MOTOR LEARNING OUTCOMES OF OVERHAND THROWING USING VISUAL AND VERBAL CUES WITH COLLEGE AGED NOVICES

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ABSTRACT

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science in Exercise Science to the Graduate College of East Stroudsburg University of Pennsylvania.

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Abstract:

Previous studies have shown that focus of attention, in the form of instruction and feedback, is highly effective in increasing learning (Shafizadeh, 2013). Cues facilitate the learning of motor skills (McCullagh, Stiehl, & Weiss, 1990; Masser, 1993; Zetou, Tzetzis, Vernadakis, & Kioumourtzoglou, 2002) because they direct the performer's attention to regulatory conditions in the environmental context and also to the key movement components of a skill (Shafizadeh, 2013). Cueing technique has frequently been shown to be effective in overcoming the potential problems associated with visual modelling in novice performers (Shafizadeh, 2013). This is also shown in verbal analogies as well. The purpose of the analogy is to make the performer focus on the movement instead of individual body parts such as the elbow or wrist during a throw. Studies demonstrated that focusing attention on movement goals (external focus) rather than on movements themselves (internal focus) led to faster learning (Shafizadeh, 2013). The current investigation is designed to analyze the learning benefits of visual and verbal external cueing incorporated into the overhand throwing routine of a novice while also examining kinematic changes and confidences of throwing. The investigation will include 15 male and female subjects, aged between 19-28 years of age. The testing involves 45 throws, as well as confidence scoring, over 3 testing days. 15 throws will be performed each testing session and separated into 3 sets of 5 throws with a 2-minute rest period between sets. The first session will serve as a pre-test, the second session will serve as the testing session, and the third session will serve as the retention test 48 hours following the second session. The retention test allows to establish whether learning has occurred over the course of the investigation.

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Introduction

Conveying the proper information to athletes to create a motor performance is a task that many coaches do not use properly or understand. A majority of coaches prescribe their athletes detailed instructions on how to use the perfect movement to perform a skill. An example of this would be a baseball coach trying to correct a pitcher that throws sidearm. What the coach does not understand that as long as that pitcher is successful and consistent at throwing a strike, that is the perfect throwing motion for the pitcher. The overhand throw is a motor skill of great complexity involving the entirety of the body to create a kinetic chain that begins with the legs and then progresses to the pelvis, trunk, and finally ending with the wrist and fingers. The torque from the pelvis and trunk pulls the proximal to distal portions of the throwing arm to create a ballistic motion to propel the baseball forward to its intended target (Fortenbaugh, 2011). In baseball making an accurate throw is a crucial portion of the game and an asset that all skilled players must possess; this skill being most important to be a successful pitcher (Seroyer, S. T., Nho, S. J., Bach, B. R., Bush-Joseph, C. A., Nicholson, G. P., & Romeo, A. A. 2010). Theoretically, an individual's maximum pitching velocity potential is a product of optimal pitching mechanics. The notion of optimal pitching mechanics for anyone is a concept that is difficult to address due to the dynamic and complex nature of the movements involved in throwing and the inherent differences in the anatomical, neuromuscular, and physiological makeup of each individual (Seroyer, S. T., Nho, S. J., Bach, B. R., Bush-Joseph, C. A., Nicholson, G. P., & Romeo, A. A. 2010). A pitcher's maximal velocity is indicative of kinematics, kinetics, and relative timing of segmental interactions that lead to effective transfer of momentum to the baseball. Slight changes in a pitcher's mechanics may result in higher or lower ball velocity. When analyzing baseball throwing, studies have reviewed the mechanics and kinematics of overhand throwing and discovered that the role of the trunk and elbow flexion torque, shoulder proximal force, and elbow proximal force were the only kinetic parameters significantly associated with increased ball velocity (Stodden, et al., 2005). Coordinated lower extremity muscles (quadriceps, hamstrings, hip internal and external rotators) provide a stable base for the trunk (core musculature) to rotate and flex (Seroyer, S. T., Nho, S. J., Bach, B. R., Bush-Joseph, C. A., Nicholson, G. P., & Romeo, A. A. 2010). The rotation of the pelvis, torso, and trunk forward tilt within the kinetic chain gives the thrower the torque and momentum to throw the ball at increased velocities (Stodden, et al., 2001). The extremely rapid rate of this motion makes assessment difficult. The time elapsed between front foot contact and ball release is only 0.145 seconds, followed by an additional half second for the ball to reach home plate (Seroyer, S. T., Nho, S. J., Bach, B. R., Bush-Joseph, C. A., Nicholson, G. P., & Romeo, A. A. 2010).

Maximum humeral internal rotation velocity during throwing may reach 7500 to 7700 degrees per second (Seroyer, S. T., Nho, S. J., Bach, B. R., Bush-Joseph, C. A., Nicholson, G. P., & Romeo, A. A. 2010). This is an attribute that a novice does not possess and is usually taught through self-exploration. It is plausible that novice learners can be guided without prescribing movements and enhance the self-exploration/self-organization process and produce consistently accurate throws as well as increasing velocity.

Visual and verbal cueing is a form of direction and feedback to help with skill acquisition and obtain performance proficiency. The transmission of augmented information to the learner, in the form of verbal instructions or visual demonstrations, has been the primary concern for motor learning theorists for many years (Newell, Morris, & Scully, 1985). This study will compare the effectiveness of visual and verbal cueing when teaching novices movement patterns of increasing complexity to efficiently use the kinetic chain to achieve peak velocity and accuracy. Using the constraints led approach, we can redefine motor learning as an ongoing dynamic process involving a search for stabilization of specific, functional movement patterns across the perceptual-motor landscape as each individual adapts to a variety of changing constraints (Davids, et al., 2008). The Constraints-Led Approach is defined as the simple proposition that the coordination and control of movements emerge from the confluence of constraints associated with the organism, the environment, and the task (Davids, et al., 2008).

Providing small verbal cues, we enhance the subject's ability to interpret their constraints, affordances and perception. When providing visual cues, the subject is aided with the process of observational learning by allowing the subject to learn from others' mistakes and successes. Observational Learning is the process of a person assimilating and sometimes adopting or replicating the behavioral patterns and actions of others as a direct consequence of observing those behaviors (Ashford, Bennet, & Davids, 2006) (Davids, et al., 2008). Findings of visual perception research on biological motion concerning what information is perceived from demonstrations have been conceptually linked with Newell's (1985) framework of motor learning stages (Al-Abood, Davids, Bennett, 2001). During skill acquisition, early learning requires the search for and assembly of a functional coordination pattern. In a laboratory setting where a pitcher would not be anticipating a batter to hit the pitch, the pitcher's environment would be considered stable and thus a closed motor skill (Moir, G., 2016). Expert performers are able to select and adopt relevant information from a context (e.g., an opponent's body) and disregard irrelevant cues better than novice performers ((Williams & Davids, 1998; Ward, Williams, & Bennett, 2002) Shafizadeh, 2013). Skill acquisition then becomes the ongoing process of attaining functional movement task solutions to satisfy the goal of motor skills (Davids, et al., 2008). The skill acquisition process in this study will be aided through external verbal and non-verbal ques. Previous studies have shown that focus of attention, in the form of instruction and feedback, is highly effective in increasing learning and these studies demonstrated that focusing on movement goals (external focus) rather than on movements themselves (internal focus) led to faster learning (Shafizadeh, 2013). A skilled performance is characterized by high levels of movement effectiveness and efficiency (e.g., Guthrie, 1952) (Wulf, G., 2013). Through guided self-exploration, subjects can discover the most efficient movements to perform the tasks at hand with the given constraints and change their perceptual attunement. Since the human body is seen as a complex system that has many independent components working at different structural and functional levels, therefore the actions the body need to be coordinated and controlled to be successful (Moir, G., 2016). These independent motor systems are represented by Degrees of Freedom (DOF). In order to successfully complete the task of overhand throwing, the subject must release and organize their DOF, thus coordinating their motor system (Moir, G., 2016). The external cues provided are aimed to aid novices in releasing and coordinating their DOF.

