 1990). Perceptual modalities have been identified as visual, auditory, and kinesthetic (Barbe, Swassing, Milone, & Kampwirth, 1981). In the 1980s, the learning style perspective was widely accepted as an approach teachers could take to facilitate learning (Dunn, 1984). The theory behind this approach (also known as the Matching Hypothesis) maintained that the learner would be most proficient learning in their primary modality (Witkin, Moore, Goodenough, & Cox, 1977). Therefore, teachers should adapt their teaching style to meet the needs of their students.

More recently, numerous researchers have discounted the notion of learning styles (Curry, 1990; Pashler, McDaniel, Rohrer, & Bjork, 2008) based on a number of contentions: the conceptualization of learning styles is incoherent, the measurement of learning style inventories is inadequate, and certain tasks may be learned best by all people in the same way. I first review evidence supporting learning styles and then present problems identified in learning styles research.

Evidence supporting learning styles. The Qualifications and Curriculum Authority Guidance for High Quality Physical Education and School Sport (Rycroft, 2007) suggests that teachers should consider visual, auditory, and kinesthetic learning styles to ensure that students are not disadvantaged in the way that information is taught.

A meta-analysis of studies that assessed the effectiveness of the Dunn and Dunn's (1978) learning style model was conducted to determine the value of teaching students in

their preferred learning style in the academic classroom (Dunn, Griggs, Olson, Beasley, & Gorman, 1995). Forty-two studies between 1980 and 1990 were identified; however, six studies were dropped from analysis due to validity threats. The remaining 36 studies were meta-analyzed. Overall, a mean difference effect size (*d*) was .75. This result indicated that students whose learning styles were accommodated would be expected to achieve 75% of a standard deviation higher than students who were not matched for their learning style (Dunn et al., 1995).

Within the physical education literature, a number of papers have been written about how teachers can implement learning styles into their classrooms (Coker, 1996; Reed, Banks, & Carlisle, 2004). However, only a few empirical studies have evaluated the effectiveness of learning styles to teach motor skills. In one investigation, participants completed the Verbalizer-Visualizer Questionnaire (Kirby, Moore, & Schofield, 1988, as cited by Laguna, 2001). Based on learning style preferences, participants were randomly assigned to a model demonstration group, a verbal instructions group, or a combined model demonstration and verbal instruction group. Results showed that participants who were visual learners learned more in the model demonstration group while the verbal learners learned best in the verbal instruction group, supporting the Matching Hypothesis of learning styles (Laguna, 2001).

Using a case study design, other investigators reported that matching learning preferences to coaching methods helped a high school wrestling coach develop a winning team (Brunner & Hill, 1992). At the beginning of the wrestling season, athletes on the team completed the Learning Styles Inventory (Dunn, Dunn, & Price, 1989). During practices, the coach tailored instruction to each type of learner. The practice area was

redesigned so athletes could work in areas that would meet their visual, auditory, or kinesthetic preferences. Results of the study reported that the wrestling team had a strong performance and went undefeated throughout the season. Team members also reported high levels of confidence and self-esteem. Moreover, team members showed a positive attitude toward academics and fewer members became academically ineligible. It was concluded that adapting lessons from learning style research improved athletic skills, led to higher academic achievement, and enhanced self-esteem (Brunner & Hill, 1992).

Criticisms of the learning styles model. In opposition to evidence showing support for learning styles, a number of critics have outlined weaknesses in the evidence for learning styles. First, a wide discrepancy exists in the way learning styles are defined and conceptualized. These models include (a) visual, auditory, and kinesthetic elements (Barbe et al., 1981); (b) environmental, emotional, sociological, physical, and psychological features (Dunn & Dunn, 1978); and (c) concrete experience, reflective observation, abstract conceptualization, and active experimentation (Kolb, 1981). After comparing 11 of the major learning style models, De Bello (1990) noted that there were almost as many definitions of learning styles as there were theorists.

Second, the inventories that assess learning styles show inadequate reliability and validity. A major difficulty of learning style inventories involves poor psychometric properties. For a test to be predictive, it first must be reliable. Many tests used to assess learning styles have not demonstrated adequate reliability. According to Stahl (1999), the Carbo Reading Style Inventory, the Dunn and Dunn Learning Styles Inventories, and the Myers-Briggs Inventory have moderate reliabilities in the range of .60 to .70. A major problem arises if the student cannot be appropriately placed within their accurate learning

modality. Adding to the difficulty with low test reliability, learning style inventories have not been replicated by independent researchers (Rushby, 2007), indicating problems with validity as well. Further refutation of validity in learning style inventories arises due to the fact that few random-assignment experimental design studies have been conducted that support the Matching Hypothesis (Pashler et al., 2008). A case study of a wrestling coach showed that using learning styles can be effective in coaching (Brunner & Hill, 1992). However, these methods of examination have not been deemed worthy to clearly support the hypothesis for learning styles. A study by Ford and Chen (2001) is one of the few experimental designs that showed support for the Matching Hypothesis in graduate students learning to write HTML computer code in an online class.

A third weakness of the learning styles models is the difficulty in determining the best instructional strategies (Curry, 1990). Witkin and colleagues (1977) suggested that students and teachers should be matched according to cognitive style. Contrary to this view, some researchers have advocated for mismatching students as they become more proficient at learning the material (Snow & Lohman, 1984, as cited by Curry, 1990). It has also been argued that certain activities are learned best in a particular modality by all people. An example of this would be how learning a sport involves a kinesthetic orientation. Nearly everyone would agree that someone can learn more from playing tennis than from simply watching someone else play tennis. Another example is how everyone prefers a demonstration in a science class compared to an uninterrupted lecture (Stahl, 1999). As opposed to thinking that different methods are appropriate for different children, we should consider the idea that different methods might be appropriate to children at different developmental stages. For example, increasing young children’s

motivation to read might be accomplished by allowing them to choose what they read. At a later developmental stage, what they read might need to be assigned to increase word recognition and comprehension (Stahl, 1999).

In conclusion, although there is evidence supporting and refuting the use of learning styles, overwhelming evidence does not exist to support this instructional strategy. One of the complexities of learning styles research is that researchers discount learning styles and are unconvinced of its utility (Curry, 1990; Pashler et al., 2008); however, many teachers find it effective in practice (Davenport, 1997; Rushby, 2007). Rycroft (2007) depicts the positive experience using learning styles that many teachers experience: “I am convinced that this focus on providing high quality visual input in my physical education lessons has enhanced the quality of pupils’ learning” (p. v).

Perhaps the major take-home message from the literature on learning styles is that although students might have varying preferences for ways of learning, this does not mean they should be placed in a class that only focuses on their mode of learning. If anything, the instructor could use a variety of teaching styles to fit many types of learners. Moreover, the instructor could find the best method of teaching their specific content. Finally, it is worth considering that students might benefit from being challenged and make attempts to learn in new and diverse ways (Curry, 1990).

The debate over the use of learning styles as an educational approach had relevance to this study because the possibility existed that athletes had preferences for the ways they learned. Some athletes might prefer hearing verbal feedback; whereas, other athletes might prefer seeing visual feedback of their performances.

Contrary to this circumstance, the possibility also existed that all athletes learn better when verbal feedback is enhanced with a film depicting the skill concurrently. The findings of this study might help answer if volleyball players had preferences for the type of feedback they received when learning to spike. Generalizing from these findings, the possibility also existed that athletes in other sports might have preferences for learning with verbal or visually-enhanced feedback. Finally, these findings might help clarify if learning styles existed in motor learning and if matching these preferences to learning situations was an effective approach.

Preliminary Investigation

During the spring semester of 2010, I conducted a pilot study entitled "Learning to Jump-Serve in Volleyball Using Visual Feedback." The jump-serve is where an athlete throws the ball in the air and then jumps and hits the ball into the opponents' court as a way to initiate a rally. The primary goals of the study were to gain experience conducting an experiment measuring motor skill acquisition and to examine differences participants had while learning with different manipulations of visual feedback.

Rationale

Coaches seek ways of improving instruction and increasing the acquisition of skills. Studies are inconclusive in their findings about the utility of visual feedback in teaching motor skills. The study sought to compare coaching feedback, visual feedback, visual feedback with an expert model, and a treatment combining all three types of feedback. The skill of jump serving in volleyball was evaluated. Each session consisted of 40 total repetitions. Participants completed a pretest of 10 repetitions, learned through

one of the feedback conditions for 20 repetitions, and then completed a posttest of 10 repetitions. A within-subject design was used to assess skill acquisition of participants. Form and accuracy of participants' performances were measured to evaluate differences in learning based on type of instruction. It was hypothesized that Treatment 4 (combined feedback) would be the most effective, followed by Treatment 1 (coaching feedback), Treatment 3 (visual feedback from an expert model), and Treatment 2 (visual feedback). Treatments 2 and 3 were hypothesized to be less effective since verbal feedback was not provided as well.

Methods

Participants. A total of 8 adolescent girls between the ages of 11 and 13 participated in the study. Because of time conflicts and other unforeseen events, only three participants completed all four treatment conditions of the experiment. Participants were volleyball players with considerable experience playing volleyball for their age. All participants were female athletes involved in club volleyball. Club volleyball is a competitive level outside of the middle school and high school season where many athletes attempt to get recruited to play volleyball in college.

Procedure. Each athlete participated in four skill acquisition sessions where she learned the "jump serve" in volleyball. The order of these sessions was determined by a random number generator for each participant. The four sessions involved different instructional methods including coaching feedback, visual feedback, visual feedback with modeling, and a combination of all feedback treatments. Each session took approximately one hour. After the final session, the Survey of Learning to Jump Serve was administered. The survey took less than 15 minutes.

In the coaching feedback instructional method, the participant received verbal feedback from a coach after each repetition of the acquisition phase. In the visual feedback instructional method, the participant saw an instant replay of her serve. Participants' performances were shown to them on a laptop using Dartfish software (Version 4.0.7.0). An HP Compaq nx9420 laptop with Windows XP was used. In the visual feedback with modeling instructional method, participants had the opportunity to see a replay of their performance while simultaneously viewing an expert model performing the jump serve. A highly skilled college athlete was videotaped performing the skill to allow the participant to learn through this comparison. Finally, a combination of all techniques was implemented utilizing video feedback with modeling and coaching feedback. Each skill acquisition phase began with a pretest, at which time the participant performed the jump serve 10 times. Next, the participant completed 20 repetitions in the intervention phase. Finally, a posttest of 10 repetitions was completed.

Evaluation of serving accuracy. For each repetition, the researcher recorded how accurately the participant was at serving to the designated zone. If the participant hit the target zone, a score of three was recorded. If the serve was near the zone, the participant received a score of two. A serve in the court but away from the zone received a one and a missed serve received a zero. This method of evaluating serving accuracy was untested but was used because it more effectively assessed accuracy since degrees of accuracy were evaluated according to recommendations by Magill (2007). Figure 1 shows a graphical depiction of the measurement system used to assess the jump serve in this study.

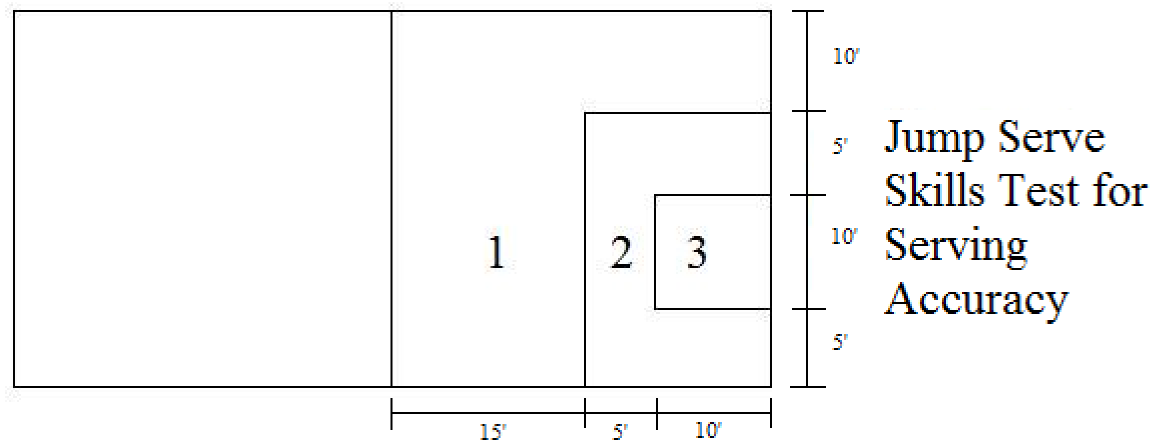

Figure 1. Jump serve skills test for serving accuracy.

Evaluation of technique. To evaluate the technique and form that each participant performed, all repetitions of serving were videotaped (Sony Digital Video Camera Recorder DCR-TRV340). Thirty-two components of the jump serve were evaluated by two veteran volleyball coaches based on the jump serve rating rubric. The rubric was developed for the preliminary investigation by Rhoads and Da Matta (Rhoads, 2010b). Three phases were identified in the rubric with seven categories and 32 components. The phases included the Preparation Phase, the Execution Phase, and the Follow-Through Phase. The categories included Stance, Toss, Approach, Take-off, Flight, Contact, and Follow-through. Stance is where the athlete is in an athletic stance, observing the opponents court and preparing to serve. Toss is where the athlete throws the ball in the air to initiate the serve. The approach involves the athletes' footwork and arm movement as they move toward the ball. The take-off is where the athlete jumps into the air. Flight is where the player is in the air, arches his or her back, and draws his or her arm back in preparation to hit the ball. Contact is where the athlete swings his or her arm and hits the ball. Follow-through is where the athlete swings through the ball

and lands on the ground after contacting the ball. The 32 components are contained within the categories. Each component was rated according to whether the performance was *sufficient* (1) or *insufficient* (0) according to the criteria listed.

Results

For the analysis of accuracy, a paired samples *t*-test for each individual participant was conducted to compare changes from pretest to posttest for each intervention. Treatment 1 (coaching feedback) for Participant 2 was significant, $t(9) = 2.21$, $p = .05$. Also, Treatment 3 (visual feedback with an expert model) for Participant 3 was significant, $t(9) = 4.13$, $p < .01$.

In this pilot study, the observed agreement for technique analysis was $r = 0.83$ with a Cohen's Kappa Statistic of 0.51. A univariate ANOVA was conducted for technique analysis. To analyze the scores for the athletes' technique, a few procedures were undertaken. First, the technique scores from both raters were averaged. Next, the difference score was calculated between pretest and posttest and analyzed according to treatment phase. The between-subjects effect for treatment was not significant, $F(3, 6) = 1.00$ $p = .45$.

To examine within-subject improvements in the technique utilized by the participants, I conducted a paired samples *t*-test and compared the pretest and posttest for each individual at each treatment. Treatment 2 (visual feedback) was significant for Participant 1, $t(31) = -4.38$, $p < .01$. Treatment 3 (visual feedback with an expert model) was also significant for Participant 1, $t(31) = 5.07$, $p < .01$. For Participant 2, Treatment 2 (visual feedback) was significant, $t(31) = 4.21$, $p < .01$. Treatment 3 (visual feedback with an expert model) was also significant for Participant 2, $t(31) = 2.23$, $p = .03$. For

Participant 3, only Treatment 3 (visual feedback with an expert model) was significant, $t(31) = 3.45$, $p < .01$.

Discussion

The pilot study was an examination into the effect of visual feedback on skill acquisition in jump-serving in volleyball. The major limitation of this study was the small sample size. Only three participants completed all treatments of the experiment; thus, the proper statistical procedures to answer the research questions could not be completed. However, useful information was gleaned from the available data and a number of useful procedural considerations were obtained from the process.

After comparing differences in the treatments for each subject, a noticeable trend was observed. Treatment 2 (visual feedback) and Treatment 3 (visual feedback with an expert model) showed significant improvement from pretest to posttest for Participants 1 and 2. Treatment 3 was also effective for Participant 3. Although not statistically significant, these results showed that visual feedback was effective at some level for the participants.

In conclusion, this pilot study was very beneficial in laying the groundwork for my dissertation. Numerous considerations and improvements from the pilot study were incorporated into my dissertation topic. After completing the pilot study, I became aware of the high rate of participant attrition. For my dissertation, I started with a larger sample to help alleviate this concern. Before beginning the study, I also notified participants that they needed to be able to attend all sessions in order to join the study. I also decided to change the volleyball skill to be examined. Rather than jump-serving, I decided to focus on spiking. A major source of error in jump-serving was the participant's toss, which

was highly unreliable. I theorized that using a setting machine would standardize this element of the experiment. In addition, I modified the jump-serve rating rubric for spiking. During the study, I also kept notes of the things I was coaching based on a coaching script. Finally, the form analysis was dropped because of its time-consuming nature. Instead, I focused on the outcome measures of height of contact (measured in Dartfish) and velocity of the ball after contact (measured with a radar gun).

Rationale for Research Questions

The preceding body of literature provided background information on my topic and presented previously reported findings on issues I address in this dissertation. Using prior research as a starting point, I attempted to demonstrate five things: (a) visually-enhanced feedback is more effective for motor learning; (b) athletes with at least basic levels of experience gain more from visually-enhanced feedback; (c) athletes with a visual learning style gain more from visually-enhanced feedback; (d) athletes have different thought processes when learning with verbal feedback versus verbally-enhanced feedback; and (e) higher improving learners have more advanced cognitions when learning.

