A Comparison of the Effects of Imagery and Action Observation on Baseball Batting Performance

by

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ABSTRACT

This study investigated the effect of two different preparation methods on hitting performance in a high-fidelity baseball batting simulation. Novice and expert players participated in one of three conditions: observation (viewing a video of the goal action), visualization (hearing a script of the goal action), or a no-preparation control group. Each participant completed three different hitting tasks: pull hit, opposite-field hit, and sacrifice fly. Experts had more successful hits, overall, than novices. The number of successful hits was significantly higher for both the observation and visualization conditions than for the control. In most cases, performance was best in the observation condition. Experts demonstrated greater effects from the mental preparation techniques compared to novices. However, these effects were mediated by task difficulty. The difference between experts and novices, as well as the difference between the observation and visualization conditions was greater for the more difficult hitting task (opposite-field hitting) than for the easier hitting task (sacrifice fly). These effects of mental preparation were associated with significant changes in batting kinematics (e.g., changes in point of bat/ball contact and swing direction). The results indicate that mental preparation can improve directional hitting ability in baseball with the optimal preparation methods depending on skill-level and task difficulty.

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Introduction

In the early history of competitive sports the physical prowess of athletes was the primary emphasis. Those deemed “talented” were often more muscular, more coordinated, stronger, and faster than their opponents. As time went on, and the amount and variety of sporting events increased, the physical attributes of athletes were not the only characteristics essential for success; the mental side also became a critical factor required to reach the highest level of competition in sports (Cox, 2002; Cumming & Hall, 2002). Differing sports require different levels of mental and physical preparation. Regardless of the level of preparation, each sport still requires a certain thought process and mental awareness of what actions and thoughts are needed to perform. For example an athlete preparing to run a marathon prepares differently than an athlete preparing for an at-bat in a baseball game. Even though the type of preparation is different, both athletes ready their minds and bodies for the coming task. This study compares two mechanisms for mental preparation: imagery and action observation.

Imagery

Imagery is a cognitive-behavioral (involving the mind to alter behavior) technique that utilizes the senses and memory to create a picture in one’s mind. When an athlete utilizes imagery for performance preparation it is deemed “mental rehearsal” and it is used to prime or prepare the athlete for the correct execution of a physical skill (Cox 2002). Visualization, on the other hand, typically involves a relaxation technique where the individual is guided by an outside source through a series of imagery techniques. For example, when a basketball player prepares to shoot free-throws, the facilitator will have the person sit comfortably and close his/her eyes. Then the player will visualize standing at the free-throw line, feeling the ball in his/her hands. The facilitator describes the experience in detail, and has the person picture the experience in as much detail as possible in order to feel like he/she is performing the action. Visualization has been utilized in a variety of sports to increase accuracy and performance of specific tasks.

To look at imagery and its effects on a person's performance in various tasks, Driskell, Copper and Moran (1994) conducted a meta-analysis of 35 studies. The main selection criterion was that the study had to report on tests or measurements of performance under a mental practice condition in comparison to the performance of a no-treatment control group (with no mental practice). The term mental practice was defined as "the symbolic, covert, mental rehearsal of a task in the absence of actual, overt, physical rehearsal" (Driskell, Copper & Moran, 1994, p. 481). In addition, researchers were interested in studying the effects of moderators on the performance of individuals. These moderators included the following: experience level, retention interval, the type of task involved, the duration of mental practice, and the type of control group used in the study. A total of 35 studies involved 100 separate hypotheses and 3,214 subjects.

One of the main findings was that the effects of mental practice and physical practice are significantly different. Mental practice has a moderate and significant effect on performance, yet these effects are not as strong as the effects of physical practice. Further, mental practice was more effective when the task involved cognitive components (see examples below). A significant negative relationship was found between the retention interval and the magnitude of practice-performance effects: the strongest effect of mental practice was found immediately after (0 days retention); the effects were reduced by half when the performance occurred 14 days after, and the effects were negligible by 21 days.

Experienced individuals benefited equally well from mental practice regardless of whether the task was primarily physical or primarily cognitive while novice individuals benefited more on cognitive tasks rather than physical tasks. Mental practice for physical tasks involved preparing oneself for an action that required muscle strength, endurance and coordination. This preparation is best utilized for sports such as weightlifting or cross-country running. The cognitive tasks involved mental processes such as searching for and acquiring information, comparing and contrasting, reading, and making decisions. This type of preparation is best utilized for sports such as golf and baseball.