Internal and external attentional cues have been compared in many studies and have been shown to differ between novices and experts. When using an external attentional focus, an athlete will focus on variables external to the body and in particular to the outcome of movements that they are performing (Wulf, G., 2013). Conversely, when using an internal attentional focus, an athlete focuses on the variables associated with their body and movement itself (Wulf, G., 2013). Studies have provided converging evidence that an external focus of attention speeds up the learning process so that a higher skill level – characterized by both increased effectiveness and efficiency – is achieved sooner (Wulf, G., 2013 (Wulf, 2007b)). In this study we will be using external attentional focused ques because it has been shown to be the most effective. An external attentional focus most likely rules out the constraint imposed on the movement by an internal attentional focus; an internal focus might potentially interfere with the natural self-attentional focus organizing properties associated with the motor system that hinder the acquisition of a functional movement task solution (Southard, 2011). In general, verbal instructions that promote an external attentional focus have been shown to be more effective in promoting learning (as determined by retention and transfer tests) (Wulf, G., 2013). These instructions contain terms relating to the outcome of the movement rather than referencing specific body parts, as this would be too prescriptive. Other researchers have supported the use of biomechanical analogies in the verbal instructions presented to the athletes (Lam, Maxwell, & Masters, 2009). Such analogies reduce the prescriptive nature of the instructions and allow the natural self-organizing tendencies of the motor system to emerge (Moir, G., 2016). Subjects in the visual cuing group will be using observational learning to construct their motor coordination pattern. Observational learning by watching a model, in this case a video, will provide relative motion information to the learner that would not necessarily be present in verbal forms of instructions (Moir, G., 2016). This is important in the early stages of learning when the learner is assembling his or her coordination pattern and has been shown to result in in a more rapid acquisition of an appropriate coordination pattern (Sakadjian, Panchuk, & Pearce, 2014). These cues will be used to aid the process of Implicit learning externally. Learning is defined as a relatively permanent improvement in performance and is assessed through the use of retention and transfer tests (Magill, 2011). Implicit learning occurs when the athlete accumulates task-relevant information without conscious awareness of what has been learned (Moir, G., 2016). Implicit learning has been shown to be resistant to factors including anxiety, emotions, and changes in environmental constraints that act to perturb the learned movements (Moir, G., 2016 (Masters & Poolton, 2012)). This study will add to the body of literature suggesting the avoidance of motor skills being taught in an explicit and prescriptive manor and instead to promote self-exploration.

In order to assess the learned skills of the subjects they will need to have a retention test. A retention test entails the administration of a test after a period of time during which the performer has not been practicing the skill (Moir, G., 2016). The period of abstinence from practice allows for the dissipation of other factors that allow the performance level to be determined (Magill, 2011). This will test the adaptability of the skill learned by the subject and establishes whether learning has occurred or not.

Consequently, the investigation at hand is designed to compare the subject motor learning outcomes of accuracy, velocity, and kinematics of shoulder internal and external rotation by using verbal and non-verbal external cues to promote implicit learning. The perfect movement pattern is not the aim for the subjects. The aim for the subjects is to find the coordination pattern the provides them with the most consistent success rate.

Purpose

1. The aim of this study is to compare the kinematic outcomes of using visual and verbal cueing.
2. Examine new methods to educate novice performers to overhand throw.
3. Create a consistent pattern of accuracy & ball velocity with novice throwers.

Null Hypothesis

1. There will be no statistically significant difference between visual and verbal cueing groups in change in velocity and accuracy
2. There will be no significant difference in accuracy between verbal and visual groups
3. There will be no significant difference in velocity between verbal and visual groups
4. There will be no significant difference in confidence between verbal and visual groups
5. There will be no significant difference in kinematics between visual and verbal groups

6. Using visual and verbal cuing will have no effect on the subject's performance and learning

Operational Definitions

1. Verbal Cues – prompt phrases or words used to help subject find movement patterns
2. Visual Cues – video used to help subject find movement patterns through observation
3. Anchoring bias (Confidence score; 0-5) – Persuasive bias in which decision makers are influenced by random or uninformative numbers or starting points
4. High anchor – Independent variable, use of a high number to influence subject's ability to estimate
5. Low anchor – Independent variable, use of a low number to influence subject's ability to estimate
6. Observational Learning - the process of a person assimilating and sometimes adopting or replicating the behavioral patterns and actions of others as a direct consequence of observing those behaviors
7. Inexperienced/Novice Thrower – no participation in organized sports involving overhand throwing
8. Degrees of Freedom (DOF) – Each independent component of the human motor system
9. Target – 6 quadrant target 20 feet from subject

Delimitations

1. Subjects are aged 18-24 years
2. Subjects are novice in the skill of overhand throwing
3. Subjects will be free from any upper body musculoskeletal injury over the past 12 months

Limitations

1. Subject's focus and coordination on task at hand
2. Subject adherence to the program
3. Subject fatigue
4. Distance available to throw from lab constraints
5. Ability of subject to throw at a distance
6. Number of subjects

Summary

The study of external cueing methods of analogy and observational learning has gained attention due to the realization that humans learn motor tasks in numerous different ways. Previous studies (i.e., *Southard, D.,2011)* have shown that external cues, as opposed to internal cues, are superior in the learning process of improving throwing pattern and changing kinematics to increase throwing velocity. In explanation, an instruction given should be presented to promote a subject's focus on the task execution and outcome (external), rather than focusing on the motion of a specific body part (internal). When providing instruction for novices, the external cues provided should be relevant to executing techniques. Instructions provide task-relevant information to learners that can alter their intention and channel their search for an appropriate movement solution ((Newell & Ranganathan, 2010) Moir, G., 2016). Therefore, instructions represent a form of informational constraint (Moir, G., 2016).

Chapter II

Literature Review

The purpose of this study was to investigate the effects of verbal and non-verbal external cues on overhand throwing accuracy, velocity, kinematics, as well as a retention test, on inexperienced overhand throwers. This chapter will discuss literature related to the topic of overhand throwing and motor learning. The scholarly research that has been reviewed within the following chapter was used to design the study from the conclusions of others research and the factual data of the cognitive human motor system.

The subject procedures from *Southard, D. (2011). Attentional focus and control parameter: Effect on throwing pattern and performance. Research Quarterly for Exercise and Sport* for testing criteria to find substantial evidence using 30 subjects, throwing 15 times a trial, and receiving feedback every 5 throws which will reduce the risk of injury and provide statistically significant results. The 1st hypothesis that Southard proposed was to compare the effect of an internal focus of attention, external focus of attention, and/or scaling up a control parameter (velocity of throw) on changes in the throwing pattern during practice and at retention (following 1 week of no practice). The results of this experiment show that external cues are superior in the learning process of improving throwing pattern and changing kinematics to increase throwing velocity, but subjects who received feedback every 5th throw had the information become redundant. These results support the claim of using 15 throws for each subject and using external cues to change throwing patterns but the cues that will be used every 5th throw will be different than the one that they were previously given to avoid becoming redundant. Southard's second experiment's hypothesis is that when novice performers practice a skill, there is a strong likelihood that the individual's motor pattern will change (Hatze, 1971). The implication is that changes in performance are accompanied by changes in motor pattern that produce an increase in movement efficiency (Sparrow, 1983). This hypothesis states the reasoning of implying that a novice motor coordination will change from using external cues and practice and will have an increase of movement efficiency and accuracy.

A motor task is but a small portion of a motor system that is regarded as a complex system. A complex system is defined as any system that consists of many independent components operating at different structural and functional levels; The human motor system can be regarded as a complex system whose independent components (Degrees of Freedom) need to be coordinated and controlled to successfully execute the movements required to accomplish the goal of a motor skill (Moir, G., 2016). The human body is characterized a large amount of Degrees of Freedom that need to be coordinated to be successful at completing motor tasks. The coordination and control of Degrees of Freedom is achieved through the formation of coordinative structures, which is defined as a temporary organization of Degrees of Freedom that emerges through the process of self-organization under constraint (Turvey, Fitch, & Tuller, 1982). The process of self-organization associated with complex systems was a well-documented phenomenon in physical and chemical systems long before any attempts were made to empirically verify its presence in a system of human movement coordination (Schoner & Kelso, 1998). Self-organization implies spontaneous pattern generation as a consequence of the interaction of a very large collection of Degrees of Freedom that may adapt in response to changing internal and external conditions, by adopting coordination patterns without any explicit prescription of the emergent pattern (Schoner & Kelso, 1988).