The rationale for my first research question--“Is visually-enhanced feedback more effective than verbal feedback?”--was outlined in the literature review on traditional coaching techniques and coaching with visual feedback. This literature showed that coaches sought more effective ways of coaching and visual feedback appeared to be a promising avenue. However, the body of literature on visual feedback provided inconclusive evidence that visual feedback was more beneficial than verbal feedback. I believe visual feedback is superior based on the argument that visual presentation is more

proficient at specifying precise aspects of human movement (Martens, 1975) and the fact that a number of studies have shown visual feedback to be a valuable method of providing feedback (Mache, 2005; Menickelli, 2004; Zetou et al., 2009). Due to the potentially instructive qualities of visual feedback, I sought to show that visually-enhanced feedback would be more effective than verbal feedback in teaching motor skills.

My second research question asked, “Are athletes able to learn more from visually-enhanced feedback if they have more expertise?” Background information on developmental levels for motor skill acquisition was provided in the section on developmental levels. A few studies in the visual feedback literature indicated that level of experience played a role in an athlete’s ability to learn with visual feedback (Green, 1970; Magill; 1994). I hypothesized that athletes with more experience would gain more from visual feedback because they knew what the skill should look like.

My third research question asked, “Do athletes who have a visual learning preference learn better with visually-enhanced feedback?” The rationale for this question was addressed in the learning styles literature in the theoretical perspectives section of this dissertation. According to the learning styles perspective, athletes with a visual learning style should learn more under the visually-enhanced feedback condition.

The rationale for the fourth research question--“How do athletes’ cognitions differ when learning a complex motor skill with verbal versus visually-enhanced feedback?”--was outlined in the literature on visual feedback. Background information on motor cognition appeared in the theoretical perspectives section. I hypothesized that athletes would have more advanced cognitions when learning with visually-enhanced feedback.

My fifth research question asked, “How do thoughts about motor learning differ between relatively high improving and low improving learners?” Research on motor cognition indicated that more advanced learners showed greater improvement because they had more advanced cognitive representations. I expected to find that high improving learners in my study would demonstrate thoughts that were more conducive of learning.

CHAPTER III

METHODOLOGY

Both quantitative and qualitative research methods were employed to study volleyball players' ability to learn to spike in volleyball. A mixed-methods approach was taken to achieve complementarity of interpretation (Brannen, 2004). Different sets of data were collected to address different but complementary aspects of the investigation. Although there are numerous types of mixed-method designs (Greene, Benjamin, & Goodyear, 2001), I selected the triangulation design (Creswell, 2005) because quantitative and qualitative data are collected simultaneously and subsequently interpreted together with both forms of data being given equal priority. Each type of data collection offsets the weaknesses of the other form (Creswell, 2005). Whereas the quantitative study depicts a world of variables in a static state, the qualitative study describes people acting in events (Firestone, 1987, as cited by Merriam, 2009). In this study, the qualitative analysis of participants' thoughts helped inform differences in learning with verbal versus visually-enhanced feedback. In addition, I had a number of qualitative data sources that aided in triangulating the data. These included participants' think-aloud verbalizations, participants' interview responses, and my researcher's journal. All of these data sources allowed for unique perspectives of how athletes learned to spike and enhanced credibility when the findings overlapped.

Along with selecting a mixed-method analysis, a 2 x 2 randomized, experimental cross-over design (Kuehl, 2000) was used to collect more comprehensive data. A random number generator was used to randomly assign participants to the verbal feedback condition or the visually-enhanced feedback condition. A cross-over study administers a treatment to an experimental unit for a specific period of time after which another treatment is administered to the same unit. A 2 x 2 cross-over design has two treatments and two groups. In phase one, each group receives a different treatment. In phase two, the treatments are switched for the groups. The primary advantage of a cross-over design is the increased precision of treatment comparisons because both groups get the treatments and the order of treatments can be examined. A disadvantage of the cross-over design is the carry-over effect where benefits of the first treatment might carry over into the next treatment. This limitation can be addressed with a washout period where no treatments are allotted (Kuehl, 2000).

Participants

A total of 32 adolescent girls between the ages of 12 and 17 participated in the study. Of these, 26 completed all sessions. Participants were club volleyball players. Club volleyball is a more competitive level than middle school and high school volleyball. Club volleyball allows athletes to practice advanced skills and helps in their attempts to get recruited to play in college.

A sample size of 26 was deemed adequate for this study using a sample size calculator for a crossover design (Schoenfeld, 2010). According to the sample size calculator, a minimum of 19 participants was necessary to detect significance at a one-sided 0.05 significance level with power set at 90%. This was based on the assumption

that the within-subject standard deviation of the response variable was 1 and the true difference between treatments was 1 unit (Schoenfeld, 2010).

After receiving University of Northern Colorado Institutional Review Board approval (see Appendix C), I recruited participants via email. The consent form appears in Appendix D and the assent form appears in Appendix E. With permission from the club, parents of potential participants were sent an email describing the experiment. The email described the potential benefits and risks of the study. Briefly, parents were advised that participating players would receive coaching in two formats without cost. Players faced the risk of injury and fatigue; these risks were addressed by having participants warm up before each session and cool down and stretch after each session. In addition, participants were invited to take water breaks three times throughout each hour-long session, at which time they were asked how they were feeling and if they desired and felt capable to continue with the session.

The email participants' parents received had the consent form and assent form attached in case parents wanted more information about the study. The email explained that potential participants should be hitters who normally hit in a game. The email also emphasized the need for participants to attend all nine sessions. Finally, the email asked parents to contact the researcher if they were interested in having their child participate.

Procedure

Parents of participants interested in taking part in this study emailed the lead researcher. A date and time were arranged for the first testing session. The participant and parent or guardian of the participant met with the experimenter. The parent signed the consent form and the participant signed the assent form prior to participation. Any

questions or concerns were addressed at this time and subsequently throughout the experiment.

Participants completed a total of nine sessions during the experiment. Three testing sessions and six acquisition sessions took place. Participants completed the Learning to Hit Interview--Part 1 during the first session and completed Part 2 during the last session (see Appendix A). The interview was used to collect biographic information about the participants (age, level of experience, and learning preferences).

During the acquisition sessions, participants practiced spiking and received guidance from me as the coach. A randomized crossover design (Corr et al., 2004; Kuehl, 2000) was implemented; half of the participants completed one instructional style first while the other half of the participants completed the other instructional style. Then the instructional type was switched so both groups experienced the other type of instruction as well. Participants were randomly assigned to either the verbal treatment or the visually-enhanced treatment first. Participants spent three acquisition sessions learning to spike with each type of instruction (see Table 1). Three sessions were deemed adequate based on previous studies that used three or fewer sessions. These studies found a positive effect for visual feedback when studying cup tossing/catching (Dukelow, 1979), Frisbee throwing (Menickelli, 2004), a gymnastics side-horse routine (Olson, 1969), and dry-land skiing (Wright, 1979).

Table 1

Session Schedule

Session	Purpose	Type of Instruction
1	Testing Session 1 (Pretest of 10 Trials) Learning to Hit Interview Part 1	None
2	Acquisition Session 1	Feedback Type 1 45 Trials
3	Acquisition Session 2	Feedback Type 1 45 Trials
4	Acquisition Session 3	Feedback Type 1 45 Trials
5	Testing Session 2 (Pretest/Posttest of 10 Trials)	None
6	Acquisition Session 4	Feedback Type 2 45 Trials
7	Acquisition Session 5	Feedback Type 2 45 Trials
8	Acquisition Session 6	Feedback Type 2 45 Trials
9	Testing Session 3 (Posttest of 10 Trials) Learning to Hit Interview Part 2	None

In both the verbal feedback condition and the visually-enhanced feedback conditions, athletes received verbal feedback about their performance after every fifth repetition (trial). Different components of the skill were brought to the learner's attention by the coach based on the coach's observation of skills with which the learner was struggling. Examples of components of the skill the coach focused on included the athlete's speed of movement, body orientation, footwork, etc. Based on skill components

the athlete was struggling with, the athlete was instructed to make changes using verbal cues (Kountouris & Laois, 2007). Verbal cues from the coach are described in the Coaching Script for Hitting in Volleyball (see Appendix F). The coaching script was developed for this study to standardize verbal feedback provided to the athletes (Markland & Martinek, 1988). To examine the influence of verbal cues on learning, I kept a journal during the experiment where I tracked the types of cues I gave to each participant. In this way, I assessed differences in verbal feedback I provided during different treatments and was able to examine how the verbal cues I provided were aligned with skill changes the athlete needed to make.

In addition, during the acquisition sessions, the participants partook in a think-aloud procedure to examine their cognitions during learning. The think-aloud procedure has been used previously to examine cognitive processes in the physical education and sport setting (Rikard & Langley, 1995). The think-aloud procedure has also been used with participants learning to serve in volleyball (Ram & McCullagh, 2003). In Ram and McCullagh's (2003) study, participants were asked to "verbalize what you notice on the videotape and how the videotape makes you feel." These instructions were modified for the current study. Instead, participants were asked to "verbalize what you were thinking about during the previous five repetitions you just completed." This protocol was different in that participants did not view a replay of themselves concurrently while talking about their thoughts from learning. However, they would have just viewed a video of themselves if they were taking part in the visually-enhanced condition. At the end of the study, recorded verbalizations were transcribed and analyzed. Participants

were sent an email to review their verbalizations to ensure that the transcriptions were accurate and to attain clarification if necessary (Ram & McCullagh, 2003).

In the verbal and visually-enhanced feedback conditions, participants received verbal feedback as described previously. In the visually-enhanced condition, participants also received visual feedback. Participants' performances were shown to them immediately after every fifth repetition while also receiving verbal feedback from the coach. The visual feedback of the participant's previous spiking performance was shown to the participant on an HP Pavilion dv5000 laptop with Windows XP 2002 using the Dartfish program (Version 5.5.20909.0). Dartfish allows for video analysis and feedback. One of the functions of Dartfish used in the current study was the frame-by-frame view. During a replay, the video could be stopped and moved forward or backward frame-by-frame to show minute details. This feature was generally used to show the athlete's contact with the ball. Dartfish has a number of other tool capabilities that were not used in this experiment. Dartfish has been used by sporting associations around the world and has received many awards for its innovative technology. It was also shown to be effective for administering visual feedback in prior research (Mahdi, 2007).

In the first session, a pretest was conducted. While one participant was being tested, the other participants were occupied passing the ball back and forth with one another. This procedure was followed so that performance of participants was not affected by other participants observing the testing session. Participants completed 10 repetitions of spiking while they were being filmed; the speed of the ball produced by the players' hits was recorded with a radar gun. Radar gun recordings were obtained using

the Sports Radar Tracer SRA 3000 Radar Gun. According to procedures outlined by Palao and Valades (2009), the radar gun should be placed at a height of two to three meters from the ground and oriented in the direction where the volleyball player is contacting the ball. Video footage was filmed using a Canon 3CCD DM-GL2 digital camera. The video clip from each spiking repetition was analyzed using Dartfish software. Dartfish allows for measurements to be made based off of a reference measurement. The height of contact when the hitter contacted the ball was measured. This measurement was obtained to evaluate proficiency in timing the spike approach and to examine proficiency of jumping. To ensure an accurate and consistent set for the participants to learn how to spike, a setting machine was used. The Volleyball Tutor (Sports Tutor Manufacture--USA) was shown to deliver a precise set (coefficient of variation = 3.2%) in a prior study of spiking in volleyball (Kountouris & Laois, 2007). The coefficient of variation is defined as the ratio of the standard deviation of a number of measurements to the arithmetic mean (Hendricks & Robey, 1936). In addition, Molten Super Touch volleyballs used in NCAA Division I women's volleyball were used for this study along with a standard height, women's volleyball net (7' 4 1/8").

In the second session, participants completed the first acquisition session. The acquisition session timeline is presented in Table 2. Participants learned in small groups of two to six. Groups were arranged based on participants' availability. They completed a total of 45 repetitions of learning to spike. After every fifth attempt, the participant received verbal feedback about her performance. For every fifth attempt in the visually-enhanced feedback, the participant viewed a replay of her last five attempts on a laptop while also receiving verbal feedback from the coach. Visual feedback was presented

individually on a laptop computer so other participants could not see. This was done to reduce anxiety in individuals who may not have wanted other participants observing their performance. A break was allotted two times during each acquisition session (after 15 repetitions and after 30 repetitions). Participants were invited to drink water at this time; they were also free to take water breaks as needed any time during the study. During the break, participants were asked how they were doing. They were also asked how their body was feeling and if they desired to continue with the study or needed to stop. This was done to prevent injury to participants by checking to see if they were feeling too fatigued. It was also done to ensure they were not feeling overly anxious or psychologically unable to continue with the experiment.

Sessions three and four were also acquisition phases. As in the first acquisition session, participants completed 45 repetitions of learning to spike with the first instructional style. Again, they received a break after 15 repetitions and after 30 repetitions and were asked if they were able to continue with the experiment.

In session five, participants completed a second testing session. This session acted as a posttest for performance acquisition from the first instructional type. This session also functioned as a pretest prior to the second form of instruction. The testing session consisted of 10 repetitions of the participants spiking while being filmed and having the velocity of the ball recorded with a radar gun. This testing session also acted as a washout period as participants did not receive any feedback about their performance at this time.

Table 2

Acquisition Session Timeline

Minutes	Sessions		
0-5 minutes	Warm-up		
5-10 minutes	5 reps		
10-15 minutes	5 reps	Feedback	
15-20 minutes	5 reps		
20-25 minutes	Water Break		
25-30 minutes	5 reps		
30-35 minutes	5 reps	Feedback	Think/Aloud Verbalization
35-40 minutes	5 reps		
40-45 minutes	Water Break		
45-50 minutes	5 reps		
50-55 minutes	5 reps	Feedback	
55-60 minutes	5 reps		
60-65 minutes	Cool-Down		

After this testing session, participants began the sixth acquisition session. The same protocol was followed with participants conducting 45 spiking repetitions. However, participants received the other condition (verbal or visually-enhanced feedback) that they had not yet received. The seventh and eighth acquisition sessions also followed these same procedures.

The ninth and final session was a posttest. Participants completed 10 spiking repetitions while being filmed and had the velocity of the ball recorded with a radar gun. After the participants completed the posttest, the Learning to Hit Interview--Part 2 was conducted (see Appendix A). Participants were asked what instructional style they preferred (verbal versus visually-enhanced). In addition, participants were asked how their think-aloud responses differed between treatment types. At the end of this session,

participants were given the debriefing form (see Appendix G) and encouraged to ask any questions they had about the study. Each participant was sent her individual results of the study and a summary of results upon completion of the data analysis.

Throughout the study, I kept a journal to record my experiences as a researcher and to note important events. This journal was useful for me to note how the participants' learning was influenced by being in a group. Also, I documented any potential biases as a researcher by keeping this journal. Thus, the journal helped to address the notion of dependability in my qualitative analysis. I also recorded difficulties of the study and shortcomings in the journal.

Data Analysis

For the quantitative analysis of data, a repeated-measures ANOVA was conducted to evaluate differences in verbal feedback versus visually-enhanced feedback. The repeated measures included the three testing phases: pretest, mid-test, and posttest. The ANOVA procedure was run for the average of the top 5 out of 10 scores from radar gun measurements and for height of contact measurements. The top five scores were used instead of all 10 because many participants had values of zero for velocity from when the ball was hit into the net. Individuals were analyzed as a nested factor within groups. The independent variable was treatment type and the dependent variables were ball velocity and height of contact measurements. The independent variables were the treatment types and the dependent variables were radar gun and height of contact measurements. Differences in participants' ability to learn with either type of feedback based on level of experience were assessed using a covariate analysis. Assumptions of the repeated-

measures ANOVA were also tested. For the ANOVA and ANCOVA, an alpha level of $p = .05$ was set to assess significance.

For the qualitative analysis of participants' responses from the Learning to Hit Interview and from think-aloud verbalizations, a phenomenological approach was taken. A phenomenological study looks at lived experiences and meanings that participants describe about a phenomenon (Creswell, 2007). In this study, this perspective involved participants answering questions about their experiences learning with verbal feedback and visually-enhanced feedback. In addition, the lived experiences were examined based on participants' think-aloud verbalizations as they talked about their thoughts while learning. Themes that emerged from this process were compared to prior categories identified in the research using the think-aloud procedure (Menickelli, 2004; Ram & McCullagh, 2003).

To assess reliability of the participants' responses, a member-check took place. The participants were emailed their transcripts to confirm or clarify any statements they made during think-aloud verbalizations or in the interview. In addition, participants had the opportunity to read over preliminary analyses to assess if the researcher's interpretations were consistent with the participants' experiences (Merriam, 2009).

The responses of individuals were examined and common experiences were highlighted to describe the universal essence of "how" athletes learn to spike (Creswell, 2007, p. 58). Using the "significant statements" of participants' responses, the researcher analyzed the statements looking for themes and meaningful units. Significant statements depict how an individual experiences a phenomenon (Creswell, 2007). Each response from participants' think-aloud verbalizations was treated as a significant statement. Each

response to a question in the Learning to Hit Interview was viewed as a significant statement. From these significant statements, themes were identified.