The duration analysis showed no significant relationship between the number of practice trials and performance. However, there was a significant negative relationship found between the length of mental practice and performance. Even though mental practice has an overall positive effect on performance, as the length of mental practice increased beyond 20 minutes the beneficial effect on performance decreased. The greatest benefit was obtained from a mental practice session that lasted approximately 20 minutes.

A research team at the University of Northampton (Arvinen-Barrow et al., 2007) examined the differences in imagery use in novice versus elite athletes in open and closed sports. Open sports are those such as rugby or hockey which involve a constantly changing environment and a high degree of reactive actions. Closed sports such as golf and figure skating are those which involve primarily pre-planned actions. These classifications are not mutually exclusive: they lie on a continuum with varying degrees of changing environment and interaction with others. In this study, 40 male and 43 female athletes from both open and closed sports participated. The Sport Imagery Questionnaire (SIQ) was given to participants and completed no more than 24 hours prior to them competing. The questionnaire is comprised of 30 Likert scale questions which address the frequency and method of imagery use by the athlete. Results showed that elite athletes use imagery more than novices. Specifically, elite athletes utilize imagery for a more cognitive function (mental preparation) than their novice counterparts. Results also demonstrated that athletes show differences in their use of imagery based on whether they are involved in open or closed sports. Athletes in open-sports use more Motivation-General Arousal (to get “psyched up”) imagery than athletes in closed sports. The general findings in this study showed that, “generally athletes use imagery for maintaining or improving mental toughness, confidence, and positive attitude prior to competition” (Arvinen-Barrow et al., 2007, p. 99).

Cumming and Hall (2002) looked at the deliberate imagery practice of 159 athletes from various sports. They distributed the Deliberate Imagery Practice Questionnaire to the subjects and analyzed their responses. The subjects were comprised of male and female athletes from three different competitive levels of sport: recreational, provincial (state-level), and national. The questionnaire inquired about each athlete’s use of imagery by having the subject rate certain aspects of imagery practice on a scale of 0 to 10 (0 = not at all and 10 = highly). The specific aspects being examined included: the extent to which imagery was relevant to improving the individual’s performance, relevant to competing effectively, and how enjoyable it was to perform regardless of outcome and mental exertion. The questionnaire also surveyed the athletes’ use of imagery throughout the week while in training and which type of imagery they utilized. The types of imagery included in this questionnaire were skills, strategies, the achievement of goals, the stress and excitement of performing, and imagery of being confident and motivated. The questionnaires were administered to all the athletes who were currently in the competitive phase of their sport.

One of the main findings of this study was that an athlete’s perceptions of the relevance of imagery to improving their performance correlated with their perceptions of the relevance of imagery to competing effectively, to the mental concentration needed to perform imagery, and the enjoyment of performing mental imagery regardless of the outcome. The questionnaire also revealed that national athletes had accumulated significantly more hours of imagery practice than recreational athletes. There were no differences found between male and female participants or between different sports. This study demonstrates how an individual’s perceptions of the use of imagery affect the overall attitude, thoughts, and performance of the athlete who is utilizing imagery as a part of training. While this study examined athletes’ thoughts and perceptions about imagery, it was limited to only individual’s perceptions. To look more closely at imagery and its effectiveness, actual performance must also be examined.

Short, Tenute, and Feltz (2005) used questionnaires to determine the relationship between one’s efficacy for imagery, the use of imagery, and one’s ability to image. Three questionnaires were used: the Sport Imagery Questionnaire (imagery use), the Movement Imagery Questionnaire-Revised (imagery ability), and a revised version of the Sport Imagery Questionnaire (efficacy in using imagery). The term efficacy was operationally defined in this study as meaning confidence. Seventy-four female collegiate athletes from various sports participated in the study. They answered questions by rating their responses according to separate Likert scales from each questionnaire. Questions referring to imagery use were rated on a scale from 1 to 7 (1= rarely; 7= often); those looking at imagery ability were rated on a scale of 1 to 7 (1=very hard to see/feel; 7= very easy to see/feel); while questions accounting for efficacy in using imagery were rated on a scale of 0 to 10 (0= not confident at all; 10 very confident). This study utilized Paivio’s (1985) conceptualization of imagery which involves cognitive and motivational functions of imagery that work on general and specific levels. This breaks imagery into four subscales: Cognitive Specific (imaging skills), Cognitive General (imaging strategies), Motivation Specific (imaging goal-oriented responses and activities), and Motivation General (affect and arousal). For the purposes of this study, the Motivation General subscale was split into two categories: MG-Arousal (imaging physiological and emotional arousal) and MG-Mastery (imaging being confident and relaxed).