Confidence Score: Anchoring

Before each trial, subjects will be asked how many times out of 15 throws they will hit the center of the target. This concept is known as anchoring and is defined as persuasive bias in which decision makers are influenced by random or uninformative numbers or starting points. The subject will rely on the initial score that they believed they would produce, use it as use it as an arbitrary focal point or benchmark, "anchor" themselves to it, and attempt to reach or beat the score. Anchoring seems especially relevant to a bargaining setting such as the purchase of residential real estate, where (1) the fair market value (FMV) of the piece of property is not objectively determinable, and (2) a bidding process is used to arrive at the property's actual selling price. The first value of the bidding process- the seller's asking or listing price-might serve as an anchor, effectively determining the neighborhood of appropriate prices for subsequent price negotiations (Lam, W. K., Maxwell, J. P., & Masters, R. 2009). In negotiations, anchoring is setting a boundary that outlines the basic constraints for a negotiation. The anchoring effect is where we set our estimation for the true value of the item at hand (Tversky, A., & Kahneman, D. 1974). In addition to the initial research conducted by Tversky and Kahneman, multiple other studies have shown that anchoring can greatly influence the estimated value of an object (Orr, D., & Guthrie, C. 2005). If a subject estimates that they will only hit the center of the target 7 times or less out of the 15 throws, this is considered a low anchor, and if the subject estimates that they will hit the target greater than 7 times out of 15 throws, this will be considered a high anchor. The outcomes can be explained by the Insufficient Adjustment Theory and the Numeric Priming Theory. The Insufficient Adjustment Theory, which is defined as anchoring because we fail to adjust and first focus on the anchor and then make a series of dynamic adjustments toward their final estimate. Because these adjustments are insufficient, the final answer is biased toward the anchor (Orr, D., & Guthrie, C. 2005). This would mean that a subject focused on the anchor too much and made adjustments that made the thrower throw closer to the anchor rather than exceeding the number that they have chosen out of 5. In previous motor learning studies, anchoring has been shown that many subjects will end up with a successful amount of trials that almost match the anchor that they had chosen.

This confidence scoring is also used to assess he subjects interest in the task at hand. During the learning process, research has shown that learners must have a 50% success rate in order to keep the subjects interested in learning and to have the motivation to continue with the task. If a subject has a low success rate, it is most likely that they will no longer be interested in the task and provide less effort.

Unconscious learning

The learning process that this study will abide is the Constraints-Led Approach which is based upon non-linear pedagogy. This is a learner-centered approach to skill acquisition that uses task and environment to develop skill acquisition. Coordination and control of movements emerge from the confluence of constraints associated with the organism, the environment, and the task (Davids, et al., 2008). A constraint is defined as a variable that limits the configuration of the motor system, guiding the movements of the performer as he or she executes a motor skill (Newell, 1986). Organismic constraints are associated with the performer and include the physical properties of the motor system as well as biomechanical and logical variables (Moir, G., 2016). According to Schoner and Kelso (1988), the many possible coordination patterns of a movement system will eventually converge around a limited set of stable coordination patterns (Moir, G., 2016). This convergence is known as an attractor state. These attractor states can be illustrated on a topological graph of the perceptual motor workspace as wells. The perceptual motor workspace contains the constraints, information of the motor skill, and the intrinsic dynamics of the individual subject for the motor skill that is to be learned. The goal of unconscious learning is for the subject to self-explore their perceptual motor workspace and discover new information to complete the motor task. The constraints that are given to subjects can be changed in order to help with the learning process and change intrinsic dynamics. Providing different analogies of movement or different visual demonstrations may provide new information and allow a subject to perceive the task in a new way.

Attentional Focus

The attentional focus of an athlete refers to the location of the sources of information to which the athlete attends when executing a motor skill (Moir, G., 2016). In this study the subjects are provided 2 things that they are able to attune themselves to during the throwing trials. These may include the target in which they are throwing at and either the video shown, or the verbal analogies spoken to them. In this case the purpose of the cues given are to encourage an external attentional focus. As previously mentioned, adopting an external attentional focus is more effective during learning than an internal attentional focus which focused on the movement itself (Wulf, G., 2013). Research has shown that focus of attention of movement goals (external focus) contrasting focus on movements themselves (internal focus) leads to increased rates of learning. Associating observational learning and attentional focus for the purpose of teaching motor skills is imperative for multiple reasons. Firstly, the focus of attention has been used in previous studies for other methods of explicit learning as a form of instruction or feedback and it is important to examine its functionality in other forms of explicit learning such as demonstration because it can facilitate the acquisition of a movement idea before attempting to perform a skill (Shafizadeh, 2013). Secondly, cognitive mediating theory does not consider the focus of attention during the acquisition stage of observing a model (Shafizadeh, 2013). Lastly, according to the specificity of learning hypothesis (Proteau, 1992), compatibility between the technique of the skill presentation and the learning context is important in the learning process (Shafizadeh, 2013). The verbal instruction and feedback provided to a subject, in terms of sensory modality, may not meet the attentional demands for the motor skill at hand. A visual representation may be best suited for certain situation because it relies upon visual sensory instead of verbal interpretation of a movement description or analogy. On the other hand, the focus of attention during a demonstration requires overt attention, whereas verbal instruction and feedback mostly require covert attention (Shafizadeh, 2013).

Visual and verbal provisions of instruction and feedback have been shown to be successful. Although some subjects may be more proficient with one way of learning than the other. Providing information that a subject may not perceive correctly may perturb the learning process by possibly causing the subject to think internally rather than externally.

External Focus

External attentional focus is defined as having an athlete focus on variables external to their body and in particular outcome to the of the movements they are performing (Wulf, G., 2013). When defining an internal attentional focus, an athlete focuses on variables associated with their body and movement itself (Wulf, G., 2013). An external attentional focus likely rules out the constraint imposed on the movement by an internal attentional focus; an internal focus might potentially interfere with the natural self-organizing properties associated with the motor system that hinder the acquisition of a functional movement task solution (Southard, 2011). Southard (2011) discovered that providing the same verbal ques during a 15-pitch throwing trial becomes redundant. In order to limit redundancy, 3 different verbal ques will be used for one subject. This will satisfy learning-transfer experiences of different subjects because not all subject will share the same life experiences as others and can better relate to certain analogies of throwing (Rosalie, S. M., & Müller, S. 2012). Providing a larger range of analogies will provide the subject with a broader range of successful responses (Rosalie, S. M., & Müller, S. 2012). As well as avoiding redundancy for this study, redundancy of cueing for further research will be considered as well by asking subjects after the pre-test trial what they think about during the pitching trial. This will help tailor ques to specific athletes and create new ques for further research and provide knowledge of self-motivation during subject activity.

Feedback

Feedback is the information that is provided to the learner after the performance of a motor skill in relation to the task goal (Moir, G., 2016). During the testing process for this study, the only feedback that will be provided to the subject will be from themselves or the cueing that they receive. This is contingent upon how they react to the cues and apply them to their motor skills through the learning process. The outcome of the movement relative to the goal of the motor skill, known as knowledge of results, provides feedback to the performer (Moir, G., 2016). The knowledge of results that the subjects will have will be hitting or missing the target they are throwing at. Due to the fact the subjects do not receive feedback on their movements this cannot be considered knowledge of performance.