Next, a peer examination took place where a second coder conducted a thematic analysis to triangulate the data. Inter-rater agreement of themes was assessed and a Cohen's Kappa of .70 was met to ensure reliability (Cohen, 1960). From these themes, a *textural description* of participants' experiences was written depicting the meaning that participants conveyed about their experiences. Textural descriptions describe "what" participants in a study experience with a phenomenon (Creswell, 2007, p. 159). Next, a description of the setting and context that influenced the participants' experiences was written in the *structural description*. Structural descriptions describe "how" participants experience a phenomenon (Creswell, 2007, p. 159). In this study, the structural description described how learning with different types of feedback influenced learning to spike. Finally, a composite description highlighting the essence of learning to spike was formulated (Creswell, 2007). In addition, content analyses of participants' think-aloud responses were undertaken to quantify the content of these verbalizations (Ahuvia, 2001). To help simplify all of the analyses of this investigation, a data analysis diagram is provided (see Figure 2).

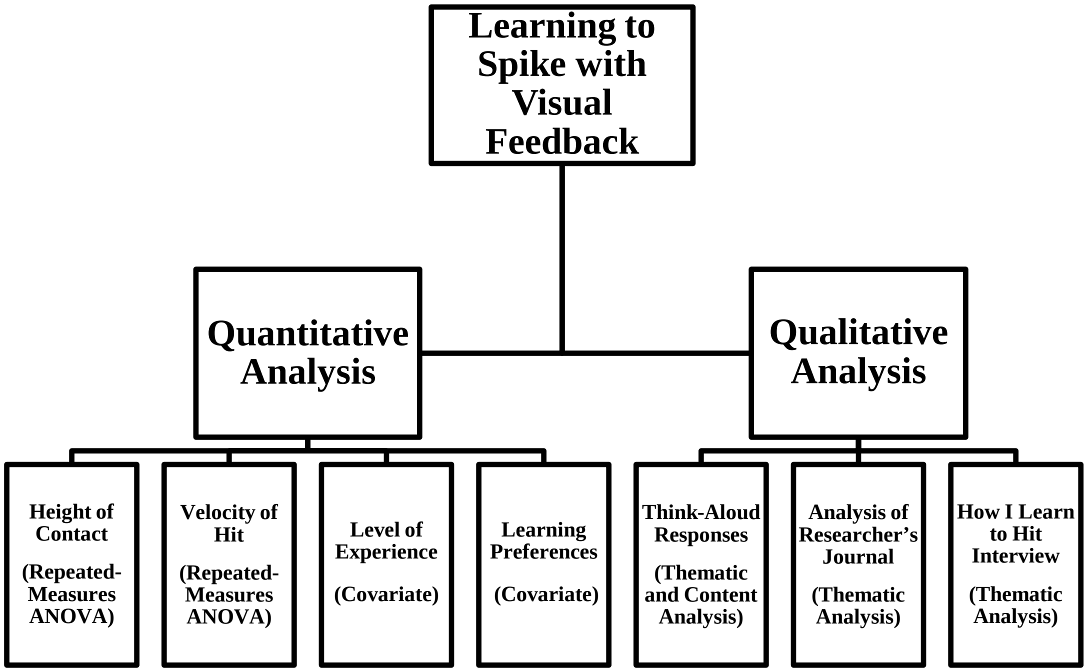

Figure 2. Data analysis diagram.

CHAPTER IV

RESULTS

The results section is divided into two main parts: quantitative results and qualitative results. Within the quantitative results, I first discuss the descriptive statistics of the study. In addition, the average scores for 12-17 year-old-girls are reported to provide normative data for coaches and practitioners. Next, tests of statistical assumptions are presented along with measurements pertaining to potential confounding variables and instrument reliability. Subsequently, findings from the repeated-measures ANOVA are provided on participants' velocity and height of contact when spiking. Contrasts are assessed between pretest measurements and test measurements after verbal and visual feedback. Finally, results from an ANCOVA controlling for volleyball experience and for learning preference are presented.

The qualitative analysis begins with an examination of common thoughts of participants expressed during their think-aloud responses and is followed by a description of emergent themes from these responses. In addition, the results of the qualitative analysis of the Learning to Hit Interview are presented. Subsequently, results from a content analysis of comments to athletes are provided followed by visual depictions of the five most commonly coached skills in the study. Finally, reflections on my experiences as the researcher are presented.

Quantitative Results

Descriptive Findings

The descriptive statistics were based on self-report responses from the Learning to Hit Interview. The mean age of participants was 14.12 years (*SD* = 1.28). The age range was 12-17. Participants reported a mean of 5 years of volleyball experience (*SD* = 2.13) and a mean of 2.73 years of club volleyball experience (*SD* = 1.61).

In response to the question "Do you learn best by hearing or seeing?," 3.8% of participants (1/26) reported learning best from verbal feedback; whereas 96.2% of participants (25/26) reported learning best by seeing. In response to the question "When playing volleyball do you learn best by hearing or seeing?," 15.4% of participants (4/26) recounted learning volleyball best by hearing and 84.6% of participants (22/26) indicated they learned volleyball best by seeing.

From the 10 trials that were recorded of velocity and height of contact across the testing sessions, the five highest scores were used in the analysis. This method was followed because numerous participants had velocity measures of zero when they spike the ball into the net. These scores of zero were removed so they would not adversely skew the results for each participant.

At the end of the study, the mean of participants' posttest scores for velocity was 31.20 mph (*SD* = 4.70). The mean height of contact of participants' posttest scores was 4.43' (*SD* = .36') from the bottom of the net. This height is equivalent to 14" above the net or 8'6" above the ground. From pretest to posttest, participants demonstrated an average improvement in velocity of 2.38 miles per hour. Moreover, from pretest to posttest, participants demonstrated an average improvement in height of contact of 1.58."

The means and standard deviations for the treatment sessions for velocity and height of contact are shown in Table 3.

Table 3

Descriptive Statistics of Treatment Sessions

	Pretest Velocity	Verbal FB Velocity	Visual FB Velocity	Pretest HOC	Verbal FB HOC	Visual FB HOC
Mean	28.82	31.42	31.56	4.30	4.46	4.40
SD	5.90	4.61	4.75	0.56	0.43	0.43

Note. Velocity is in miles per hour and Height of Contact (HOC) is in feet from the bottom of the net. FB refers to Feedback.

The mean scores for participants' treatment sessions for velocity are shown in Figure 3 with vertical lines representing standard deviations.

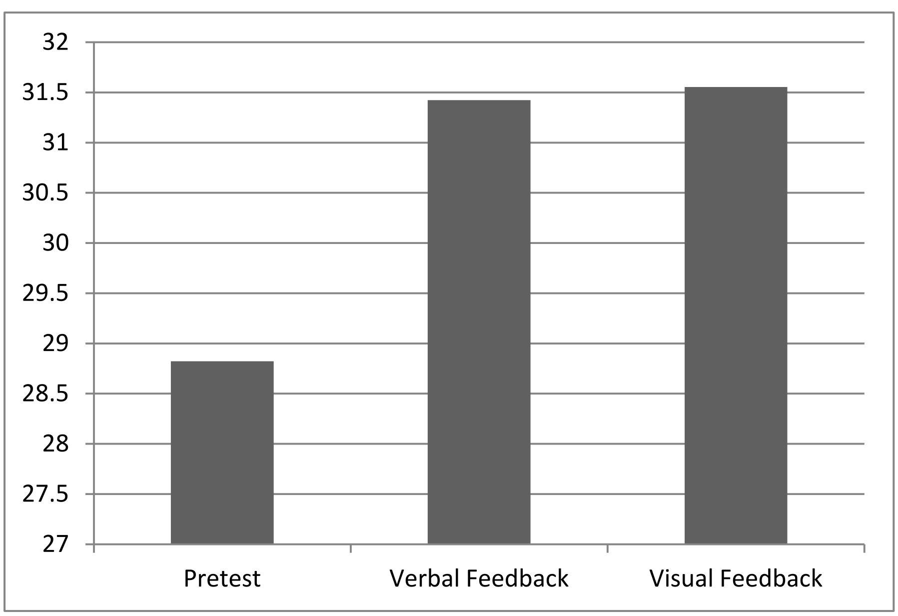

Figure 3. Average velocity (MPH) for treatment sessions.

The mean scores for participants' treatment sessions for height of contact are shown graphically in Figure 4 with vertical lines representing standard deviations.

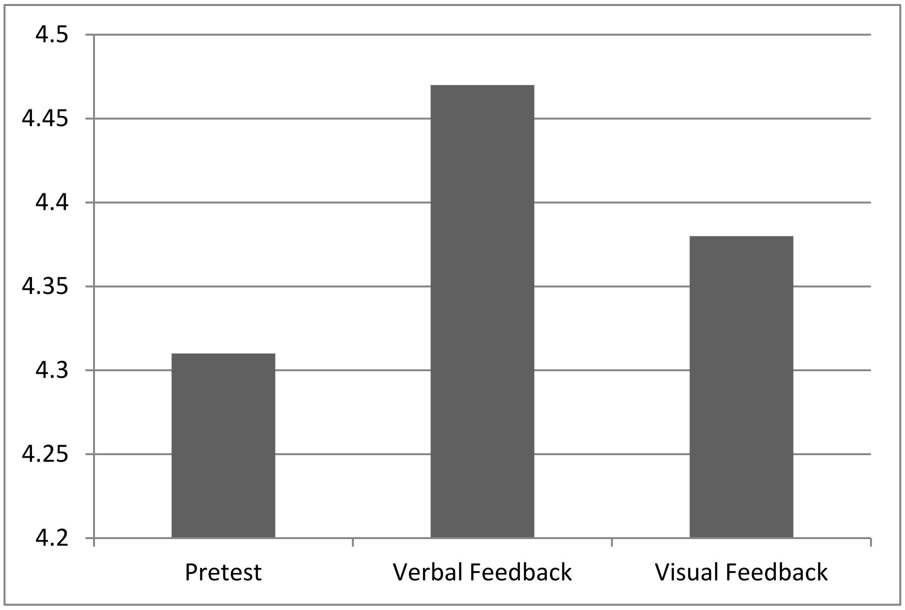

Figure 4. Average height of contact (feet) for treatment sessions.

A graphical depiction for the time series of the testing sessions for velocity and height of contact is depicted in Figures 5 and 6, respectively. These figures appear with vertical lines representing standard deviations.

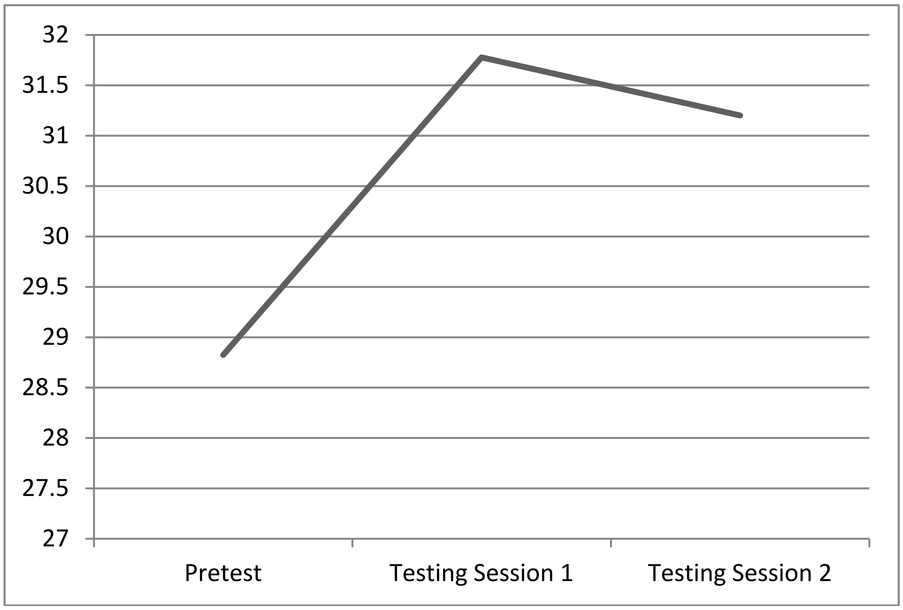

Figure 5. Average velocity (MPH) for treatment sessions over time with treatment scores combined.

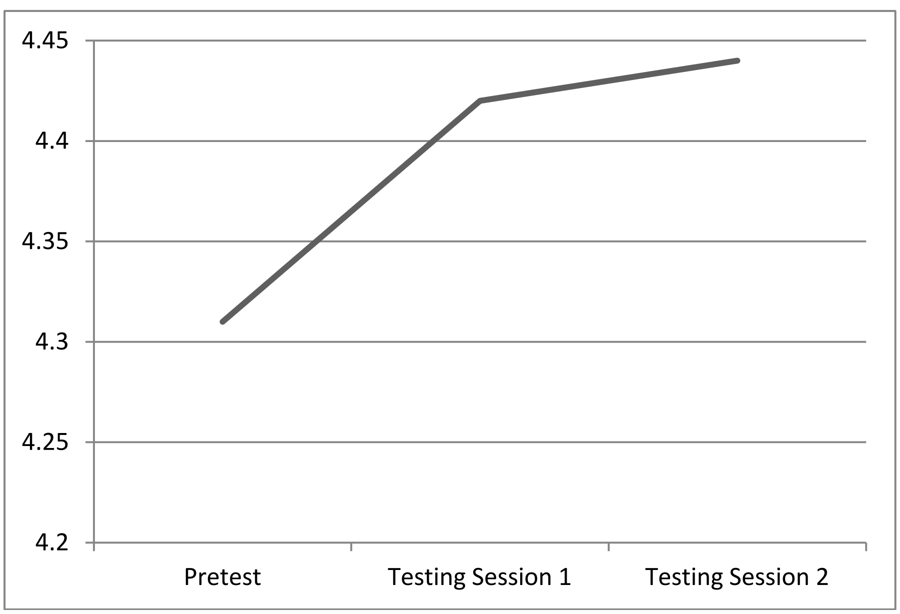

Figure 6. Average height of contact (feet) for treatment sessions over time with treatment scores combined.

The raw data for each participant and group for velocity and height of contact are contained in the Appendices for each treatment session. Specifically, the velocity scores for each participant are shown in Appendix H. The height of contact scores for each participant are shown in Appendix I. The velocity scores for each group appear in Appendix J and the height of contact scores for each group are presented in Appendix K.

Test of Assumptions for Repeated-Measures ANOVA

Independence. The first assumption that must be met before running ANOVA is that participants received the treatment independently of one another. While individuals in this study could not be viewed as being independent because they were given the treatment within groups, the assumption of independence was met for this analysis because individuals were nested within groups for the model to control for this. Thus, groups were independent of one another. Individuals stayed within their respective group for the duration of the study and all coaching interventions were delivered by me. Also, I assigned the order of treatments to each group using a random number generator. By nesting individuals within groups, a certain kind of dependence was assumed that did not violate the assumption of overall independence and allowed for a statistical calculation of individuals by changing the degrees of freedom.

Normality. To test for the assumption of normality, the Shapiro-Wilk test was used. This test concludes the data are normally distributed if non-significance is found at alpha = .05. The pretest data for participants were shown to be normally distributed, $p = .41$. The visually-enhanced feedback data were also normally distributed, $p = .35$. However, the verbal feedback testing session data were not normally distributed, $p < .01$. Although it was concerning that the verbal feedback data were not normally distributed,

ANOVA is robust to violations of normality if the assumption of homogeneity of variance is met using Levene's *F*-Test (Gastwirth, Gel, & Miao, 2009).

Homogeneity of variance. Another important assumption to be met to compute an ANOVA was to check for equal variances of the groups. Using Levene's test of equality of error variances, non-significance should be found at alpha = .05 to show equal variances. The data for this study met the assumption for homogeneity of variance, $F(2, 75) = .95$, $p = .39$.

Comparison of Treatments (Verbal Feedback vs. Visually-Enhanced Feedback)

A repeated-measures ANOVA was conducted to compare differences in the two treatment types (verbal feedback vs. visually-enhanced feedback) with individuals nested within groups. The treatment type was used as the independent variable and the participants' scores on velocity and height of contact measures were used as dependent variables. Separate ANOVAs were computed for velocity and height of contact measures. The level of significance was set at $p = .05$. In addition, it was found that the two outcome variables--velocity and height of contact--were strongly correlated, $r(78) = .79$, $p < .01$.

In the analysis of velocity measures, there was a significant main effect for treatment, $F(2, 36) = 4.16$, $p = .02$. After performing a simple contrast, significance was found between the pretest and Treatments 1 and 2, $p < .01$. An effect size of $d = .48$ was found when comparing pretest to verbal feedback (Treatment 1) velocity scores. An effect size of $d = .50$ was found when comparing pretest to visually-enhanced feedback (Treatment 2) velocity scores. However, a significant contrast was not found between

Treatments 1 and 2, $p = .51$. This non-significant difference corresponds to an effect size of $d = .05$.