Researchers found that the subjects used MG-Mastery imagery the most, followed by MG-Arousal, Cognitive General, Cognitive Specific, and Motivation Specific imagery; respectively. This means that the subjects imagined themselves being confident in their respective sports. When looking at the correlations between efficacy, ability, and imagery use; results demonstrated that the more efficacy (confidence) that the athlete had in her ability to use a certain image, the more she used it. For example, if the athlete had high efficacy ratings for utilizing Cognitive Specific Imagery, then she most likely had high ratings in her overall usage of that type of imagery as well. The majority of subscales on the efficacy scale correlated higher with the imagery ability for that subscale than the imagery ability and imagery use for the pairs. The only exception was the Cognitive Specific efficacy and the kinesthetic imagery ability; which demonstrated a higher correlation between the imagery use and ability.

This study demonstrates that a person's ability to image is not necessarily the underlying factor in whether a person utilizes imagery. Rather, it is the person's efficacy (confidence) in using imagery that predicts an individual's actual use of imagery. To have an athlete utilize imagery to enhance performance, supporters can help boost the athlete's confidence in using imagery. Instead of focusing all efforts on making the athlete a better "imager," coaches and others can help the athlete have more confidence in his/her own ability to image. This could lead to higher use of imagery which can then enhance efficacy in a positive feedback loop. The overall goal of utilizing imagery is to enhance performance in sport, and with higher levels of efficacy, athletes may use imagery more, and reap the benefits it has to offer. Much like the study carried out by Cumming & Hall (2002), one limitation of this study was that it did not actually have the subjects actively using imagery. Future research can expand on this by engaging the participants in an actual imagery session followed by performance measurement.

Cumming, Law & Olphin (2007) conducted a study in which participants were led through a series of imagery scenarios while their heart rates were recorded. After each imagery session, participants reported their feelings of anxiety and confidence utilizing the Immediate Anxiety Measures Scale. The study was comprised of forty competitive athletes; including 21 males and 19 females. The subjects imaged five different scenarios: mastery, coping, anxiety, psyching-up, and relaxation. Results showed an increase in heart rate for the anxiety, psyching-up, and coping imagery sessions. The anxiety session produced the most cognitive and physiological anxiety and was reported as the most debilitative by the subjects. An interesting finding demonstrated how the combination of Motivation General-Arousal imagery (anxiety) and the Motivation General- Mastery imagery (coping) enabled the subjects to experience anxiety symptoms alongside confidence-based cognitions (Cumming, Law & Olphin, 2007). This combination of feelings and cognitions can be utilized to enhance athletes' performances by reducing the physical symptoms of anxiety. Through visualization, feeling the anxiety, and then overcoming the anxiety, athletes are able to better cope when performing; thus improving performance.

Imagery can be a powerful tool that can make the person physically feel the anxiety, mentally work through it, and then visualize a positive outcome. The positive, confidence-boosting thoughts can then replace the anxious feelings and self-doubt that previously existed. In this format, imagery is utilized as a coping strategy in order to prepare the person for future performances. Overall, this study provided a sound demonstration of how imagery affects athletes mentally and physically and how it can possibly be used to enhance performance. One limitation is that physiological measures were not taken during actual performance to see how they related to the measures taken during the imagery session. There is a definite possibility that arousal levels and physiological responses during actual performance will be more intense than those experienced during the imagery session. Regardless of the intensity, however, the study shows what types of responses athletes have in such scenarios, and there are valuable findings which can help enhance performance of those using imagery.

Fourkas, Bonavolonta, Avenanti & Aglioti (2008) carried out a study on kinesthetic imagery and its physical effects on tennis players. A total of 16 tennis players (8 novices and 8 experts) served as participants. Recordings were taken of the participants' corticospinal (relating to the cerebral cortex and spinal cord) excitability in their forearm and hand muscles as they mentally practiced a tennis forehand, a table tennis forehand, and a golf drive. The recording was taken from a single-pulse transcranial magnetic stimulation from a device attached to the participants. Expert tennis players had increased corticospinal facilitation in the tennis forehand condition but not in the other conditions. Novice players did not show this type of facilitation in any condition. These results suggest that long term experience plays a key role in how the body is represented during mental rehearsal of sports. In other words, due to their experience, expert tennis players had a mental image of how to physically conduct the task. This study provides evidence that those who have experience performing a certain action create sensorimotor connections that can be strengthened with the use of imagery.