Figure 1: *Perceptual Motor Skill Framework*

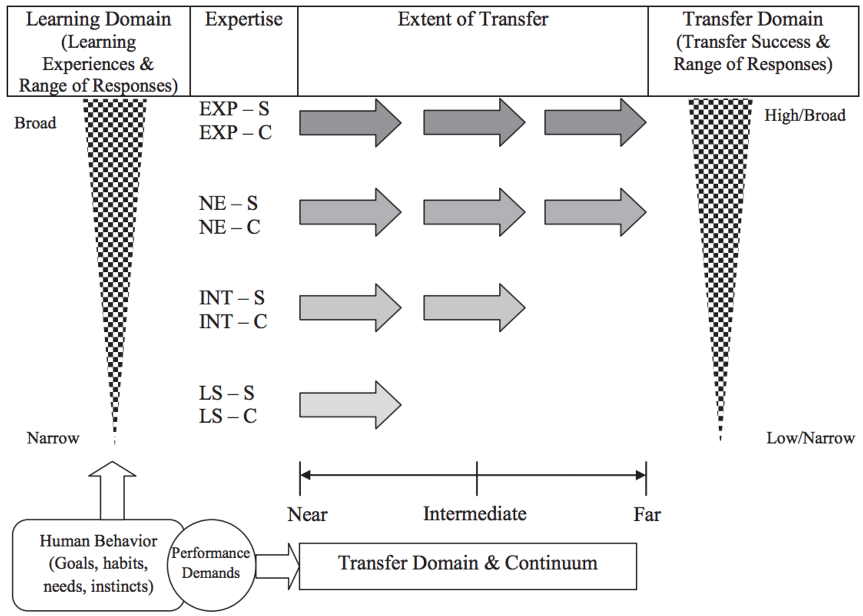


Figure 1. Schematic representation of the framework for transfer of perceptual-motor skill learning. In the learning domain, skill acquisition across the expertise spectrum (expert to low skilled) is driven to satisfy human behaviors (goals, needs, habits, and instincts) and is motivated by performance demands. Increasing expertise levels may be characterized by broader learning-transfer experiences (adaptation) over several performance trials (checkered boxes), which may develop a broad range of successful responses. This breadth of experiences may then contribute to transfer of perceptual-motor skill learning through different anticipatory mechanisms (subconscious and conscious), which, in turn, may contribute to the extent (near, intermediate, and far transfer) and success of transfers (checkered boxes) within the transfer domain. Abbreviations, EXP, NE, INT and LS refer to expert, near-expert, intermediate and low skilled, respectively. Abbreviations, S and C refer to subconscious and conscious transfer mechanisms, respectively.

Rosalie, S. M., & Müller, S. (2012).

Expert performers are able to select and adopt relevant information from a context (e.g., an opponent's body) and disregard irrelevant cues better than novice performers (Williams & Davids, 1998; Ward, Williams, & Bennett, 2002).

Chapter III

Methodology

The purpose of this study is to investigate the effects of verbal and visual external cuing on inexperienced overhand throwing accuracy and velocity using a regulation tennis ball. This chapter will discuss the collection and analysis of data that was collected in the research laboratory of The East Stroudsburg University of Pennsylvania.

Subjects

This study included 15 healthy college aged (18-28 years) males and females.

Inclusion criteria consists of having no prior experience with overhand throwing. This means that the subject cannot have participated in organized sports that required overhand throwing.

Exclusion criteria consists of the subjects having prior injury or surgery to the throwing arm. Other injuries that could affect the motion of throwing will also exclude the subject from testing.

Subject Demographics

15 subjects that included 8 males and 7 females. The average subject age being 23 ± 2.1 years.

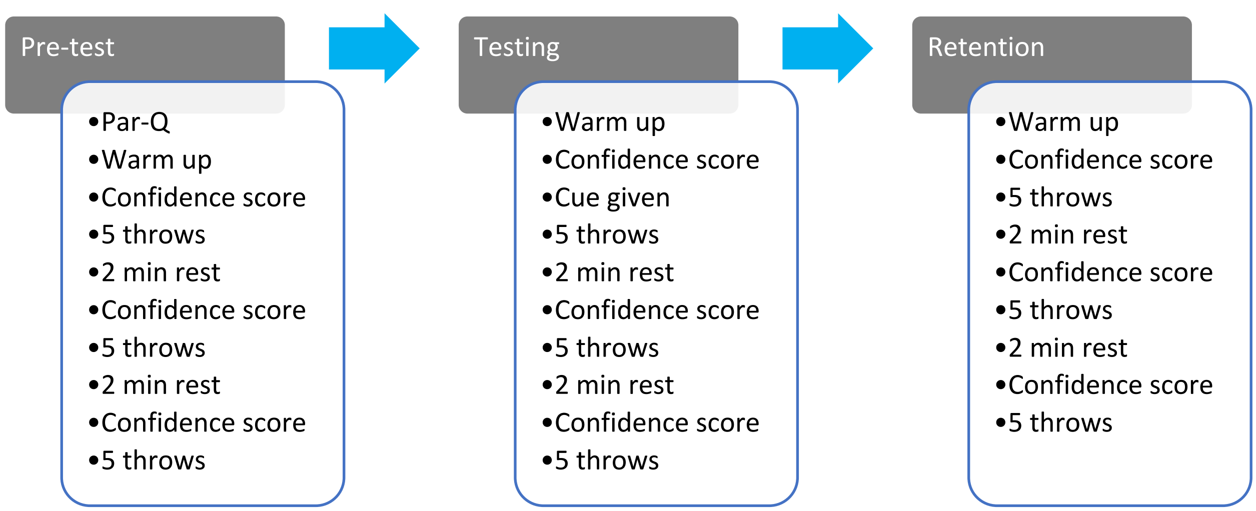
Subject Recruitment

Subjects will be recruited from classrooms within the exercise science department and were asked to fill out a questionnaire asking them of their age, training status, sports played currently and or previously, right or left-handed throwing dominance, and previous injuries or abnormalities.

Procedures

The following procedures were conducted after recruiting and include 3 days of testing. The first day of testing was used to establish the baseline for subjects and for group placement. The second day of testing was used to provide visual or verbal instruction to aid in the process of learning. The third and final day of testing was a retention test that was done 48 hours after the previous session to establish is learning had occurred.

Flow Chart



Detailed Procedures

1. Group 1: Control
    a. Pretest
        i. Par-Q
        ii. Subject warm up
        iii. Subject asked confidence score
        iv. Subject instructed to throw the ball at the target 5 times
        v. Subject 2-minute rest period
        vi. Subject asked confidence score
        vii. Subject instructed to throw the ball at the target 5 times
        viii. Subject 2-minute rest period
        ix. Subject asked confidence score
        x. Subject instructed to throw the ball at the target 5 times
        xi. Subject asked what they think about when throwing the ball
    b. Testing
        i. Subject warm up
        ii. Subject asked confidence score
        iii. Subject instructed to throw the ball at the target 5 times
        iv. Subject 2-minute rest period
        v. Subject asked confidence score
        vi. Subject instructed to throw the ball at the target 5 times
        vii. Subject 2-minute rest period
        viii. Subject asked confidence score
        ix. Subject instructed to throw the ball at the target 5 times
    c. Retention Test
        i. Subject warm up
        ii. Subject asked confidence score
        iii. Subject instructed to throw the ball at the target 5 times
        iv. Subject 2-minute rest period
        v. Subject asked confidence score
        vi. Subject instructed to throw the ball at the target 5 times
        vii. Subject 2-minute rest period
        viii. Subject asked confidence score
        ix. Subject instructed to throw the ball at the target 5 times
2. Group 2: Visual
    a. Pretest
        i. Par-Q
        ii. Subject warm up
        iii. Subject asked confidence score
        iv. Subject instructed to throw the ball at the target 5 times
        v. Subject 2-minute rest period
        vi. Subject asked confidence score
        vii. Subject instructed to throw the ball at the target 5 times
        viii. Subject 2-minute rest period
        ix. Subject asked confidence score

x. Subject instructed to throw the ball at the target 5 times
xi. Subject asked what they think about when throwing the ball

b. Testing
   i. Subject warm up
   ii. Subject asked confidence score
   iii. Subject shown short video clip of over hand thrower
   iv. Subject instructed to throw the ball at the target 5 times
   v. Subject 2-minute rest period/subject shown short video clip of over hand thrower
   vi. Subject asked confidence score
   vii. Subject instructed to throw the ball at the target 5 times
   viii. Subject 2-minute rest period/subject shown short video clip of over hand thrower
   ix. Subject asked confidence score
   x. Subject instructed to throw the ball at the target 5 times
c. Retention Test
   i. Subject warm up
   ii. Subject asked confidence score
   iii. Subject instructed to throw the ball at the target 5 times
   iv. Subject 2-minute rest period
   v. Subject asked confidence score
   vi. Subject instructed to throw the ball at the target 5 times
   vii. Subject 2-minute rest period
   viii. Subject asked confidence score
   ix. Subject instructed to throw the ball at the target 5 times