In the analysis of height of contact (HOC) measures, there was a significant main effect for treatment, $F(2, 36) = 3.24$, $p = .05$. A significant contrast result was found between the pretest and Treatments 1 and 2, $p < .01$. An effect size of $d = .33$ was found when comparing pretest to verbal feedback (Treatment 1) HOC scores. An effect size of $d = .15$ was found when comparing pretest to visually-enhanced feedback (Treatment 2) HOC scores. However, a significant contrast was not found between Treatments 1 and 2, $p = .50$. This corresponds to an effect size of $d = -.15$.

The effect of treatment order was examined using a simple contrast in ANOVA comparing Session 1 with both types of treatments combined and Session 2 with both types of treatments combined. For velocity measures, there was a non-significant contrast between Session 1 and Session 2, $p = 51$. For HOC measures, there was a non-significant contrast between Session 1 and Session 2, $p = .50$. The results for both velocity and HOC show non-significance for an order effect.

The effect of athletes participating in a group was assessed as a between-subject factor in the velocity and height of contact repeated-measures ANOVA. For the velocity measure, there was a significant between-subject effect for group, $F(7, 18) = 11$, $p < .01$. For the height of contact measure, there was a significant between-subject effect for group, $F(7, 18) = 11$, $p < .01$. Group was part of the repeated-measures ANOVA model with participants as a nested factor to allow for an assessment of each participant's scores while still taking into consideration the effect of the group. However, because the effect of group was found to be significant, this factor could not be ruled out as an extraneous

variable. My assumption that groups would influence one another at an equal level was incorrect.

Analysis of Covariance for Level of Experience

In addition to the Analysis of Variance (ANOVA) that was conducted to compare differences in treatments, an Analysis of Covariance (ANCOVA) was also conducted to see if differences in velocity and height of contact might also vary by level of experience. The level of experience was based on participants' responses to the interview question "How many years have you played club volleyball?" To conduct the ANCOVA, the participants' average level of club experience was determined. The mean number of years of club experience for participants was 2.73. Based on this value, each participant's score was converted to a Z score with the average being zero. Thus, higher scores equal more experience and negative scores equal less experience than average. A Z score was also calculated for velocity and height of contact, where the pretest score for each participant was subtracted from the posttest score. Finally, to determine the ANCOVA for level of experience, the interaction between club experience and change in treatment score was calculated. Based on the velocity treatment scores, level of experience was not significant, $F(1, 22) = .12$, $p = .73$. Based on the height of contact treatment scores, level of experience was not significant, $F(1, 22) = .08$, $p = .77$.

Analysis of Covariance for Learning Preference

Originally, an ANCOVA was planned to be performed for the learning preference of the athlete. However, this analysis could not be performed due to lack of variance.

Nearly all participants stated a preference for learning volleyball with visual feedback (22/26). Only one individual reported a preference for learning with verbal feedback.

Examination of Extraneous Variables

One possible extraneous variable was the unreliability of the setting machine. Based on a sample of 50 posttest trials, a coefficient of variation = 8.1% was found for the setting machine (coefficient of variation equals the ratio of standard deviation to mean). This showed that the setting machine delivered an imprecise set that varied to a considerable degree from one trial to the next. This result differed greatly from prior research, which reported a sufficiently precise set with a coefficient of variation = 3.2% (Kountouris & Laois, 2007). An explanation for the imprecision of the setting machine appears in the discussion section.

Bias in treatment administration was another extraneous variable that was analyzed. To assess possible bias in the amount of verbal feedback from the coach between the two treatments, I kept a journal to track comments to athletes. Based on this journal, it was found that a similar number of comments were made for both treatments (verbal feedback = 623 comments, visually-enhanced feedback = 639 comments). For these two treatments, a coefficient of variation = 1.79% was found. Bias in treatment administration was also addressed by having two observers watch an acquisition session for each type of treatment. The observers rated the coaching and provided feedback. The observers were asked to rate three areas on a scale from 1-5 (low to high) including level of enthusiasm, amount of verbal feedback, and quality of feedback. The first observer had the following ratings: for level of enthusiasm, verbal feedback was rated 4 and visually-enhanced feedback was rated a 5; for amount of feedback, both treatments were

rated 4; and for quality of feedback, both treatments were rated a 5. The second observer had the following ratings: for level of enthusiasm, both treatment types were rated a 4; for amount of feedback, both treatments were rated a 5; and for quality of feedback, both treatments were rated a 5. Both observers were also asked to comment on the coach's behaviors during the lesson and any differences that might exist between the verbal feedback and visually-enhanced feedback lessons. The first observer made the following comments: "Encourage girls to ask questions? Consistency of amount of feedback was good. Of Drill was consistent and good. Water breaks are good."

The second observer made the following comments:

> Gave positive feedback first, then pointed out something that could be improved. Matter-of-fact tone of voice, not overly enthusiastic nor punitive voice. Spent equal time with each player. Appeared fair to all. Coach might ask if they have any questions. Gave only two things to work on. Kept it short, not too much information.

Based on these observations, it appeared as if treatment administration was fairly standardized.

Qualitative Results

Common Thoughts from Think-Aloud Responses

The analysis of participants' think-aloud responses began with word-art. The raw data from participants' responses were entered into the program Tagxedo (Hardy, 2011). The program creates a word-cloud using an algorithm that removes commonly used words like "the" and presents the most commonly used words in larger font sizes. Tagxedo also offers the capability to organize the word-cloud into a shape; thus, a volleyball was chosen for this study. The word-art is depicted in Figure 7.

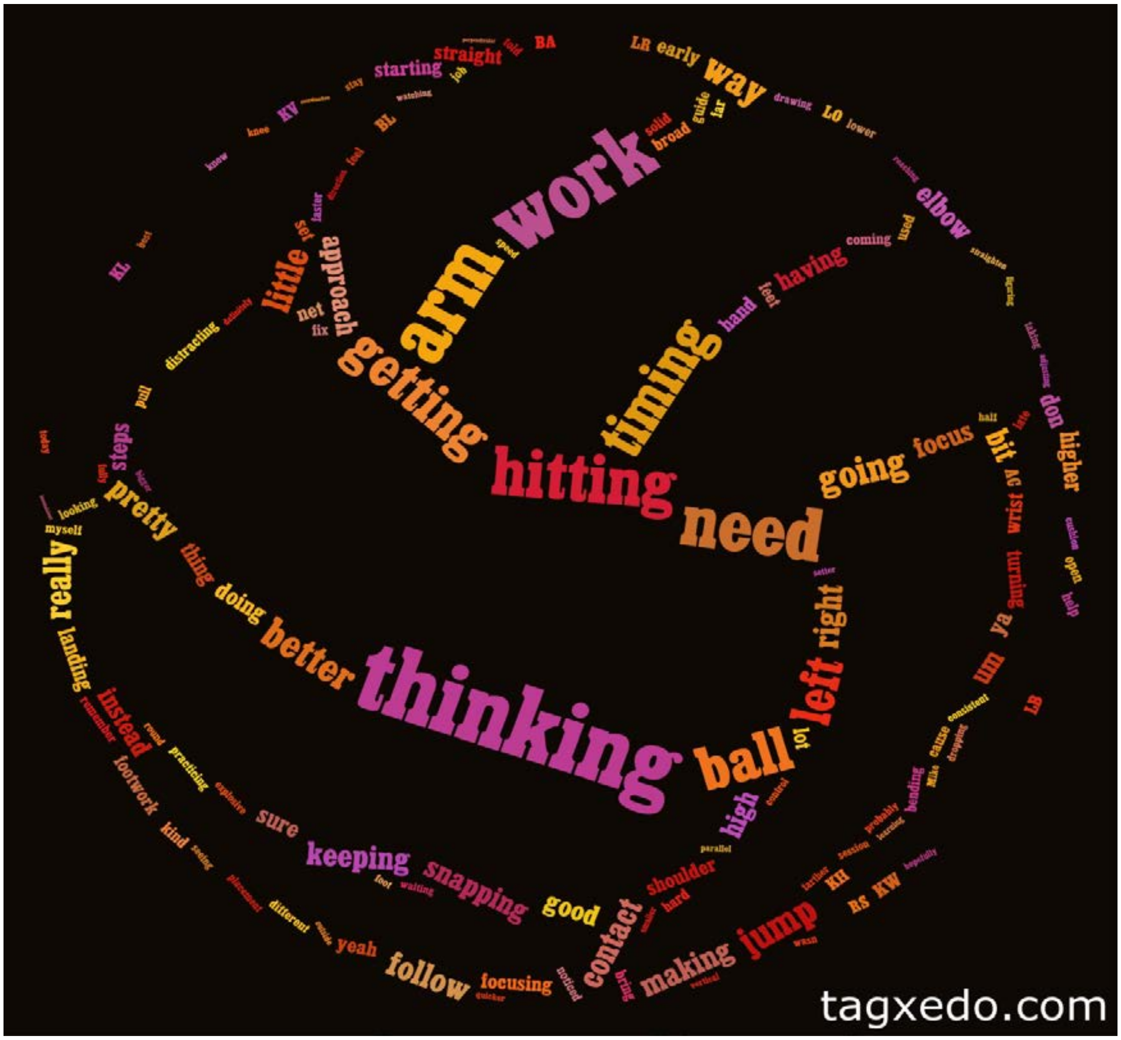

Figure 7. Word-art of participants' think-aloud responses.

This visual depiction of a volleyball using the participants' words shows some of the major elements and ideas participants were working with while learning. It was perhaps not surprising that the word "thinking" was the largest word because participants answered the question "What were you thinking about while you were learning in the last five repetitions?" You can also see some of the other major elements participants were considering while learning including hitting, timing, and needs work. Also relevant were

objects and movements that were mentioned such as arm, ball, swing, left, timing, and snapping.

Emergent Themes from Think-Aloud Responses

After analyzing the data at this preliminary level, participants' think-aloud responses were open and axially coded (Creswell, 2007). First, open coding took place whereby each think-aloud comment was analyzed independently by two coders and emergent themes were identified. Next, the two coders discussed the separate themes each person had suggested and final themes were agreed upon. After this step, axial coding took place whereby connections between themes were examined. Next, each meaning unit within the data was categorized by each coder separately and then comparisons were made. Disagreements were discussed by the two coders and the themes were reanalyzed, resulting in a final analysis with 99% agreement and Cohen's (1960) Kappa = .98. Six major themes emerged: cognitive processes, knowledge, environmental effects, self-efficacy, emotions, and visual appearance. Each theme is presented below with participants' responses that demonstrate the theme.

Cognitive processes. Based on participants' think-aloud responses, it became apparent that many athletes experienced similar thought processes. In particular, it seemed evident that as participants reflected on their learning, memory and visual metaphoric cues were involved in the process.

Memory. The following quotes show instances when athletes were involved in recalling events:

> I might have to go back to an exercise that [Coach A] taught me at 12's. (Participant JP)

> I am just thinking that I have to remember to pull my elbow all the way back, follow through, and make sure I stay behind the ball. (Participant MG)

Visual metaphoric cues. In a few instances, participants recited visual metaphoric cues they had heard from the coach or from prior coaches. These phrases reminded the player to focus on the visual image they were attempting to perform or images they should avoid.

> I just have to get my right arm into more of a bow-and-arrow (Participant KH)

> I kind of have a Barbie doll hand. (Participant BA)

> I am thinking about climbing on the ball. (Participant JP)

Knowledge. Along with cognitive processes, participants also engaged in knowledge acquisition. Participants described not only recognizing their own improvement but also recognizing how to improve at a skill and why a certain technique was used. Quotes depicting these elements are shown below under improvement recognition, improvement process, and improvement purpose.

Improvement recognition.

> I was working on my arms and I was working on fully following through and I think it went well. (Participant CR)

> I was just thinking about how just by doing the things that Mike already told me to do that I have gotten better already. (Participant MG)

Improvement process.

> I'm thinking about how to get lower and take bigger steps so I have more power going up and yeah that's about it. (Participant JP)

> I just need to work on my timing so I can hit it not on the way down so I have like my elbow up and I can really hit it at the top of my jump. (Participant BL)

> I am going to work on my wrist snap and drawing my arms back farther to get higher in the air. (Participant MD)

Improvement purpose.

> I am landing with two feet now so it's a lot better and easier on my left knee. (Participant KL)

> I think I just need to work on… keeping my hand big so I have more control. (Participant BL)

Environmental Effects. Another factor that was important in the athletes' learning was the environment around them. For the most part, the athletes described how aspects of the environment were distracting to them or how they needed to adjust to the environment.

Distraction.

> My head hurts a little bit so that was a little bit of a distraction. (Participant LB)

> My timing is off. I don't know if it's with the heat or whatever 'cause I don't do well in heat. (Participant KH)

Adjusting to the environment.

> When I was hitting I was thinking about how the placement of the set kept changing—it was like either really in the middle of the court or almost more toward the outside and I was having a really hard time adjusting to that every time and then I was having a little bit of pain in my shoulder and that was very distracting. (Participant LB)

Self-efficacy. An important element in an athlete's learning was having high self-efficacy. Participant's success at learning to hit is represented in quotes under the theme of confidence. Participants' difficulty in learning to hit is shown in quotes under lack of confidence.

Confidence.

I think I am doing pretty good. (Participant KH)

I have gotten better already. (Participant MG)

I think I did like really good and consistent. (Participant LR)

I just killed a ball. (Participant RH)

I am thinking about how that was like the best round I have ever had of hitting. My elbow was high and I used my left hand and I feel really good about it. (Participant AC)

Lack of confidence.

I feel like I am not focusing and just an off day. (Participant BP)

I think my rounds will improve because that one wasn't the best. (Participant BL)

I'm thinking about that this is probably one of my worst sessions, yet oh my gosh. Yeah it's just not pretty I don't know what it, it's just all bad. (Participant JP)

Emotions. Participants also expressed happiness and frustration while learning.

Happiness.

I think I did like really good. (Participant LR)

That was like the best round I have ever had of hitting. (Participant AC)

Frustration.

I feel like I am not focusing and just an off day. (Participant BP)

Visual appearance. Another major element for participants was having an awareness of their appearance. This was observed as participants gained familiarity with seeing themselves on camera and in reflecting on how they looked on camera.

Getting used to seeing oneself on camera.

> I am thinking about getting my left arm up mainly and how weird it is to see yourself on video, and yeah. (Participant JP)

Reflection about how one looks.

> Seeing myself, some of them look really good and then some of them don't. (Participant KL)

> I just hit 5 balls. Um my cushioning, I am starting to land on two feet a lot more and it's looking good but I still need to put my arms all the way back to get up as high as I can. (Participant KL)

Qualitative Analysis of the How I Learn to Hit Interview

To expand on the quantitative analysis comparing verbal feedback to visually-enhanced feedback, a qualitative analysis was conducted. The interview allowed for a more in-depth understanding of athlete's preferences for types of feedback, an examination of participants' think-aloud responses, an examination of bias in treatment administration, and an analysis of the effect of learning in a group. A thematic analysis was conducted by the researcher and a colleague to help ensure trustworthiness through peer examination. Final thematic coding produced 99% inter-rater agreement and a Cohen's (1960) Kappa of .98.

Preferences for types of feedback. At the beginning and ending of the study, participants were asked whether they preferred learning through auditory or visual means. In addition, at the end of the study, participants were asked whether they preferred the verbal feedback or the visually-enhanced feedback. In response to the question "When playing volleyball do you learn best by hearing or seeing?," the majority of participants (81%) preferred learning volleyball through visual means. Moreover, most participants preferred visually-enhanced feedback (92%). Many responses from participants echoed

the notion that visually-enhanced feedback was easier, better, or helped clarify the learning process.

> I preferred the verbal with the visual because it was good to hear it but then when I saw myself like I saw actually what I was doing and I'd never seen myself before that way. I could like actually see—oh, I am actually doing that so I should change it. (Participant BL)

> I liked the verbal and visual 'cause then I can see what I need to work on. (Participant MD)

> I think seeing myself actually helped a lot with like figuring out what to do. I think that was a lot more helpful than just being told. So yeah. (Participant KH)

Further evidence that participants preferred visual feedback over verbal feedback was the fact that three participants were unable to think of examples when they learned volleyball best when hearing; whereas, all participants thought of examples when they learned best by seeing.

Thoughts about think-aloud procedure. After participants completed the testing sessions, they were asked what they thought about the think-aloud procedure. The think-aloud procedure was implemented so participants said what they were thinking about after receiving feedback during the acquisition sessions. In response to the questions "What did you think about the think-aloud procedure?" and "Did you learn anything from talking about your thoughts while learning to hit?," three main themes emerged: memory rehearsal, improvement recognition, and awkward process.