3. Group 3: Verbal
   a. Pretest
      i. Par-Q
      ii. Subject warm up
      iii. Subject asked confidence score
      iv. Subject instructed to throw the ball at the target 5 times
      v. Subject 2-minute rest period
      vi. Subject asked confidence score
      vii. Subject instructed to throw the ball at the target 5 times
      viii. Subject 2-minute rest period
      ix. Subject asked confidence score
      x. Subject instructed to throw the ball at the target 5 times
      xi. Subject asked what they think about when throwing the ball
   b. Testing
      i. Subject warm up
      ii. Subject asked confidence score
      iii. Subject read verbal cue 1
      iv. Subject instructed to throw the ball at the target 5 times
      v. Subject 2-minute rest period
      vi. Subject asked confidence score
      vii. Subject read verbal cue 2

viii. Subject instructed to throw the ball at the target 5 times
ix. Subject 2-minute rest period
x. Subject asked confidence score
xi. Subject read verbal cue 3
xii. Subject instructed to throw the ball at the target 5 times

c. Retention
   i. Subject warm up
   ii. Subject asked confidence score
   iii. Subject instructed to throw the ball at the target 5 times
   iv. Subject 2-minute rest period
   v. Subject asked confidence score
   vi. Subject instructed to throw the ball at the target 5 times
   vii. Subject 2-minute rest period
   viii. Subject asked confidence score
   ix. Subject instructed to throw the ball at the target 5 times

This is a study designed to guide novice overhand throwers through the self-exploration process and explore the best means of guidance in this motor skill. The protocol was completed in the research laboratory in of Koehler Fieldhouse at East Stroudsburg University of Pennsylvania. The subjects reported to the laboratory for testing 3 times each. Before testing could begin each subject was explained the possible risks and benefits of testing for the study. Each subject was asked to carefully read and complete a Par-Q and written consent forms. The subjects were thoroughly informed that participation in the study was voluntary and they could drop out whenever they pleased. The subjects were then familiarized with the protocol and asked to complete the pretest. Following the pre-test, the subjects were asked to schedule their next testing appointment. Subjects were then placed into 1 of 3 groups depending on the scores they received, 30 being the highest possible score. The subjects were carefully distributed into groups to equally distribute the subjects with high and low scores. The subjects were unaware of the group to which they were assigned. Then the subjects would report for the third day of testing which would serve as the retention test.

Pre-Test

Subjects were provided and signed a waiver of consent and explained that they could drop out of the study at any time. Subjects were also provided with a PAR-Q & You sheet (Appendix 1) that was completed and signed by all subjects. Subjects were given time to warm up and were asked a confidence score for the 5 times they would throw the ball in each of the 3 sets. Subjects were provided with a tennis ball once they have familiarized themselves and warmed up. The subjects were instructed to throw the ball at the target and hit the center of the 6 quadrants. No coaching or cueing was used during the pre-test. The subject must wait to throw the next pitch until the researcher gives them permission to do so. Subjects were instructed to take a 2-minute rest period after they had thrown 5 pitches and were informed when to begin again. After the pre-test session, subjects were asked what they were thinking about or focusing on during the throwing trials.

Testing

Subjects were given time to warm up and were asked a confidence score for the 5 times they would throw the ball in that set and were asked again before the next 2 sets. The target was placed 20 feet away from a marked point on the floor that the subject placed their rear foot on. Subjects were provided with a tennis ball once they have familiarized themselves and warmed up. The subjects were instructed to throw the ball at the target and hit the center of the 6 quadrants. The subject must wait to throw the next pitch until the researcher gives them permission to do so. Prior to throwing the first 5 pitches the subjects were shown a video of an overhand thrower or given verbal cues. They would be provided this information again during the 2-minute rest periods after the 5th and 10th pitches. No researcher feedback will be given to subjects during or after testing. Only knowledge of results will be provided by the subject themselves by whether or not they strike the center of the target. Subjects were told to refrain from practicing any throwing in the days before the third testing session.

<u>*Verbal Cues Used*</u>

1. Pre-first 5 pitches – “Use your body like a whip”
2. Post-first 5 pitches – “Use the ball to touch the target”
3. Post-last 5 pitches – “Shift your weight forward, pulling the ball forward”

<u>*Retention*</u>

Three days after the testing period, subjects were given time to warm up and were asked a confidence score for the 5 times they would throw the ball and again before the next 2 sets. Subjects were provided with a tennis ball once they have familiarized themselves and warmed up. The subjects were instructed to throw the ball at the target and hit the center of the 6 quadrants. No coaching or cueing was used during the retention test. The subject must wait to throw the next pitch until the researcher gives them permission to do so. Subjects were instructed to take a 2-minute rest period after they had thrown 5 pitches and were informed when to begin again.

Data Collection

All throwing blocks were recorded for each subject.

Figure 2. Subject joint angle measurement

Figure 2 shows the measurement of subject joint angle using Dartfish software. Starting from the olecranon process, the angle was measured by placing markers at the acromion and between the distal ends of the radius and ulna.

Data & Measures

The data collected in the research laboratory was analyzed by a 1-way ANOVA using the SPSS 24.0 (IBM Corporation) software. Subjects were recorded by 2 video cameras that uploaded images to the Dartfish software that was able to analyze kinematic data. One camera was placed posteriorly to the subject to capture the lower extremities and to record the location of the ball when it struck the target. The second camera was placed to the side of the throwing arm to capture the open stance of the subject in order to record the internal and external rotation of the glenohumeral joint. The velocity of the tennis ball was recorded using a pitching radar gun in miles per hour. The scores of subject throwing sessions was calculated by a 6-quadrant pitching target that included a target in the very center of the 6 quadrants. If a subject hit the very center of the target they would receive 2 points. If a subject hit inside any of the quadrants they would receive one point. If the subject missed the quadrants they would receive no points. The confidence or self-efficacy score was asked before each set of 5 throws, allotting to a total of 9 sessions of 5 throws. The subject was asked how many time they felt that they would hit the target out of the 5 throws. Zero being the least confident and five being the most confident.

Data Analysis

SPSS 24.0 (IBM Corporation)

Instrumentation

Dartfish system – two cameras

Radar gun

Pitching target

Confidence score questionnaire

Measures

Accuracy – Pitching target: yes/no

Velocity – Radar gun: Average velocity across 15 pitches each session

Kinematics – Dartfish System: Internal, external shoulder rotation, stride length

Confidence Score – Questionnaire: Scale of 0-5 confidence of hitting the target out of the 5 throws per set

Protocols

A normal collegiate pitching mound is 60 feet and 6 inches away from home plate and a little league mound is 46 feet from home plate. In order ensure that the subjects will hit the target at a 50 percent success rate, the distance that subject stands away from the target is 20 feet, increasing the perceived affordances of the motor task at hand. This shortened distance is used to ensure quality data, to keep subjects interested in learning, to avoid overuse injury, drop out and is also due to laboratory constraints. Stride length of the pitches will be measured through video analysis via 5 markings on the floor spaced 1 foot apart. The markings were not to be used as visual cuing or learning objectives.

Chapter IV

Results

The purpose of this study was to compare the kinematic outcomes of using visual and verbal cueing to educate novice performers to overhand throw and create a consistent pattern of accuracy as well as increasing the ball velocity. Performance was evaluated in the terms of accuracy, kinematic changes, and ball velocity. This chapter will present the statistical analysis for changes in velocity, joint angle, and accuracy changes across pre, mid, and post (retention test) sessions between visual, verbal and control groups.

In the pairwise comparison of the velocity factor revealed that the 2.75 increase between pre-testing and mid testing were approaching statistical significance with a p-value of .086. The change from pre-testing to retention which was 2.06 was not statistically significant with a p-value of .237. There were no statistically significant differences for joint angle, scores and no main effect for time.

Although there was no statistical significance the control group shows on average that there is a linear trend of becoming more accurate in terms of score. The verbal group shows a decrease in score during pre to mid and mid to retention, though the verbal group started at a higher point than the other two groups. The visual group does become more accurate in terms of score from mid-testing to retention test but because of the variation none of these differences are statistically significant. Although remaining insignificant, as confidence score would rise accuracy would increase as well. As these two factors would increase the velocity of the ball would decrease. The opposite effect would occur if velocity increased. Accuracy and confidence would decrease the ball velocity increased.

Table 1. Averages of measures

Group	Velocity 1	Velocity 2	Velocity 3	Joint Angle 1	Joint Angle 2	Joint Angle 3	Score 1	Score 2	Score 3	Con. 1	Con. 2	Con. 3
Control	41.584	43.264	43.316	60.412	60.898	60.1	8.4	9	9.6	2.7	2.58	2.76
Verbal	32.646	35.09	35.782	72.014	75.056	74.762	11	9.6	8.6	2.76	2.7	2.66
Visual	29.796	33.914	31.102	55.668	60.72	58.566	7.6	7	9.8	2.22	2.64	3.24

Table 1 shows the means of group measures. Velocity, Joint angle, Score, and Confidence score.