Memory rehearsal. The most common element that participants described was that talking about their thoughts was helpful and specifically encouraged them to remember what they should be working on. Examples of when participants' responses exhibited memory rehearsal included

> Well I think it was helpful. You got to listen to yourself say something. You don't just forget about it. (Participant AE)

> Yeah, that was good for me because when I like hear a correction then I usually just like repeat it so I can remember, so that was helpful. (Participant BL)

> Um, it kind of helped you think a little bit more, like focus on what you need to do and like narrow it down into some key points. (Participant EN)

> Um, just like remembering what I need to think about recalling what I am thinking about when I am hitting. (Participant RT)

Improvement recognition. Another theme many participants discussed was recognizing improvement as they talked about and reflected on their learning. The following are comments from participants demonstrating recognition of improvement:

> I definitely improved my hitting. (Participant AC)

> Yeah, I learned like what I was thinking like that I didn't even know that I was thinking. Just kind of like know what you need to work on . It like helped. (Participant LR)

Awkward process. The final aspect participants commented on was that the think-aloud process was awkward. A few people stated that standing alone and talking into a microphone was a little strange. The following are comments along those lines:

> I thought it was awkward. (Participant BP)

> It was kinda awkward in a way, but like I felt like I said the same thing a lot. (Participant KL)

Bias in treatment administration. Another goal from interviewing the participants was to assess their perceptions of bias in the treatment administration. Participants were asked whether they thought they had received the same amount and quality of verbal feedback from the coach in both the verbal feedback treatment and the visually-enhanced feedback treatment. Based on the question "Did you experience differences in how you were coached when learning with verbal feedback compared to

verbal and visual feedback?," four participants experienced bias in treatment administration; whereas, nine participants said there was no bias and that the verbal feedback was equivalent in both treatments. Many participants did not understand the question; it was not possible to decipher if they had or had not experienced bias in the treatment administration.

Bias. Participants who experienced bias on the side of visually-enhanced feedback had the following comments:

You had more things to say. (Participant BA)

I thought the description was easier to understand. (Participant TD)

No bias. Participants who did not experience bias in the treatment administration had the following comments:

They were pretty much the same. (Participant EN)

It was basically the same. (Participant JP)

It was the same. (Participant RS)

You said the same stuff. (Participant AC)

Group effect. The interview was also useful in gaining an understanding of the participants' experiences when learning in a group. It was demonstrated in the quantitative results that there were significant differences between groups. However, the reasons for these differences were unclear. The qualitative perspective allowed for an exploratory analysis of these factors. In response to the question "Did you feel that your learning was influenced by being in a group? If so, how did the group influence your learning?," five major elements emerged showing how groups could influence learning: support, fun, seeing others, social comparison, and distraction.

Support. Participants described how learning in a group offered a source of support . The following are examples of comments from participants:

> Like you gotta make friends and you are comfortable hitting around them. If you made a mistake it wasn't a big deal. (Participant LO)
>
> When you have a group and they are actually like cheering you on and stuff then I think that helps more. (Participant KH)

Fun. Another factor that participants described when learning in a group was having fun. For instance, participants stated:

> It was fun that way and then you get to see other people progress and it makes you want to progress. (Participant JP)
>
> It's just fun to be in a group. (Participant LR)
>
> It was more fun. (Participant TD)

Seeing others. The major element most participants described as a benefit of learning in a group was getting to see others. Watching and observing others appeared to be a major benefit as described by a number of participants:

> You can watch them. (Participant AC)
>
> You can just learn from them visually. (Participant AE)
>
> I would be able to see other people who were doing really well and the stuff that they were doing, too. (Participant RS)

Social comparison. In addition to being able to see others, many participants described how learning in a group led to social comparison. Participants described how they were motivated to improve so their next round would be as good or better than other people in their group:

> When I see other people then I can learn from them and try to do what they are doing so it's like a demo. (Participant BL)

> I got to see how they did like in terms of what I did so I got to see what I was doing wrong. (Participant CR)

> Yeah, cause when I could see other people hit I would try to, if they got a good hit I would try to improve that on my next hit. (Participant KW)

Distraction. The only negative influence of learning in a group that participants described was that group members could be distracting. Participants stated that having other people around could lead to side conversations or a lack of focus:

> Sometimes you got off topic. (Participant LO)

> Like the only thing was maybe like I wasn't able to concentrate like as well. (Participant CR)
> Well maybe sometimes it's hard to concentrate." (Participant TD)

Content Analysis of Think-Aloud Responses Comparing Treatments

To assess differences in participants' think-aloud responses between the verbal feedback sessions and visually-enhanced feedback sessions, a content analysis was conducted. After coding was completed by both raters and final agreements between themes arose (99% observed agreement), a count was taken for each theme. A graphical depiction of the differences between observed themes appears in Figure 8.

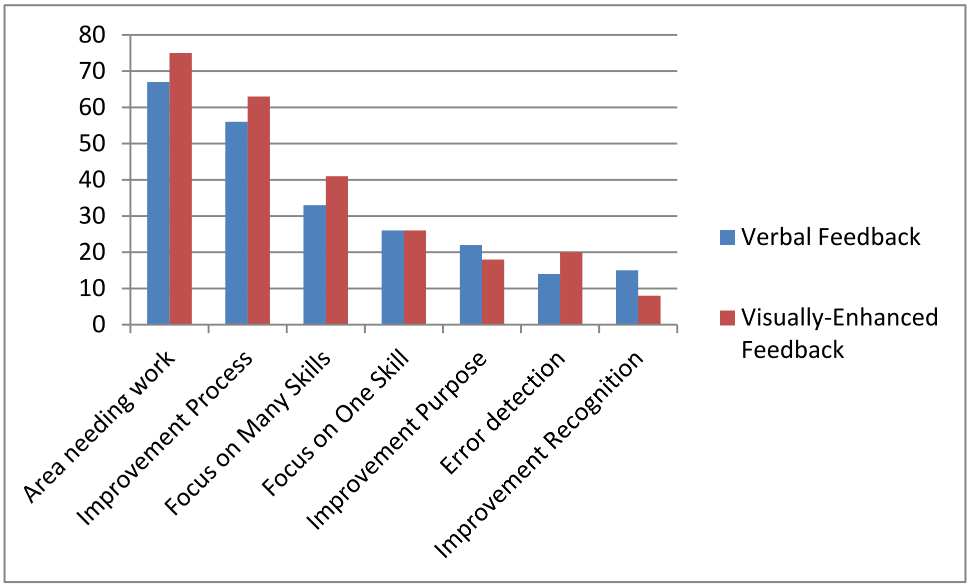

Figure 8. Comparison of responses based on treatment type.

The most commonly observed theme from participants' responses during the think-aloud procedure was "area needing work." This theme was coded by the raters any time a participant stated that they needed to work on a skill or needed to improve in some area of spiking. For the most part, participants would repeat what I as the coach had just told them to work on. Therefore, it might be expected for this theme to appear most often. Interestingly, participants talked more about areas they needed to improve on under the visually-enhanced feedback condition. One might infer that this condition provided more information or outlined more things for the athlete to work on than did the verbal feedback condition.

The second most commonly observed theme in participants' responses was "improvement process." This is where participants verbalized learning how to improve at a skill. Participants described improvement process more often under the visually-

enhanced feedback type. Thus, visual feedback might be more beneficial at showing participants how to improve a skill.

The third theme involved participants focusing on many skills. A greater number of participants made comments along those lines during the visually-enhanced feedback. This might demonstrate that visual feedback could offer more attributes to focus on than verbal feedback. However, participants were possibly overwhelmed by focusing on more than one skill. This theme might also explain why visually-enhanced feedback was not more beneficial than verbal feedback.

The fourth theme was “focus on one skill.” Participants displayed an equal occurrence of thinking about one skill while learning under both instructional styles.

The fifth theme was “improvement purpose.” In some cases, participants talked about having an understanding of why a movement was being performed. This theme was similar to “improvement process” where participants had an understanding of how to improve. However, this theme was viewed as more advanced since the athlete not only understood how to improve but also why the movement was more effective. More participants’ responses were categorized as “improvement purpose” under the verbal feedback condition. Perhaps focusing solely on the words the coach was using aided athletes in understanding why a movement was utilized.

The sixth theme was “error detection.” This was where participants described having knowledge that they were performing the movement incorrectly. This theme was identified more often under visually-enhanced feedback. Presumably, the ability for the learner to observe him- or herself aided in detecting errors in movement.

For the seventh theme of "improvement recognition," there were more responses from participants under the verbal feedback condition. Thus, it appeared that participants recognized their own improvement more often under verbal feedback.

Content Analysis of Think-Aloud Responses Comparing Learners

In addition to comparing participants' responses based on type of treatment, a comparison was also made when looking at the amount of learning each participant experienced. A total difference score was calculated for each participant showing the total amount of improvement they experienced. Then participants were split up based on how much they improved. Participants were categorized into two groups: the top half (high improvement) and the bottom half (low improvement). Based on this grouping, a comparison was made between participants' responses. Major differences that emerged are presented in Figure 9.

Figure 9. Comparison of responses based on level of learners' improvement.

Based on the level of improvement learners experienced, four major differences were observed. First, learners who benefitted the most from the feedback in the investigation focused on many skills versus just on one skill. This was evidenced in Figure 9, wherein high improving learners discussed focusing more on many skills than on just one skill. Also, learners who improved the most discussed recognizing their improvements and experienced happiness at higher levels than did low improving learners.

Content Analysis of Comments to Athletes

A content analysis of comments to athletes was conducted for two reasons: (a) to assess bias and measure if there were marked differences in the amount of feedback provided to participants in the two treatments; and (b) to provide a descriptive account of the movements that were most frequently coached in the study. This information can be useful to coaches by providing them with a greater understanding of components of spiking that female athletes commonly struggle with at this age. Although not all coaches observe the same errors in movement or coach the same components of a skill, I believe the descriptive findings from this study are still useful. Figure 10 shows the percentages for each skill that were most frequently coached during verbal feedback. Figure 11 shows the percentages for each skill that were most frequently coached during visually-enhanced feedback. A total of 623 comments were made to athletes during verbal feedback and a total of 639 comments were made during visually-enhanced feedback, a comparison that indicates the total amount of feedback for each treatment was relatively similar.

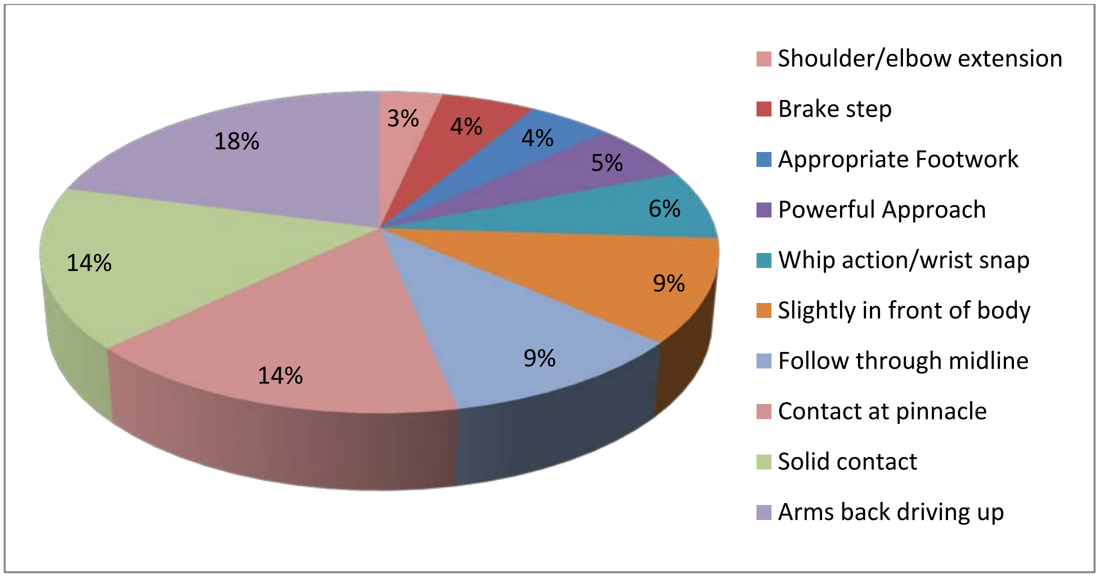

Figure 10. Comments to athletes: Verbal feedback. A description of each skill component and corresponding key words used for coaching are provided in the Coaching Script for Hitting in Volleyball (see Appendix F). Only the 10 most frequently coached skills are depicted to simplify the graph.

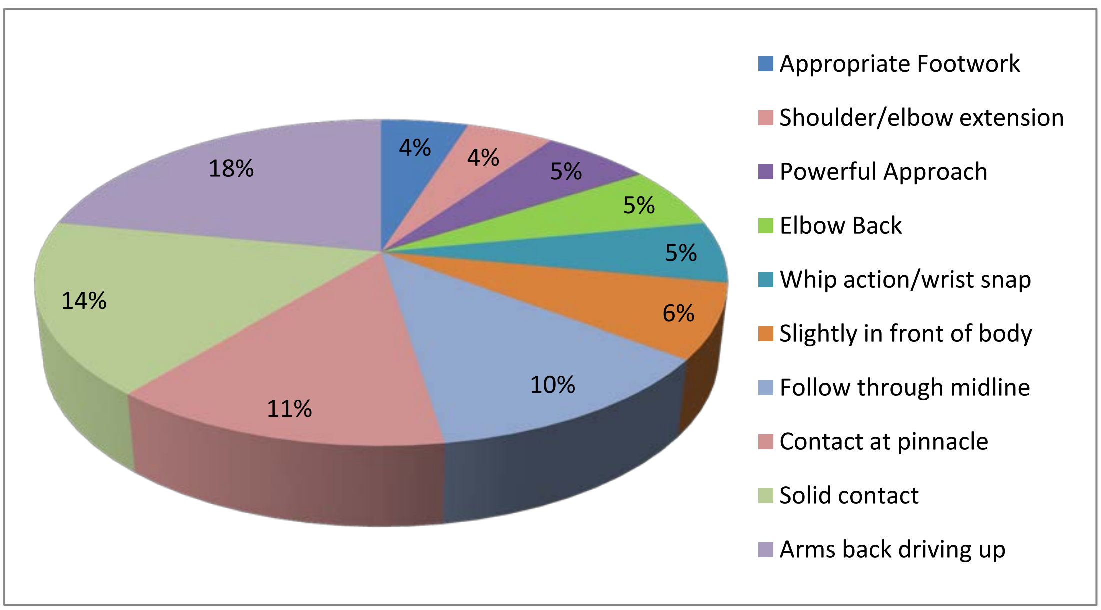

Figure 11. Comments to athletes: Visually-enhanced feedback. A description of each skill component and corresponding key words used for coaching are provided in the Coaching Script for Hitting in Volleyball (see Appendix F). Only the 10 most frequently coached skills are depicted to simplify the graph.

Visual Depictions of Movements

To give the reader a richer sense of the athlete's movements and what elements were being coached in the study, the following images show visual depictions of the top five most commonly coached sub-skills in the study: (a) arms back driving up, (b) solid contact, (c) contact at pinnacle, (d) follow through, and (e) contact slightly in front of body. Each image shows a still frame from the video of an athlete during an acquisition session. The image on the left is the athlete learning the movement and the image on the right is the same athlete performing the movement in a more proficient manner. A description of differences in the movement of the athlete follows each image.

Figure 12. Visual depiction of arms back driving up.

The sub-skill I coached the most often in this study was arms back driving up. The two images above show a difference in how far back the athlete's arms are getting. The more proficient movement is shown at right and reveals that the arms are parallel to the ground. Athletes can jump higher if they get their arms back and then swing them forward and upward as they jump. Biomechanical research on volleyball players has demonstrated that the arm swing is a significant contributor to jump height (Hsieh, 2006).

An interesting developmental observation of this investigation was that many participants did not initially use their arms to jump. During the learning process, several participants began to bring their left arm back while leaving their right arm forward. After instruction, this progressed to having their right arm back but their left arm coming to the side of their body. Finally, participants brought both arms back before bringing them up to allow them to jump higher.

A second critical element that even more experienced volleyball players struggle with is having a solid contact. This means the hand contacts the ball solidly in the palm in a manner that maximizes the force of impact on the ball to maximize velocity of the ball. In the image on the left of Figure 13, you can see the learning attempt wherein the athlete almost misses the ball and hits it weakly with her fingers. In the image on the right, you can see the improved performance wherein the athlete contacts the ball solidly, while getting on top of the ball and creating top-spin. Although a solid contact might appear easy based on the fact that the ball is round and a player's hand is not perfectly flat and the hand is less strong in the fingers versus the palm, a solid contact is actually quite difficult. Often times, other skills are necessary precursors to a proficient volleyball attack with a solid contact being one of the final components mastered.

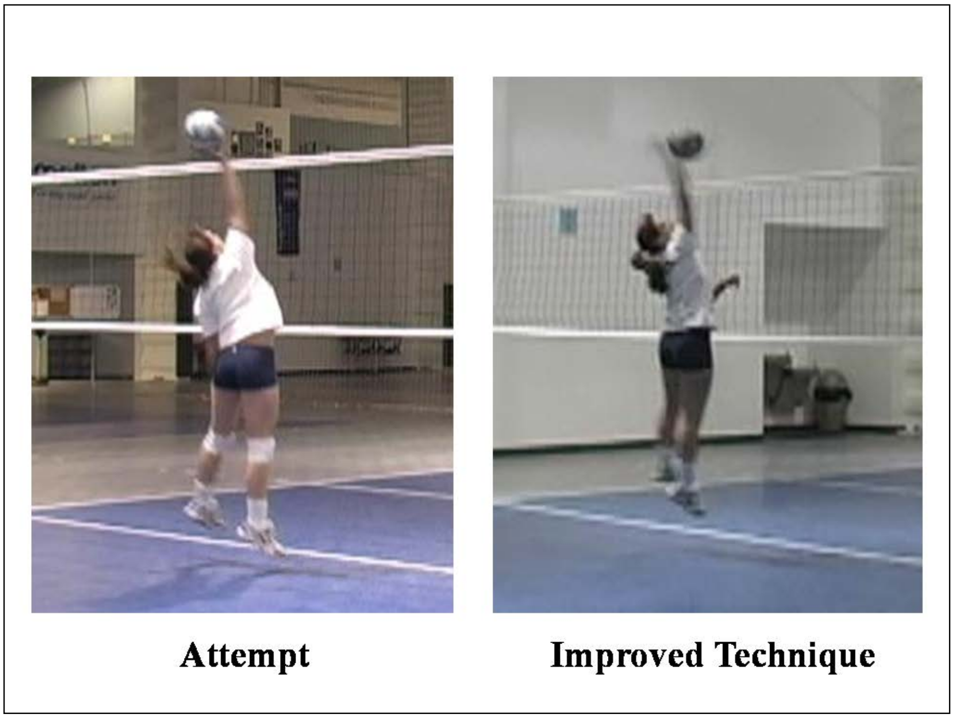

Figure 13. Visual depiction of solid contact.