Table 2. Means & changes of score

Group	Day 1-2	Day 2-3	Overall
Control	0.6	0.6	1.2
Verbal	-1.4	-1	-2.4
Visual	-6	2.8	2.2

Table 2 shows the changes of overall score and day to day between groups.

Table 3. Means and changes of velocity

Group	Day 1-2	Day 2-3	Overall
Control	1.68	0.052	1.732
Verbal	2.444	0.692	3.136
Visual	4.118	-2.812	1.306

Table 3 shows the changes of overall velocity and day to day between groups.

Table 4. Means and changes of joint angle

Group	Day 1-2	Day 2-3	Overall
Control	0.486	-0.798	-0.312
Verbal	3.042	-0.294	2.748
Visual	5.052	-2.06	2.898

Table 4 shows the changes of overall joint angle and day to day between groups.

Table 5. Means and changes of confidence score

Group	Day 1-2	Day 2-3	Overall
Control	0.12	0.18	0.06
Verbal	-0.06	-0.04	-0.1
Visual	-0.42	0.6	1.02

Table 5 shows the changes of overall joint angle and day to day between groups.

Figure 3. Averages of scores between groups

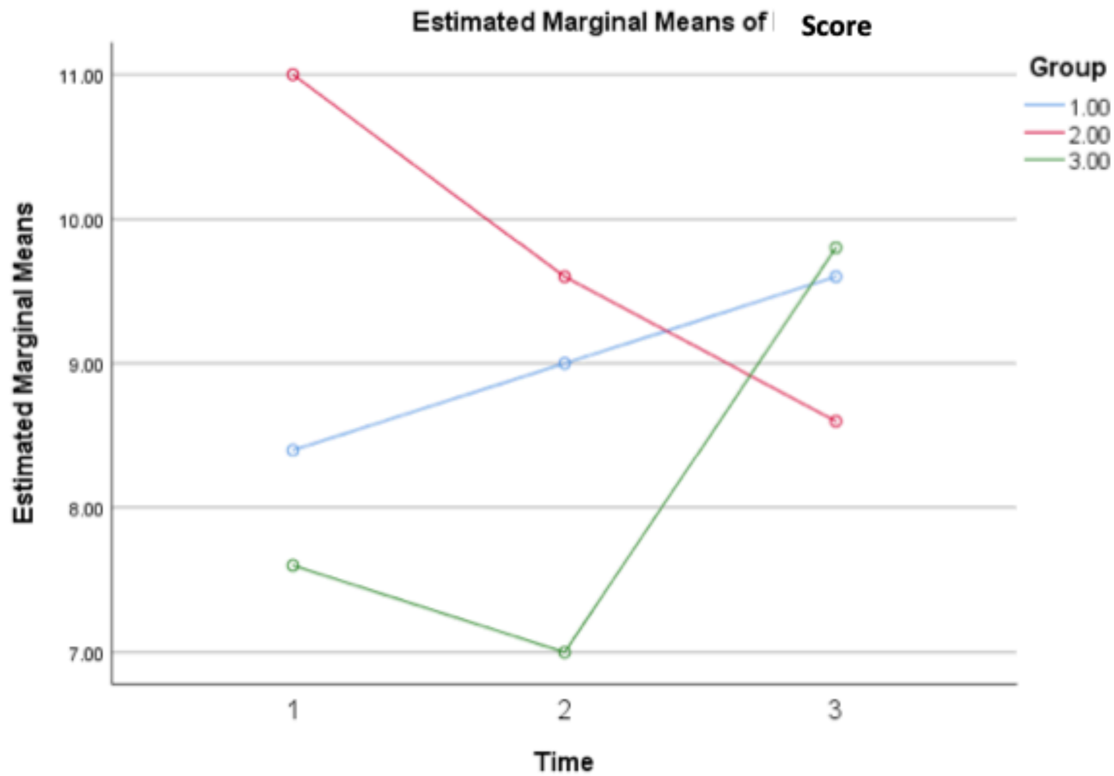


Figure 3 shows the averages of scores between the Control (group 1), Verbal (group 2), and Visual (group 3). The Verbal group began as the highest scoring group and dropped to the lowest scoring group after retention testing.

Figure 4. Averages of velocity between groups

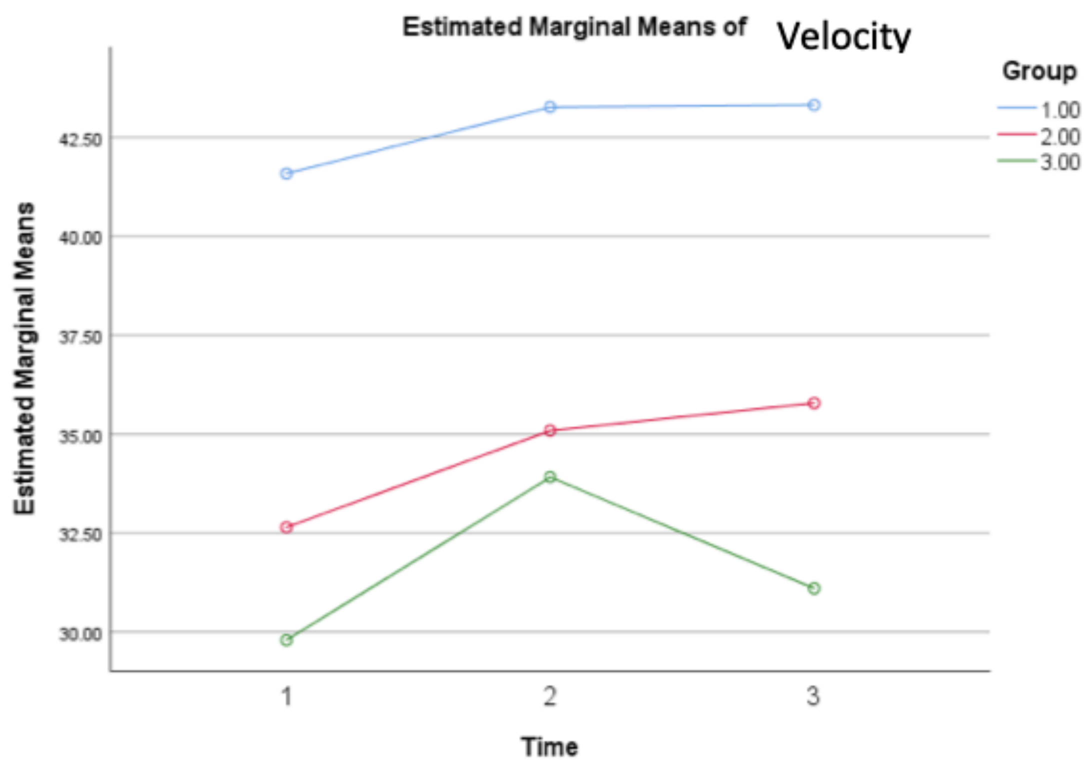


Figure 4 shows the averages of velocities between the Control (group 1), Verbal (group 2), and Visual (group 3). All groups show an increase in average velocity from pre-test to retention test.