A third critical element that was a major focus of feedback was for the athlete to contact at pinnacle. For the most proficient execution, an athlete contacts the ball at the top of their jump. Biomechanical research has demonstrated that the spiker (hitter) should contact the ball at the top of their jump. This contact at the top of a spiker's jump has been found to occur between 0.3-0.4 seconds of the spiker's duration in the air (Liu, Liu, Sue, & Huang, 2008). Commonly, an athlete who is learning will contact the ball as he or she is jumping up or most commonly while coming down from jumping. This movement is much like a jump shot in basketball where the shooter wants to release the ball at the top of his or her jump. In Figure 14, you can see the athlete improve her movement by contacting higher relative to the net. This skill is also related to the

outcome variable Height of Contact, which was used in the quantitative analysis to assess improvements in spiking.

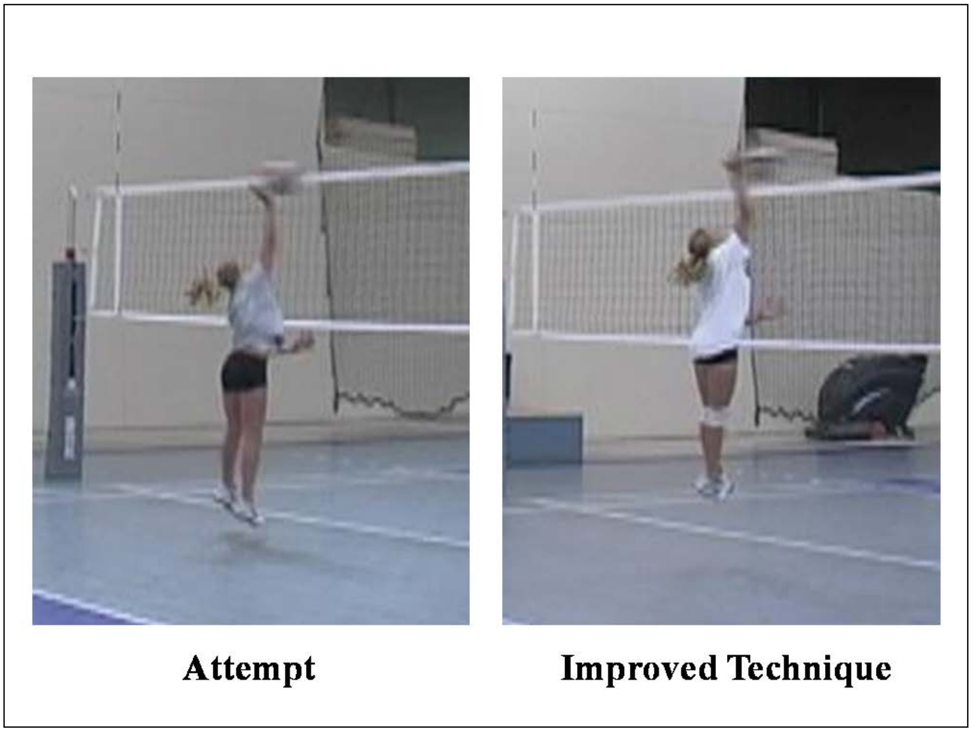

Figure 14. Visual depiction of contact at pinnacle.

A fourth factor that is important for athletes to perform after contacting the ball is the follow through. This skill is important to prevent injury to the rotator cuff. The ideal movement allows the shoulder to slow down gradually after moving rather than abruptly stopping. On the left in Figure 15, you can see an athlete stop her arm right after contact while the same athlete eventually brings her arms down to the side of her body while gradually slowing down her arm motion.

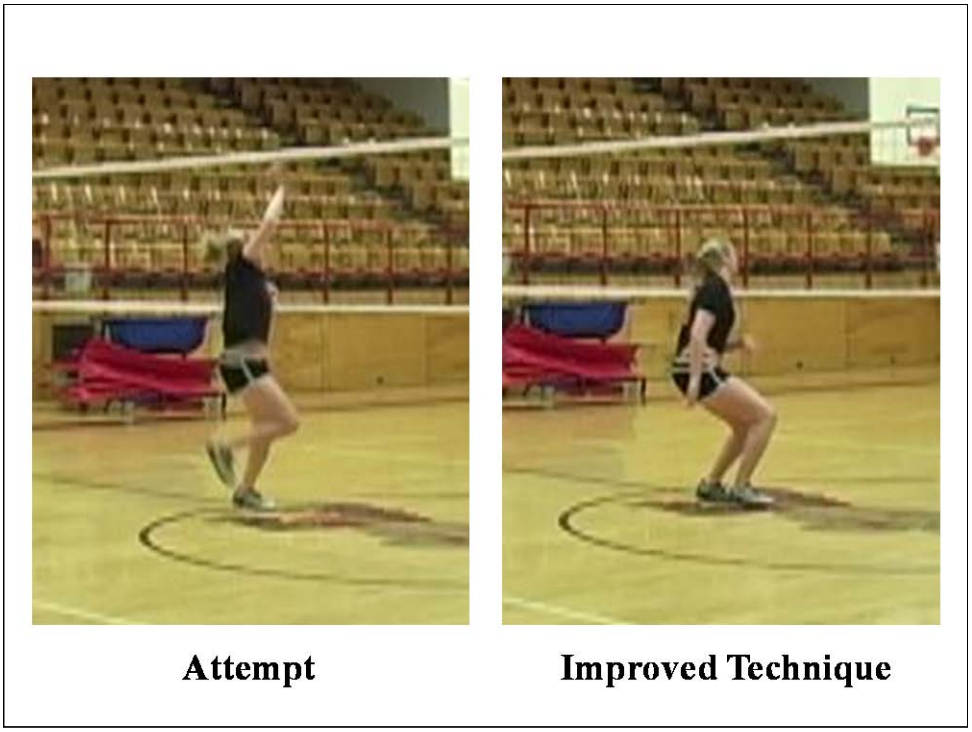

Figure 15. Visual depiction of follow through.

A fifth skill that received much attention in this study was contact slightly in front of body. Because the volleyball is a moving projectile, it is quite difficult to get one's body to the ball in a manner that allows for full extension of the arm above the shoulder and hitting of the ball slightly in front of one's body (see Figure 16). It is very easy to hit the ball behind one's head (as is shown in the image on the left), or to hit it too far in front of the body, or too far to one side of the body or the other. Not only is more power possible when keeping the ball in front of the body but it also prevents injury to the shoulder by hitting the ball slightly in front of the body. Injury occurs to the shoulder when the ball is not slightly in front of the body because shoulder hyperextension occurs.

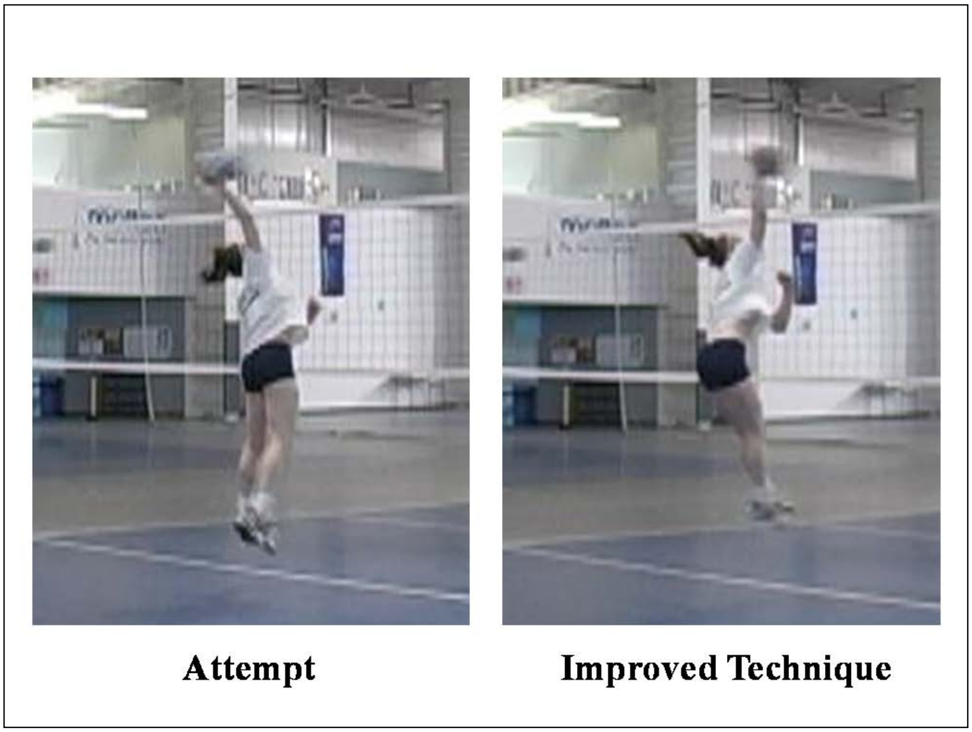

Figure 16. Visual depiction of contact slightly in front of body.

**Researcher's Experience During
Data Collection**

After collecting data, I looked over my researcher's journal and reflected on the process of data collection. I actually enjoyed the majority of the data collection since I was mostly performing a job I enjoy— coaching. However, there were also aspects of the data collection that were tedious and trying. The following three limericks were created after data collection as a form of qualitative analysis. The first poem (Learning Limerick) reflects the fear of not finding significant results. The second limerick (Study Buddies) describes observing participants during the study. Part of me was happy that my participants were making friends and enjoying being around one another. However, as a researcher, I was concerned that participants were distracting one another by talking

rather than focusing on learning. This poem reflects my observation of the group influence on learning. This effect was also demonstrated quantitatively and was reported by participants in interviews. The final limerick (Scheduling Woes) depicts the difficulty of scheduling participants for the experiment and in retaining participants throughout investigation. Although I was disheartened to have my sample size diminish from 32 to 26, I was glad the final number of participants reached my desired goal and that the participants were equally counterbalanced between the two conditions.

Learning Limerick

I conducted a study in volleyball
To see which coaching style would fall
    The chances seemed bleak
    Visual feedback was neat
Now I'm stuck with my back to the wall

Study Buddies

Serendipitously while doing my study
I found girls change from strangers to buddies
    Always full of chatter
    Forgetting what matters
Till the strength of my variables turned muddy

Scheduling Woes

My study was planned and prepped
My participants ready to become more adept
    Other plans interceded
    Further scheduling was needed
Their attendance so sporadic I wept

CHAPTER V

DISCUSSION

This chapter interprets the results of this investigation. Specifically, the chapter summarizes the quantitative and qualitative results as they relate to the research questions, discusses potential sources of bias and possible extraneous variables, considers limitations of the study, proposes needs for future research on visual feedback, and finally derives implications for the use of visual feedback by coaches, teachers, and practitioners.

Summary of the Study

The primary purpose of this study was to examine the effectiveness of visual feedback in learning motor skills. Several distinct technologies were used in the administration of visual feedback, which is becoming increasingly prominent despite a scarcity of empirical evidence that supports such use. Along with this need, a number of variables that might enhance the effectiveness of visual feedback warrant further investigation, e.g., the learner's preference and the athlete's level of experience. Also, few studies have explored the learner's thoughts while learning with visual feedback.

This study had four specific objectives. The first objective was to determine statistically if visually-enhanced feedback was superior to verbal feedback when training athletes to spike. The next objective was to examine variables that might enhance visually-enhanced feedback, e.g., the amount of experience or the learning preference of

the athlete. A third objective was to analyze the types of thoughts athletes had while learning with visually-enhanced feedback and to examine what types of thoughts were associated with learning while receiving different types of feedback. A final objective was to compare and synthesize the quantitative and qualitative results.

To assess differences between verbal and visual feedback, an experimental cross-over design was conducted. This design allowed participants to experience both types of treatments, which in turn permitted a statistical comparison of improvement of performance and also provided an opportunity for participants to comment on their preferences for coaching methods in the Learning to Hit Interview. In addition, a think-aloud procedure was implemented in an attempt to assess an athlete's thoughts while learning to spike. The quantitative portion of the study sought to answer the following research questions:

Q1 Is visually-enhanced feedback more effective than verbal feedback?

Q2 Are athletes able to learn more from visually-enhanced feedback if they have more expertise?

Q3 Do athletes who have a visual learning preference learn better with visually-enhanced feedback?

The qualitative portion of the study sought to address the following research questions:

Q4 How do athletes' cognitions differ when learning a complex motor skill with verbal versus visually-enhanced feedback?

Q5 How do thoughts about motor learning differ between relatively high-improving and low-improving learners?

Research Question 1

To address research question 1, a repeated-measures ANOVA was conducted for both outcome measures (velocity and height of contact). Based on an ANOVA contrast,

it was found that participants improved significantly from the pretest to posttest measurements. Thus, it was shown that both coaching styles helped athletes in their ability to produce greater ball velocity from their hit and to contact the ball at a higher point. However, an ANOVA contrast comparing the two treatments (verbal and visually-enhanced feedback) revealed a non-significant result for both the velocity and height of contact measures. This result suggests that neither type of coaching was superior to the other despite self-reported preferences for visual feedback by athletes.

The results of this study were fairly consistent with prior research. In a meta-analysis examining studies that compared verbal and visual feedback, an effect size of $d = .28$ was reported, showing a slight advantage for the use of visual feedback (Rhoads, 2010a). My investigation also compared these two types of treatments and found an effect size of $d = .05$ for velocity and $d = -.15$ for height of contact. These results indicated a negligible advantage from using visual feedback; whereas other known studies showed a small effect. It is possible that adding visual feedback was ineffective because the format was not instructive. However, a more plausible reason was that visual feedback led to information overload for the learner and provided more information than the learner was able to process (Carroll & Bandura, 1987).

Research Question 2

To answer research question 2, an ANCOVA was conducted. After assessing participants' level of club volleyball experience as a covariate with their ability to learn spiking with the two treatment types, no significant difference was found. I had hypothesized that participants with more expertise would learn more easily with visual

feedback. This study was unable to show that participants' level of expertise played a role when learning with visual feedback.

Research Question 3

To answer research question 3, an ANCOVA had been planned. However, due to the fact that most participants reported a preference for learning volleyball with visual feedback (22 of 26), not enough variability existed to analyze this question.

Research Question 4

To address research question 4, a qualitative content analysis was conducted. Prior to presenting the content analysis, the thoughts athletes had while learning with visual feedback are discussed.

Thought processes while learning. The current study added to the body of literature examining thought processes of motor learning and our understanding of knowledge representation of athletes when learning. Specifically, this study added to the cognitive stages of learning outlined by Hebert et al. (1998) and elements of learning identified by Ram and McCullagh (2003). Hebert and colleagues identified four cognitive stages in learning with visual feedback: getting used to seeing oneself on camera and making general observations, detecting errors, making connections and recognizing tendencies, and correcting errors and reaching closure. In a study with a similar focus, Ram and McCullagh described five themes that emerged using think-aloud procedures in motor learning: description of the sequence of movement, description of movement process, description of scenery, thoughts and affect, and shock and surprise. In comparison, the six major themes I identified in my investigation were cognitive processes, knowledge, environmental effects, self-efficacy, emotions, and visual

appearance. Within each category, I also found sub-themes. Sub-themes of cognitive processes included memory and visual metaphoric cues. Elements of knowledge included improvement recognition, improvement process, and improvement purpose. Elements of environmental effects included distraction and adjusting to the environment. Sub-themes of self-efficacy included confidence and lack of confidence. Sub-themes of emotions included happiness and frustration. And finally, elements of visual appearance included getting used to seeing oneself on camera and reflection about how one looks.

After comparing the themes indentified in my study to those previously outlined, a number of overlapping themes were found. All of Hebert et al.'s (1998) cognitive stages were identified in my study. Participants made general observations in the current study by describing what they were struggling with and needed to work on. Also, participants detected errors, recognized how they could improve on these errant tendencies, and found ways of correcting these errors in movement.

In addition, all of the themes Ram and McCullagh (2003) discussed were also evident in my study. Participants described the movement sequence, how to perform the movement, the scenery and environmental elements, emotional components, and their reactions upon seeing themselves on camera.

While my study showed evidence for thought processes identified in previous research, I also identified a few elements that have not been described in earlier research on visual feedback in motor learning: memory, self-efficacy, and adjustment to the environment. The two aforementioned studies did not describe how athletes talked about needing to remember elements of a skill in order to improve the movement. Also, prior studies did not mention how athletes discussed needing to adjust to the environment.