Figure 5. Averages of joint angle between groups

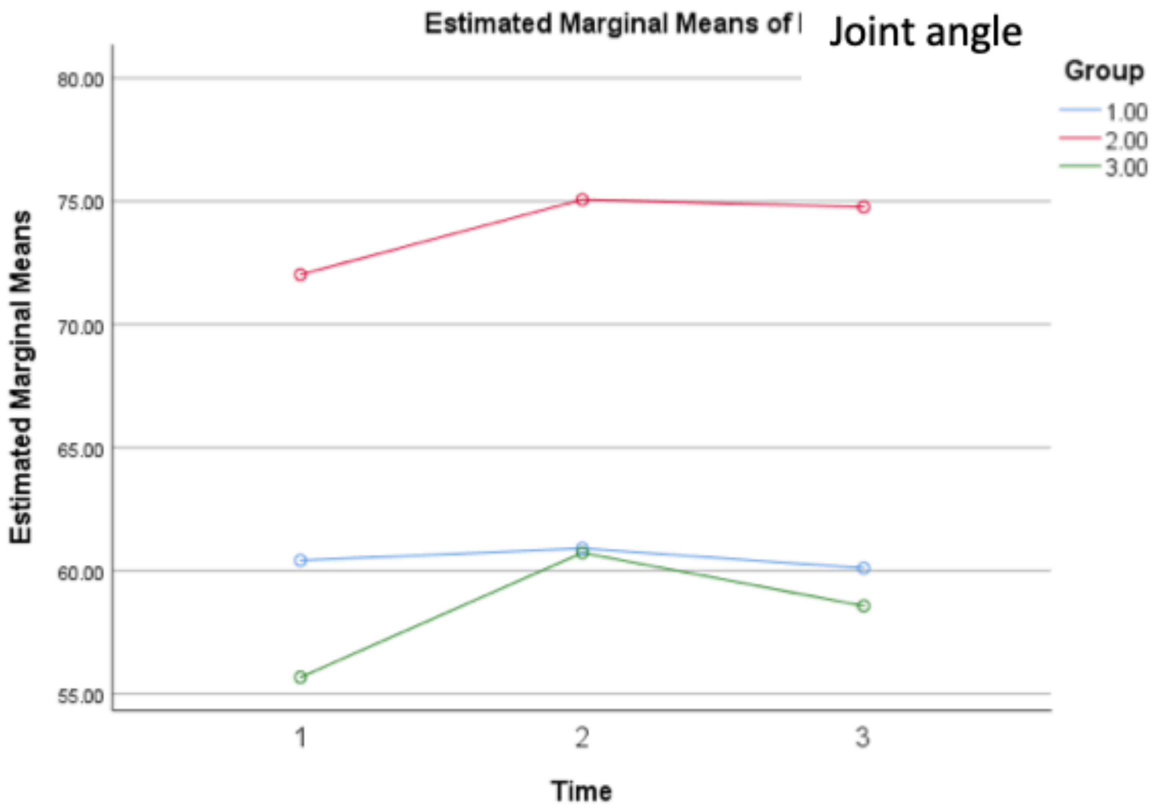


Figure 5 shows the averages of joint angle between the Control (group 1), Verbal (group 2), and Visual (group 3). The Verbal and Visual group showed an increase in joint angle from pre-test to retention test but, the Control group remained almost unchanged through 3 testing sessions. The Control group showed the most consistent increase in average score and maintained the highest average velocity.

Figure 6. Changes of average confidence score between groups

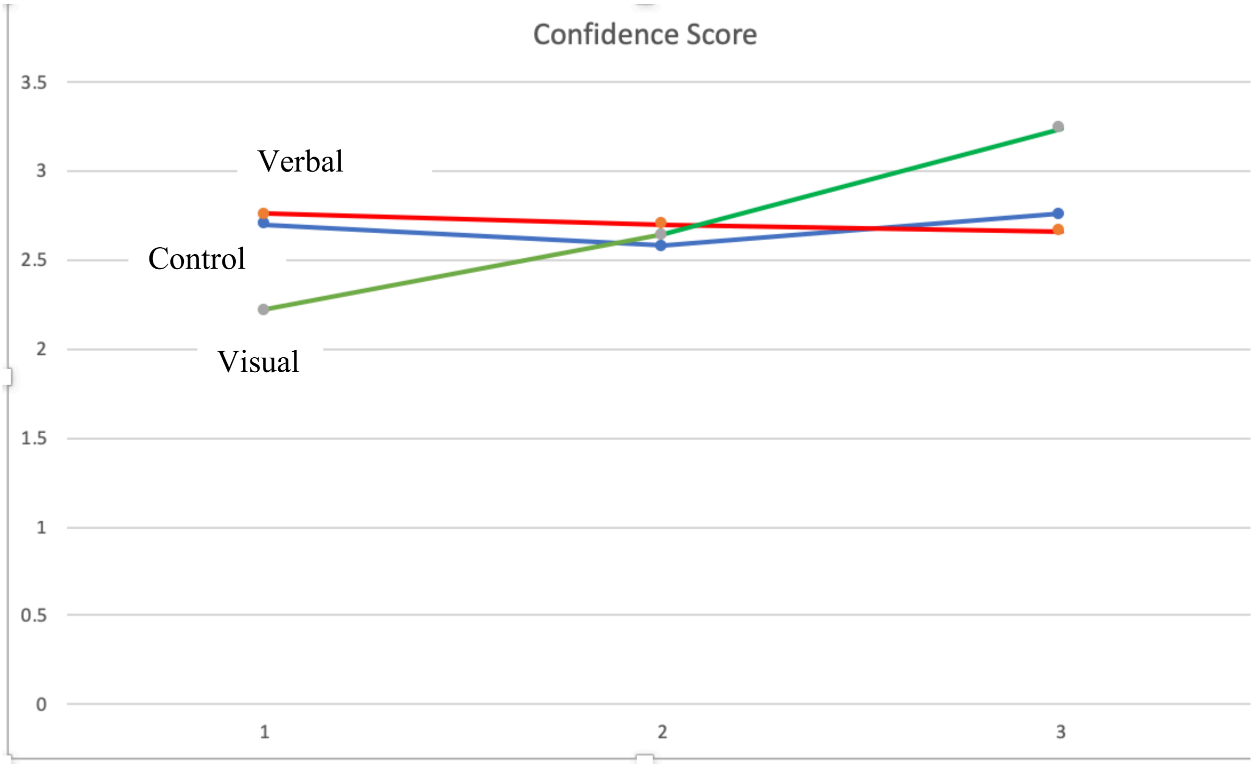


Figure 6 shows the changes of average confidence score between Control (blue), Visual (green), and Verbal (red) groups. There is no statistically significant difference between the groups. The visual group showed the most consistent and highest increase of confidence while the verbal began with the highest confidence, it became the group with the lowest confidence after retention.

Chapter V

Discussion

The purpose of this study was to investigate and compare the kinematic outcomes of using visual and verbal external cueing to educate novice performers to overhand throw and create a consistent pattern of accuracy as well as increasing the ball velocity in both acute and retention performance.

The cues that were given were in the form of verbal analogies and a video of a professional pitcher in slow motion. Subjects were asked how many times they felt they would place the ball inside the 6-quadrant target prior to throwing and were asked to hit the center of 6 quadrants. The number they chose (0-5) would be their confidence score for that set of 5 pitches. Following the 3 sets of 5 pitches the subjects were separated into groups by accuracy scoring outcome. The confidence score that subjects gave for each set cannot be used to objectively compare with accuracy scores. Most subjects were not very confident on a scale of 0-5 but all subjects believed that they could successfully strike the target with the ball at least once in 5 throws.

There were no statistically significant differences in accuracy, velocity or joint angle in visual, verbal or control groups. The control group did show an increase in accuracy score that continued through all 3 sessions. It can be said that the increase occurred due to simply more experience throwing from the testing sessions. Due to the fact that the subjects are novices there is not much room for a subject to decrease in success. It can also be said that they were simply able to focus more on hitting the target with no verbal or visual cues possibly causing perturbations.

There were only 3 subjects that had changed somewhat significantly in any factor that was observed. 2 subjects increased accuracy scores by 8 and 9 points from pre-test to retention and both subjects were included in the visual group. The subject with the most dramatic decrease in accuracy score was in the verbal group and dropped by 6 points from pre-test to retention. The verbal group was shown to have started with the highest scores and dropped the most significantly and finished with an average score lower than the visual and control group. Perhaps the verbal analogies were causing more perturbation to the perceptual motor workspace or perception action coupling and caused the subjects to interpret the cues internally and more explicitly rather than externally.

Although the visual group showed the greatest increase of average score, with 4 subjects having an increase of greater than 40% from mid-test to retention test. These increases were not truly significant. A subject from the Visual group had a pre-test score of 3 and had a retention test score of 12, being a 300% percent increase. Other subjects from this group had a pre-test score of 5 and 2. The subject with a pre-test score of 2 ended with a retention test score of 10, being 400% increase. The subject that began with a pre-test score of 5 had a mid-test score of 1 and a retention test score of 2. The increase of 1 to 2 is a 100% increase. The visual group began with such low scores and had such high percentage increases from mid-test to retention test causing figure 3 to show the Visual group as the greatest increase of score. This group began with lower scores than the other 2 groups, therefore the slightest increase of score would show as a drastic increase with graphed.

Figure 7. Averages of velocity, joint angle, and score with individual groups

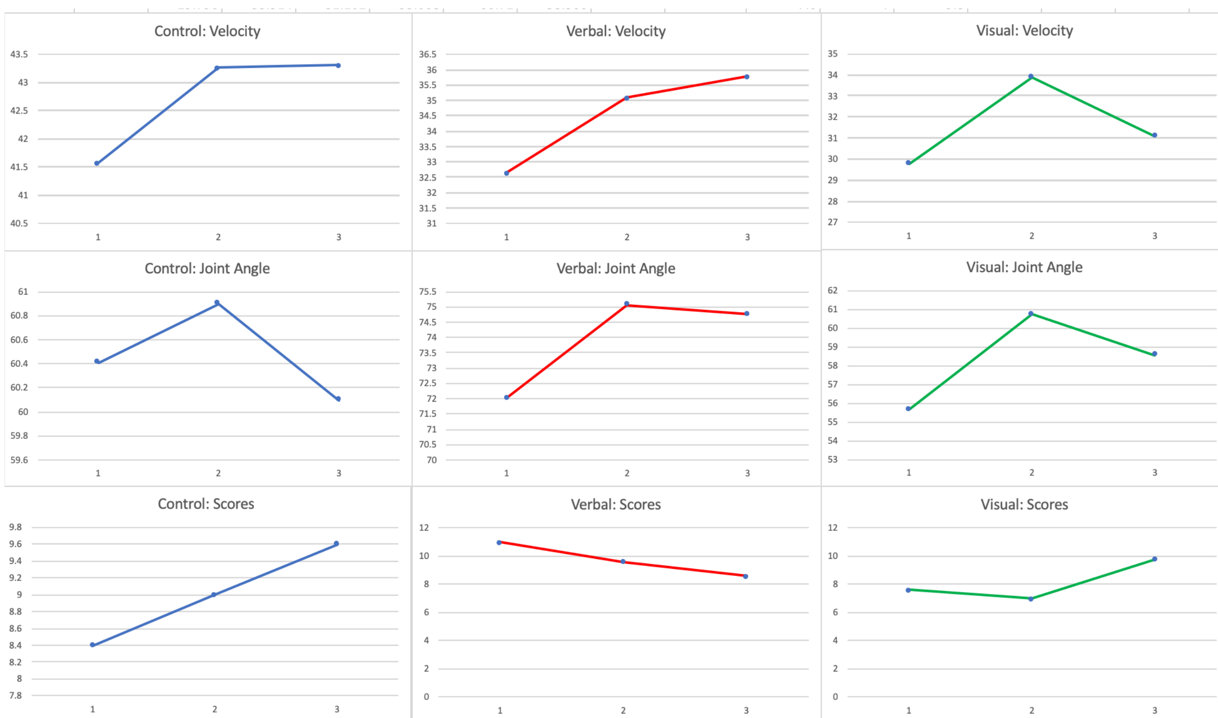


Figure 7 shows the averages of velocity, joint angle, and scores with individual groups to represent the changes within each group and in comparison, to the other groups throughout the 3 testing sessions.

While some results could be found as significant to an individual standpoint, there were no significant differences found in all of the 3 groups. Certain limitations, such as location and individual subject factors, must be taken into consideration when dissecting this study. This study was performed indoors in a laboratory and regulation baseballs could not be used due to laboratory constraints. This renders the results relatively useless in regard to actual baseball pitching performance mostly due to the different consistency and weights of a baseball compared to a tennis ball as well as distance from “mound” to target.

Other factors of limitation include the focus of the individual subject with the motor task at hand, stress levels, age, previous experiences and the amount of sleep that the subject had following the motor tasks. Studies have shown that motor learning can be enhanced by NREM sleep. This has been shown in humans as well as rodents with odor-reward association tasks. Together, these findings support the hypothesis that learning-related activity before sleep can selectively modulate the brain activity involved in sleep spindle generation. It has been demonstrated that spindle-related spike discharges can induce long- term potentiation in neocortical cells. Based on our findings, sleep spindles would be the ideal physiological mechanism to facilitate the neuronal plasticity related to motor memory consolidation processes per se (Morin, A., 2008). Although much more research is needed to strengthen this hypothesis.

There was no statistically significant difference between control, visual and verbal cueing groups in velocity, accuracy, and kinematics. It is important to remember that learning involves success and failures. If learning is to occur, one must learn from the failures and adapt to create success. If a learner succeeds less than 50 percent of the time they will not be as involved or focused in the activity in which they are participating in because it becomes frustrating. If a subject succeeds at every attempt they will not learn to adapt to different situations. When teaching movements to novices there must be a balance of success and failure for the learner to remain involved and enjoy what they are doing. This is something that must be understood by the person teaching the movements or their efforts may be redundant. When teaches novices, the attempts that end in failure are as important as the attempts that end in success.

Appendix I

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East Stroudsburg, PA
18301-2999

PREPARE TO SERVE
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East Stroudsburg University Institutional Review Board
Human Research Review
Protocol # **ESU-~~IRB~~-500-1819**

Date: **November 2, 2018**
To: **Matthew Miltenberger and John Nemeth**
From: **Shala E. Davis, Ph.D., IRB Chair**
Proposal Title: **"Motor Learning Outcomes of Overhead Throwing Using Visual and Verbal Cues with College-Aged Adults"**

Review Requested:	Exempted **X**	Expedited	Full Review
Review Approved:	Exempted **X**	Expedited	Full Review

FULL RESEARCH

____ Your full review research proposal has been approved by the University IRB (12 months). Please provide the University IRB a copy of your Final Report at the completion of your research.

____ Your full review research proposal has been approved with recommendations by the University IRB. Please review recommendations provided by the reviewers and **submit necessary documentation for full approval.**

____ Your full review research proposal has not been approved by the University IRB. Please review recommendations provided by the reviewers and resubmit.

EXEMPTED RESEARCH

__**X**_ Your exempted review research proposal has been approved by the University IRB (12 months). Please provide the University IRB a copy of your Final Report at the completion of your research.

____ Your exempted review research proposal has been approved with recommendations by the University IRB. Please review recommendations provided by the reviewers and **submit necessary documentation for full approval.**

____ Your exempted review research proposal has not been approved by the University IRB. Please review recommendations provided by the reviewers and resubmit, if appropriate.

EXPEDITED RESEARCH

____ Your expedited review research proposal has been approved by the University IRB (12months). Please provide the University IRB a copy of your Final Report at the completion of your research.

____ Your expedited review research proposal has been approved with recommendations by the University IRB. Please review recommendations provided by the reviewers and **submit necessary documentation for full approval.**

____ Your expedited review research proposal has not been approved by the University IRB. Please review recommendations provided by the reviewers and resubmit, if appropriate.

Please revise or submit the following:

East Stroudsburg University of Pennsylvania
A Member of Pennsylvania's State System of Higher Education
An Equal Opportunity/Affirmative Action Employer

APPENDIX II

Physical Activity Readiness
Questionnaire - PAR-Q
(revised 2002)

PAR-Q & YOU

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES	NO		
☐	☐	1.	**Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?**
☐	☐	2.	**Do you feel pain in your chest when you do physical activity?**
☐	☐	3.	**In the past month, have you had chest pain when you were not doing physical activity?**
☐	☐	4.	**Do you lose your balance because of dizziness or do you ever lose consciousness?**
☐	☐	5.	**Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?**
☐	☐	6.	**Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?**
☐	☐	7.	**Do you know of any other reason why you should not do physical activity?**

If you answered

YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

DELAY BECOMING MUCH MORE ACTIVE:

- if you are not feeling well because of a temporary illness such as a cold or a fever – wait until you feel better; or
- if you are or may be pregnant – talk to your doctor before you start becoming more active.

PLEASE NOTE: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Informed Use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

No changes permitted. You are encouraged to photocopy the PAR-Q but only if you use the entire form.

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

"I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction."

NAME ________________________________

SIGNATURE ________________________________ DATE ________________________

SIGNATURE OF PARENT ________________________ WITNESS ________________________
or GUARDIAN (for participants under the age of majority)

Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.

Supported by: Health Canada Santé Canada

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