Most likely, this was an artifact of having used an inconsistent setting machine that threw off participants. The final and most significant addition to the literature was self-efficacy. Prior research did not document the importance confidence plays in learning. Many participants in my study portrayed feeling high or low levels of confidence. Self-efficacy beliefs of athletes have been shown to be a reliable predictor of sport performance (Feltz & Lirgg, 2001).

Also, an interesting connection was made after completing the word-art analysis and examining the five most commonly coached components of spiking. In the word-art, the word "arm" appeared in a fairly large font, showing participants used this word quite often in think-aloud verbalizations. The common appearance of this word related to the five most common sub-skills that I recorded coaching. All of the five sub-skills involved arm movements. Thus, arm movements might be critical components of spiking with which adolescent females struggle.

A final consideration was that my findings might have differed slightly from prior research based on the think-aloud procedures I implemented. Rather than having participants talk about their thoughts while observing a replay of themselves on camera, I had participants talk about their thoughts immediately after performing repetitions and receiving feedback. The immediacy of my think-aloud protocol might have enhanced participants' memories for the events they just experienced. On the other hand, think-aloud procedures in other studies where participants talked while observing a replay of him- or herself could have led to different thoughts and conclusions than the procedure I implemented.

Cognitions compared by condition. Several differences in participants' cognitions were identified when comparing verbal and visually-enhanced feedback. After examining differences, two themes were identified more often under the verbal feedback condition: improvement purpose and improvement recognition. It seems that participants recognized their own improvement more often with verbal feedback. Presumably, verbal feedback helped athletes understand why a movement was more beneficial since improvement purpose was recognized more often under this condition.

In addition, four elements were observed more often in participants' think-aloud verbalizations under visually-enhanced feedback than under verbal feedback: area needing work, improvement process, focus on many skills, and error detection. In line with findings by Hebert et al. (1998) and Menickelli (2004), I found evidence that visual feedback drew the learner's attention to errors in movement. I found that athletes described observing errors in movement more often under visually-enhanced feedback than under verbal feedback. This finding showed that visually-enhanced feedback might be useful in the learning process, even if overall outcome scores did not increase.

Research Question 5

A qualitative content analysis was undertaken to address research question 5. A comparison between high-improving learners (the top half of participants who improved the most) and low-improving learners (the bottom half of participants who improved the least) was undertaken to address this question. High-improving learners were higher in focusing on many skills, improvement recognition, and displaying happiness in think-aloud verbalizations. On the other hand, low-improving learners focused more on one skill than did high-improving learners. The notion that high-improving learners would

recognize more improvement and display more happiness made sense intuitively. The difference in focusing on one skill, which was more common in low-improving learners, versus focusing on multiple skills, which was more common in high-improving learners, warrants further research. Perhaps more advanced learners are better able to multi-task.

The mixed-method design of this study allowed for a more comprehensive understanding of the effects of two coaching styles on female athletes' ability to learn the skill of spiking. The quantitative analysis allowed for a comparison of verbal and visually-enhanced feedback along with covariate analyses examining the role of skill level and learning style preferences. In addition, the qualitative analysis allowed for a better understanding of what participants were thinking while learning to spike, how these thoughts differed by treatment, and what type of thoughts were most conducive to learning.

Limitations and Implications for Future Research

This study helped to understand the relative value of visually-enhanced feedback compared to verbal feedback in teaching motor skills. Yet, after completing the study, a number of limitations as well as suggestions for future research are worth discussing. First, the low sample size was an area of concern. A larger sample size would allow for more definitively generalizable findings. Second, participants in the experiment were not very diverse. All participants were female and most were White and came from middle or upper class backgrounds. Future studies should examine a more diverse group of participants including males and individuals from both genders from a variety of ethnic backgrounds and income levels. Third, a more in-depth qualitative analysis could have been undertaken. The interviews with athletes were relatively short. A more

comprehensive understanding of the participants' experiences could have been gained with a longer interview. Extremely short interviews are often susceptible to interviewer satisficing (Japec, 2006). In other words, many of the interviews in this study might have been short because the interviewee was attempting to respond with answers they thought I was looking for. Young interviewees are often more likely to respond with answers they think the interviewer is looking for because of differences in power (DeRoche & Lahman, 2008). These authors suggested that researchers should make every attempt to put in place techniques that would empower the participant to optimize the interview process.

Along with the aforementioned limitations, a number of factors within the current study design could be improved in future work. One of the major extraneous variables was the setting machine that launched the ball to be hit by the participant. Many participants described the distraction and difficulty of using the setting machine. As one participant described, "I was really focusing on where the set was. I was having a hard time with it being tight and then still being early so yeah" (Participant LB). Although a prior study reported the machine as being adequately precise to be used in experimentation, the current study found an inadequately high coefficient of variation. There are a few plausible explanations for this circumstance. Based on the setting machine's delivery of the ball using two spinning rubber cylinders, the ball would fly farther or shorter based on the inflation of the ball and the age of the ball's leather. This element was controlled for by using new balls with the same inflation. Another difficulty was that the setting machine would push the ball out at varying degrees based on how hard you pushed the ball into the machine. Lastly, the most difficult element of the

machine was that it would torque and spin to the right after each set and had to be re-adjusted after 5 or 10 repetitions.

A second weakness of the current design was the limited number of acquisition sessions. The current study determined that three learning sessions would be adequate based on prior research. In addition, this investigation found that participants improved significantly from the coaching sessions. Yet, the possibility exists that a greater number of sessions might show a difference between verbal and visually-enhanced feedback.

A third limitation in the study's design was having the researcher as the coach. This dual role potentially could have led to a bias in the administration of the coaching interventions--I expected visually-enhanced feedback to be more advantageous. Due to the fact that no difference was found between the two treatments, this effect is less likely. However, it is possible that verbal feedback might have been found to be superior if the researcher was not also the coach. To address this potential source of bias, a few measures were put in place. First, the type and amount of feedback given to each participant in each treatment was recorded and found to be relatively equivalent. In addition, two observers were brought in to observe the coach during acquisition sessions. Based on the coaching behavior checklist that observers completed, bias in treatment administration appeared to be minimal.

One of the main concerns with extraneous variables was having athletes participate in small groups. This condition was a concern because learning in a group could be either a benefit or detriment and it was difficult to determine how the effect of being in a group varied from one group to another. When planning the investigation, I deemed it ecologically valid to have athletes learn in a group since learning typically

occurs in this manner. This extraneous variable was addressed in a few ways. First, participants were asked in the Learning to Hit Interview how being in a group affected them. The main response was that learning with others was beneficial, offered support, and was a model from which to view and learn. However, a few participants mentioned that learning in a group could be a distraction since participants talked to one another. This disadvantage was particularly the case when groups became large (more than three or four). In addition, the group effect was analyzed in the repeated-measures ANOVA. This was found to have a significant effect. Therefore, it would be informative to conduct a similar study with individuals learning alone to see what the effect was. Another method would be to coach athletes in groups and examine the nested factor of athletes within groups using a hierarchical linear model. However, a large sample size would be necessary for such a statistical procedure.

An additional consideration that might allow for a greater effect size for visual feedback is to do more with technology when providing visual feedback. Using a more advanced camera could help in providing visual feedback. Many of the still images were blurry, especially when showing participants as they contacted the ball. The camera used in this study (Canon 3CCD DM-GL2 Digital Camera) provided 30 frames-per-second with 1488 x 1128 recording pixels (Canon, 2002). Currently, there are cameras that can record upwards of 1,000 frames-per-second at 1920 x 1080 pixels. The Vision Research Phantom v640 was utilized in recording the 2009 World Series at speeds up to 540 frames-per-second at 1280 x 720 pixels (Vision Research, 2010).

Along with utilizing greater camera technology when filming, a number of software tools for visual feedback could be utilized. The software used for this study

(Dartfish) included many tools that might enhance the educational capabilities of visual feedback. One of the tools implemented in the current study was the frame-by-frame capability. Using this capability, the coach could slow down and show critical elements of the skill such as footwork of the approach or contact with the ball. Another tool used in the analysis of this study was the measurement tool. This allowed for the measurement of the athlete's height of contact. This tool could also be used during instructional sessions to show athletes how to change the movement.

Another useful tool that could be implemented is called Simulcam--a split-screen appears and multiple video performances can be shown at once and synchronized. In this manner, an expert performer could be shown simultaneously with the performance of an athlete learning a new skill. An overlay of the two video images could also be done so the learner could clearly see the ideal movement compared to their own movement. Dartfish also has a tool called Stromotion that shows still-frame sequences of the movement over time so the observer can get a better sense of what is occurring during a movement.

In addition to the beneficial effects new technology might add, a number of other factors and variables could potentially enhance the effects of visual feedback. Skill level was one of these moderating variables studied in the current investigation and deserves further exploration. I hypothesized that athletes who had more experience and greater skill might gain more from visual feedback since they had knowledge of what the skill should look like. This effect might taper off at higher levels when comparing intermediate athletes to expert athletes since intermediate athletes might have the necessary knowledge of skills to profit equally. The current study found no significant

difference between more and less experienced athletes based on number of years playing club volleyball; however, prior research has found greater benefit to participants who had some experience (Green, 1970). Thus, the difference between novice and intermediate athletes deserves further attention.

Another moderator variable worth studying, which was not evaluated in this investigation, is the number of learning sessions. A number of previous studies showed that using three learning sessions was enough to demonstrate the superiority of visual feedback. Due to the fact that visual feedback was not found to be more beneficial, it is worth examining whether providing more acquisition sessions would have produced different findings for an athlete's learning to spike.

Gender is an additional variable that was not examined in the current investigation but has received some attention in prior research. My study only looked at female athletes, although I would predict that males would benefit in similar ways as the females in this investigation. A study by Barbarich (1980) found that visual feedback was helpful for men but not for women in learning the volleyball forearm pass. No explanation for gender differences was offered in that study. Perhaps males' superior spatial ability could be attributed for these gender differences (Pietsch & Jansen, 2012). Contrary to Barbarich's study, a meta-analysis comparing genders found a slight but non-significant advantage with females benefiting slightly more than males from visual feedback (Rhoads, 2010a). Thus, a more definitive conclusion is needed to determine if gender differences exist when using visual feedback.

A final factor that might be important to study is the effect of visual feedback in diverse populations. This factor was not examined in this study or in other known studies

to date. Presumably, athletes of various backgrounds and with lower socioeconomic status would benefit from visual feedback in a similar manner. Yet no study has made this the focus or clearly shown that athletes of diverse backgrounds could also benefit from visual feedback. The lack of a diverse population also limited my ability to examine group differences based on learning preferences. Almost all of my participants preferred learning with visual feedback; thus, I had a lack of variability to analyze this variable. A future study could control for this variable during selection by ensuring that half of the participants preferred verbal feedback.

Implications for Practitioners

One of the major goals of this investigation was to inform coaches, teachers, and practitioners about the possible benefits of visually-enhanced feedback for motor skill acquisition. This study also addressed several gaps in the literature including examining the roles that experience level and learning preferences play when using visual feedback to teach a motor skill. In addition, this study further examined thoughts athletes had while learning with visual feedback and the impact of visual feedback on those thought processes.

A description of common abilities of athletes in this study is discussed first, followed by athletes' preferences for types of feedback, a comparison of thought processes that were observed in this study compared to prior research, and finally remarks about the use of visual feedback for teaching motor skills.

Discussion of Descriptive Findings

This study assessed the velocity and height of contact of middle school and high school female athletes when spiking. The average participant in this study was

able to hit the ball at the end of the study with a velocity of 32 mph and contact the ball at 8' 6" from the ground. In addition, the majority of athletes reported preferring to learn volleyball through visual means. These results are useful for practitioners who might be interested in making comparisons between participants in this study and their current players. It is also useful for policy makers to consider the net height at which athlete's are playing. Young athletes who are unable to hit over an Olympic height net will benefit from a developmentally modified net height. If this recommendation is not taken into consideration, it is likely that the athlete will develop a habit of approaching under the ball to hit. This habit may become engrained as the athlete gets older and potentially lead them to hit out-of-bounds or lead to shoulder injury if the athlete does not keep the ball slightly in front of their body. Although the United States does have a different net height for athletes 12 and under, other countries such as Brazil have implemented more than just two net heights for developmental levels (Da Matta, 2004, p. 59).

After completing the interventions and recording the critical elements of spiking that participants struggled with most, it was determined that participants struggled with five sub-skills: arms back driving up, solid contact, contact at pinnacle, follow through, and contact slightly in front of body. Although we could not determine whether these proficiencies were the skills athletes struggled with most, we tentatively inferred that these were challenging skills in spiking for teenage athletes. All of these skills involve arm movements and three of them involved contacting the ball. When recalling the preliminary analysis of participants' think-aloud responses, many participants articulated the need to improve arm movements. Practitioners could take away from these findings the need to train the arm swing and contact for athletes learning to spike.

Athletes' Preferences for Types of Feedback

Although the current study did not find that visually-enhanced feedback was superior to verbal feedback, a large majority of participants stated they preferred learning through visual methods; almost all participants preferred learning with visually-enhanced feedback. Therefore, if coaches were interested in aligning their coaching methods with the preferences of their athletes, they would implement visual feedback. However, it has been shown that people are not always accurate in their perceptions of learning. For instance, research has found that students consistently overestimate their academic ability (Clayson, 2005).

Thought Processes of Athletes' Learning with Visual Feedback

After comparing athletes' thoughts while learning with visual feedback to prior studies that have examined this phenomenon, I replicated many of the elements that have previously been observed. Practitioners should be aware that athletes often proceed through a pattern of cognitive stages. First, athletes become accustomed to seeing themselves on camera and make general comments about their movements. They might express shock upon seeing themselves on camera. Also, participants commonly describe aspects of the environment that caught their attention or distracted them from performing. Second, athletes begin to detect errors in their movement. They might express surprise that their movements looked less fluid and crisp than they had assumed. A sense of frustration and lack of confidence is likely to be associated at this level. Third, athletes begin to make connections and figure out ways of improving at the skill. This often involves cognitive processes such as memory and improvements in knowledge

representation. Athletes begin to understand not only how to move more effectively but also why the movement is more efficient. Fourth, athletes learn to correct their errors and perform more effectively. Players will experience higher self-efficacy and have a sense of happiness upon recognizing their improvements.

In addition to being cognizant of the thought processes athletes often go through, practitioners should also be aware of the role learning with visual feedback has. My investigation found preliminary evidence that participants who learn with visual feedback are more able to detect errors in movement, are more aware of a variety of skills they need to work on, and have a greater capacity to understand how to improve these skills.

Practitioners should also be aware of differences that have been observed in the thought processes of high-improving and low-improving learners (high-improving learners were categorized as the top half of learners while low-improving learners were categorized as the bottom half of learners). When comparing high-improving versus low-improving learners, a few trends were observed. It was found that high-improving learners focused on numerous skills rather than on just one skill. In addition, high-improving learners were higher in recognizing their own improvements and had a greater sense of happiness according to think-aloud responses during the study.

Final Recommendations

Based on the quantitative findings of this study, it appears that visual feedback was not superior to verbal feedback. Therefore, visual feedback might not be worth the investment. It may be too costly and time-consuming to implement visual feedback. A practitioner must be willing to put in the extra time to set up equipment, which might not be worth the effort based on the quantitative findings of this research. Similar practical

suggestions were described by Brown and Messersmith (1948) who stated that visual feedback might take away from practice time. However, the time commitment for setting up visual feedback equipment will ultimately come down to the practitioner. In addition, technology is becoming more affordable. However, interested practitioners could invest in the most advanced high-speed cameras if they wanted the highest quality video with the most frames-per-second. Some of these cameras cost between $50,000 and $150,000 (Canon, 2002).

Contrary to the quantitative findings, the qualitative examination showed that athletes had an overwhelming preference for visual feedback. A practitioner could look at these finding in two ways. On the one hand, a coach might place greater credence on the quantitative findings and not use visual feedback since it did not appear to produce greater benefits than verbal feedback. On the other hand and a perspective the author took was that visual feedback must offer some benefit if such a large number of athletes preferred its use. Perhaps there is some latent learning occurring (Tolman & Honzik, 1930). Perhaps athletes were developing enhanced cognitive representations of spiking while not demonstrating an increased performance of this volleyball skill. The other possibility is that visual feedback did have beneficial effects that were not adequately measured in this study. Perhaps the benefit of visual feedback could have been shown if observer ratings of skill form were used. Prior research demonstrated improvements in form prior to improvements in outcome scores (Wiese-Bjornstanl & Weiss, 1992).

In conclusion, the present investigation found no difference between verbal feedback and visually-enhanced feedback in performance. However, it was observed that participants greatly preferred learning with visual feedback. In addition, a number of

thoughts were observed as participants were learning. Some of these findings were in line with previous research; however, many new thoughts and experiences were documented. Overall, further research is needed on the topic to clarify if visual feedback offers an added benefit beyond traditional methods. Based largely on prior research, it is the author's belief that visually-enhanced feedback provides a slight advantage over verbal feedback. This marginal advantage might not be worth implementing for the everyday athlete. However, this procedure might be worth the investment to elite and Olympic athletes who strive for even the slightest winning advantage.

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APPENDIX A

LEARNING TO HIT INTERVIEW

LEARNING TO HIT INTERVIEW--PART 1

1) How old are you?

2) How many years have you played volleyball?

3) How many years have you played club volleyball?

4) Do you learn best by hearing or seeing?

5) When playing volleyball do you learn best by hearing or seeing?

6) When playing volleyball can you think of examples when you learned best by hearing?

7) When playing volleyball can you think of examples when you learned best by seeing?

LEARNING TO HIT INTERVIEW PART 2

1) Do you learn best by hearing or seeing?

2) When playing volleyball do you learn best by hearing or seeing?

3) When playing volleyball can you think of examples when you learned best by hearing?

4) When playing volleyball can you think of examples when you learned best by seeing?

5) Did you prefer learning to hit with verbal feedback or verbal and visual feedback?

6) What did you think about the think-aloud procedure?

7) Did you learn anything from talking about your thoughts while learning to hit?

8) Did you experience differences in how you were coached when learning with verbal feedback compared to verbal and visual feedback?

9) Did you feel that your learning was influenced by being in a group? If so, how did the group influence your learning?

APPENDIX B

COACHING BEHAVIOR CHECKLIST

COACHING BEHAVIOR CHECKLIST

Instructions: Rate the coach on the following behaviors. Then include any additional comments that are pertinent to differences you observed in the coach when they were coaching with verbal feedback versus visually-enhanced feedback.

Level of enthusiasm

1	2	3	4	5
Low				High

Amount of verbal feedback

1	2	3	4	5
Low				High

Quality of feedback

1	2	3	4	5
Low				High

Comment on the coaches' behavior during the lesson, and any differences that might exist between the verbal feedback and visually-enhanced feedback lessons:

____

____

____

____

____

APPENDIX C

INSTITUTIONAL REVIEW BOARD APPROVAL FORM

UNIVERSITY of
NORTHERN COLORADO
Institutional Review Board (IRB)

May 19, 2011

TO: Carol Roehrs
School of Nursing

FROM: Maria Lahman, Co-Chair MJ
UNC Institutional Review Board

RE: Expedited Review of Proposal, *Learning to Hit in Volleyball with Verbal and Visually-Enhanced Feedback,* submitted by Michael Rhoads (Research Advisor: Teresa McDevitt)

First Consultant: The above proposal is being submitted to you for an expedited review. Please review the proposal in light of the Committee's charge and direct requests for changes directly to the researcher or researcher's advisor. If you have any unresolved concerns, please contact Maria Lahman, Applied Statistics and Research Methods, Campus Box 124, (x1603). When you are ready to recommend approval, sign this form and return to me.

I recommend approval as ~~is~~ amended. Carol Roehrs 5-31-2011
Signature of First Consultant Date

The above referenced prospectus has been reviewed for compliance with HHS guidelines for ethical principles in human subjects research. The decision of the Institutional Review Board is that the project is approved as proposed for a period of one year: 6-9-11 to 6-9-12

M. Lahman 6-9-11
Maria Lahman, Co-Chair Date

Comments:

25 Kepner Hall ~ Campus Box #143
Greeley, Colorado 80639
Ph: 970.351.1907 ~ Fax: 970.351.1934

APPENDIX D

INFORMED CONSENT FOR PARTICIPATION IN RESEARCH

UNIVERSITY of NORTHERN COLORADO

Informed Consent for Participation in Research
University of Northern Colorado

Project Title: Learning to Hit in Volleyball with Verbal and Visually-Enhanced Feedback

Researcher: Michael Rhoads School of Psychological Sciences
Phone number: (303) 507-8398 E-mail: michael.rhoads@unco.edu

Research Advisor: Dr. Teresa McDevitt School of Psychological Sciences
Phone number: (970) 351-2482 E-mail: teresa.mcdevitt@unco.edu

Your child is invited to participate in a study examining how volleyball players learn to hit. This research will help to inform coaches about possible ways of teaching skills in sports. This research will also help researchers to better understand the learning process involved with mastering motor skills.

If you decide to allow your daughter to participate, she will complete an experiment examining improvements in learning to hit in volleyball. During the experiment your child will receive two forms of feedback, namely verbal feedback and verbal feedback along with visual feedback. She will complete the learning sessions in small groups. She will complete a total of nine sessions lasting approximately one hour each. Three testing sessions will take place in which measures of hitting will be recorded. In addition, she will complete two interviews about learning to hit. During the learning sessions, your child will also describe what she is thinking about during the learning process.

I foresee no risks to participants beyond those normally encountered when learning a sport. Children's participation involves the minor risk of feeling anxious from seeing themselves on camera. This risk will be minimized by using lots of encouragement and allowing your daughter to stop participation at anytime if she feels uncomfortable. Children's participation also involves the possible risk of getting injured during participation. This risk will be minimized through adequate warm-up prior to participation and stretching at the end of participation. In the extremely unlikely event of a physical injury during your child's research participation, I will assist you in contacting an ambulance should you desire, and you will be responsible for the costs of your daughter's medical transportation and care. By participating in this study, your daughter will benefit by receiving free coaching, gym use and feedback.

Each session of the experiment should take approximately 1 hour to complete. The experiment will be videotaped to analyze the learning process. Your daughter's name will be kept confidential and all records will be securely protected. Video and audio data

will be safely secured and an external hard-drive that will be kept securely in an office on the UNC campus. The results of participants' performance will be combined and reported together so that individuals cannot be identified. The interview will ask your child questions about his or her preferences for different ways of learning to hit in volleyball. Additionally, the interview will ask participants background information about themselves. A variety of responses to the interview are expected and their honest opinion is desired. Choosing not to participate will not affect their standing on a team.

Please feel free to call or email me if you have any questions or concerns about this research. Please sign your name if you agree to have your child participate. I will also have your child sign an assent form showing his or her desire to participate in the study. Thank you for your help with my research.

Sincerely,

Michael Rhoads

Participation is voluntary. You may decide not to allow your child to participate in this study and if (s)he begins participation you may still decide to stop and withdraw at any time. Your decision will be respected and will not result in loss of benefits to which you or your child are otherwise entitled. Having read the above and having had an opportunity to ask any questions, please sign below if you would like your child to participate in this research. A copy of this form will be given to you to retain for future reference. If you have any concerns about your child's selection or treatment as a research participant, please contact the Office of Sponsored Programs, Kepner Hall, University of Northern Colorado Greeley, CO 80639; 970-351-1907

_______________________________ ___________________________
Child's Full Name (Please Print) Child's Birth Date (month/date/year)

(____)_________________
Parent/Guardian's phone number

_______________________________ ____________________
Parent/Guardian's Signature Date

_______________________________ ____________________
Researcher's Signature Date

If you consent you have your child's video footage used for instructional purposes or for presentations at conferences, please sign below.

_______________________________ ____________________
Parent/Guardian's Signature Date

APPENDIX E

INFORMED ASSENT TO PARTICIPATE IN RESEARCH

UNIVERSITY of NORTHERN COLORADO

Assent to Participate in Research
University of Northern Colorado

Hello!

My name is Michael Rhoads and I am a doctoral student at the University of Northern Colorado. I am doing research on the way athletes learn to hit in volleyball. From this research coaches will be better able to understand different ways of teaching athletes to hit in volleyball. Scientists will also have a better understanding of how people learn skills in sports.

If you choose to participate in this research, you will take part in an experiment where you will receive coaching on how to hit. While you are learning to hit I will tell you how you can improve your hit. You will also have the opportunity to watch a video of yourself hitting. The experiment will take place on nine separate days. Each session should take about one hour. You will be in a small group with other athletes who are also learning to improve their hitting. On three days you will be filmed to measure your skill at hitting. Over a period of six days you will be given instructions on how to hit. At three times during each session you will speak into a recorder and describe the thoughts you are having while learning to hit. You will also take part in an interview at the beginning and end of the study. The interview will ask about how you learn to hit. During this interview there are no right or wrong answers. I just want your opinion about how you learn.

Taking part in this experiment should be no different than learning to play volleyball from a coach. You may feel nervous watching a video of yourself learning to hit, but no one other than me will be watching the video and I will give you lots of encouragement. I will also make sure you warm up before each practice session and stretch afterwards to make it unlikely you get injured during your participation. You can choose to stop the experiment at anytime. Do you have any questions for me about this study?

If you would like to participate in my experiment please sign your name below and write today's date. Thanks!

______________________________ __________________
Athlete's Signature Date

______________________________ __________________
Researcher's Signature Date

APPENDIX F

COACHING SCRIPT FOR HITTING IN VOLLEYBALL

COACHING SCRIPT FOR HITTING IN VOLLEYBALL

	#	Skill	Feedback		
Stance	1	Athletic stance	Kees slightly bent	Left leg forward	
	2	Momentum forward	Shoulders forward	Spin ball	
	3	Observe setter	Look at setting ma-chine to time the toss		
Approach	4	Appropriate Footwork	Left, Right, Left (right handed hitter)		
	5	Powerful Approach	Wait longer	Go faster	Take bigger steps
	6	Feet set in opposition to hitting hand	Left leg forward (right handed hitter)		
	7	Linear approach	Approach in a straight line		
	8	Brake step	Front foot rotated inward (to create upward momentum)		
	9	Flow	Make your approach smooth (less choppy)		
Take-off	10	Balanced Take-off	Balance your weight at take-off		
	11	Arms back driving up	Use your arms to jump	Bring your arms back so they are parallel to the ground	
	12	Hip/knee/ankle flexion	Get Loaded (low)		
	13	Powerful take-off	Explode up	Make the movement fast	
Flight	14	Arched body	Arch your back	Make your body look like a C	
	15	Shoulder opening	Rotate your shoul-ders toward the set-	Shoulders perpen-dicular to the net	
	16	Shoulder flexion/elbow flexion/hand pronated	Pull your arm back	Bend your elbow	Turn your palm away from your face
	17	Guide Arm pulled down in saggital plane	"Pick up the apple, bring to side pocket"	Arm pulled down exclaiming "yes"	
Contact	18	Shoulder and elbow extension	High contact	Get your elbow above your head	
	19	Contact inline with hitting shoulder	Contact the ball inline with your shoulder		
	20	Slightly in front of body	Hit the ball slightly in front of your body		
	21	Whip action/wrist snap	Lead with elbow then snap your wrist		
	22	Contact at pinnacle	Contact at the top of your jump (not while jumping up or com-ing down)	Climb on the ball	
	23	Solid contact	Hit with a solid con-tact	Fingers spread	Get on top of the ball
Follow Through	24	Controlled body	Control your body	Land with balance	
	25	Follow through to midline	Follow through to the midline of your body		
	26	Decelerate your arm through follow through	Decelerate your arm through follow through	End with your arm relaxed to the side of the body	
	27	Land with cushion	Land with cushion	Absorbe the force of	

APPENDIX G

DEBRIEFING FORM

University of Northern Colorado
Learning to Hit in Volleyball with Verbal and Visually-Enhanced Feedback

The study you have just participated in was designed to evaluate the usefulness of visual feedback in volleyball. During the experiment, you completed a total of six sessions, where you received verbal feedback or verbal feedback with visual feedback. During each testing session you completed ten trials where the height of your contact with the ball was measured and the speed of the ball was measured. On the first and last day of the study you also completed an interview asking questions about how you learn to hit. During each learning session you completed three phases. In each phase you hit fifteen balls and completed a think-aloud procedure where you described your thoughts while hitting. After the first three sessions where you learned with one type of feedback, you learned with the other type of feedback in the next three sessions.

It is hypothesized that visual feedback is an effective way of helping athletes improve their skills. It was predicted that verbal and visual feedback would be more effective than verbal feedback alone. Additionally, it was predicted that visual feedback will be more effective for athletes who are visual learners while verbal feedback will be more effective for auditory learners. It was also hypothesized that athletes with more expertise in volleyball would benefit more from the visual feedback.

Previous studies have examined different types of feedback in a variety of sports. Studies have shown mixed results when examining the benefits of visual feedback for learning motor skills. Many of the studies that have been done in volleyball have not shown positive results for the use of visual feedback. Additionally, there are not studies that have examined visual feedback in athletes learning to hit in volleyball.

The effectiveness of the two types of feedback was measured based on the height of contact when the athlete hit the ball and based on the speed of the ball produced by the athlete's hit. The results of these measurements will be compared to the expertise level of the athlete and to their learning preference. In addition, responses from the think-aloud verbalizations and the How I Learn to Hit Interview will be analyzed to assess the learning process.

Please feel free to call or email me if you have any questions about this research. Please email me if you would like to receive the results of the study once it is completed.

Sincerely,

Michael Rhoads

Phone number: (303) 507-8398
E-mail: michael.rhoads@unco.edu

APPENDIX H

PARTICIPANT TREATMENT SESSION SCORES
FOR VELOCITY (MPH)

PARTICIPANT TREATMENT SESSION SCORES FOR VELOCITY (MPH)

Group	ID	Pretest Mean	Verbal Feedback Mean	Visual Feedback Mean
1	1	36.20	36.20	38.40
1	2	28.40	34.40	30.60
1	3	34.20	37.20	35.80
1	4	33.20	36.00	36.00
1	5	21.20	33.20	29.80
2	6	28.40	27.80	31.60
2	7	26.20	26.80	22.80
2	8	29.60	27.60	28.40
3	9	39.20	36.60	38.00
3	10	34.40	36.40	34.80
4	11	25.60	29.60	27.00
4	12	29.60	29.40	34.80
4	13	29.20	35.60	34.60
5	14	32.80	34.20	32.30
5	15	28.00	30.20	30.60
5	16	32.40	35.80	36.40
6	17	23.20	24.40	23.60
6	18	23.00	23.80	23.00
6	19	18.80	25.40	28.80
6	20	16.80	21.20	24.40
6	21	21.40	34.60	35.80
6	22	22.00	28.60	27.80
7	23	34.20	31.60	36.40
7	24	31.80	31.00	32.80
8	25	34.60	35.20	30.20
8	26	35.00	34.20	35.80
Total		28.82	31.42	31.56

APPENDIX I

PARTICIPANT TREATMENT SESSION SCORES FOR HEIGHT OF CONTACT (FEET)

PARTICIPANT TREATMENT SESSION SCORES FOR
HEIGHT OF CONTACT (FEET)

Group	ID	Pretest Mean	Verbal Feedback Mean	Visual Feedback Mean
1	1	5.02	5.22	4.82
1	2	4.95	5.02	4.56
1	3	4.95	4.59	4.53
1	4	4.95	5.15	4.92
1	5	4.13	4.40	4.46
2	6	4.07	4.20	4.17
2	7	4.33	4.30	4.33
2	8	4.00	4.30	4.13
3	9	4.92	4.92	4.79
3	10	4.66	4.63	4.46
4	11	3.81	3.94	4.10
4	12	4.33	4.53	4.66
4	13	4.53	4.46	4.49
5	14	4.63	4.56	4.43
5	15	4.66	4.59	4.76
5	16	4.76	4.79	4.89
6	17	3.67	4.07	3.97
6	18	3.41	3.94	3.31
6	19	3.51	3.58	3.81
6	20	3.25	3.77	3.61
6	21	4.00	4.10	4.10
6	22	3.18	4.10	4.04
7	23	4.43	4.56	4.40
7	24	4.56	4.95	4.86
8	25	4.43	4.63	4.49
8	26	4.79	5.02	4.82
Total		4.30	4.46	4.40

APPENDIX J

GROUP TREATMENT SESSION SCORES FOR VELOCITY (MPH)

GROUP TREATMENT SESSION SCORES FOR VELOCITY (MPH)

	Pretest		Verbal Feedback		Visual Feedback	
Group	Mean	SD	Mean	SD	Mean	SD
1	30.64	6.01	35.40	1.59	34.12	3.73
2	28.07	1.72	27.40	0.53	27.60	4.45
3	36.80	3.39	36.50	0.14	36.40	2.26
4	28.13	2.20	31.53	3.52	32.13	4.45
5	31.07	2.66	33.40	2.88	33.10	2.98
6	20.87	2.54	26.33	4.71	27.23	4.80
7	33.00	1.70	31.30	0.42	34.60	2.55
8	34.80	0.28	34.70	0.71	33.00	3.96
Total	28.82	5.90	31.42	4.61	31.56	4.75

APPENDIX K

GROUP TREATMENT SESSION SCORES FOR HEIGHT OF CONTACT (FEET)

GROUP TREATMENT SESSION SCORES FOR
HEIGHT OF CONTACT (FEET)

	Pretest		Verbal Feedback		Visual Feedback	
Group	Mean	SD	Mean	SD	Mean	SD
1	4.79	0.36	4.89	0.36	4.66	0.20
2	4.13	0.16	4.27	0.07	4.20	0.10
3	4.79	0.20	4.79	0.20	4.63	0.23
4	4.23	0.36	4.30	0.33	4.43	0.30
5	4.69	0.07	4.66	0.13	4.69	0.23
6	3.51	0.30	3.94	0.23	3.81	0.26
7	4.49	0.10	4.76	0.26	4.63	0.33
8	4.63	0.26	4.82	0.26	4.66	0.23
Total	4.30	0.56	4.46	0.43	4.40	0.43