Perhaps the strongest support for the use of imagery in sports performance is evidence that imagery activates areas of the brain that coincide with perceptual-motor brain areas involved in execution of the action (Langheim, Callicott, Mattey, Duyn & Weinberger, 2002). Holmes & Collins (2001) found evidence that the supplementary motor area (SMA) and premotor cortex (PMC) are active during movement-based imagery. These results demonstrate that certain areas that fire in the brain during actual physical movement, also fire through the imagery process when no physical movement is occurring. Not only did these areas of the brain fire during imagery, but the cerebellum also showed activity during the session. The cerebellum is utilized to provide somatosensory feedback of the movement to allow for precise, coordinated spatial and temporal control of the movement. There is no need for this brain area to fire during a no-movement imagery session, and yet researchers found that during imagery this area was still activated. These physical processes exemplify how imagery works to enhance an athlete’s ability to perform without actually physically going through the movement during the imagery session.

In summary, research has shown that visualization can definitely be utilized to increase performance in sports. Imagery has been shown to create mental and physical reactions within the person as if they are actually performing the action (Holmes & Collins, 2002 & Fourkas et al., 2008). It can be used as a practice tool, an aid in overcoming negative images and thoughts, and most importantly as a positive thinking strategy to enhance performance (Cumming, Law & Olphin, 2008).

Action observation

A second type of mental preparation commonly used by athletes is observing oneself or another athlete executing a desired action prior to performance. For example, performance videos utilize a model that performs the task in the same way that the person watching the video wants to perform. For instance, if the person intends to get better at shooting free-throws in basketball, then the video will show a person modeling that behavior over and over again with the correct mechanics to achieve the intended result.

It has been demonstrated that using action observation in this manner can improve sports performance. Performance changes in the form of confidence and consistency have been documented by Halliwell (1990) in athletes who utilized highlight music videotapes along with visualization techniques. Templin & Vernacchia (1995) further examined the use of highlight music videotapes as a source of modeling for elite college basketball players. In this particular study, five elite college basketball players from a National Association of Intercollegiate Athletics (NAIA) school participated in the study, and acted as their own models of performance. Actual game footage of each player was videotaped, edited, and put together in a 5-10 minute highlight video accompanied by inspirational music chosen by each athlete. The intention of the study was to provide the athletes with a tape that would “strengthen the outstanding performance images in the minds of the 5 male intercollegiate basketball players and that this would, in turn, lead to an increase in field goal percentage during actual competitive situations” (p. 43). Players received individual highlight tapes four days before competition, and they were instructed how to utilize them each day, including the day of competition. In order to examine the effectiveness of the videotapes, researchers documented each player’s field goal percentage in each game throughout the season. The results demonstrated a mean increase of 4.7% in overall field goal percentage for 3 of the 5 participants. The athlete who saw the highest changes in performance had an increase of immediacy (change in field goal percentage for 5-game average immediately prior to and after treatment) of 21% and criterion (change in the percentage of criterion score (50% or better) attainment) of 20%.

Starek & McCullagh (1999) investigated self-modeling and its effects on performance; specifically in the form of volleyball serving. This study was based on the premise that self-modeling “has been identified as a unique type of modeling that provides learners with mastery information” (p. 221). Researchers pointed out that self-modeling displays *only* “adaptive or approximations of correct behaviors” which are then shown to the observer (p.221). This is imperative so that observers can watch previous mastery experiences; which reminds the observer that he/she has mastered the skill before and can subsequently do it again. Five intermediate level volleyball players participated in this study. Video footage was recorded of each individual serving. The film was edited to show the individual accurately performing a serve 9-10 times throughout a 50 second video clip. The overall study consisted of 12 test days where the participants would serve the volleyball 10 times in a row. The serves were all recorded and later analyzed by two raters based on agreed upon criteria. The study involved a baseline phase in which participants watched a 50 second video clip of two unrelated physical skills (e.g. archery, ballet, golf, t-ball). After watching the video clip, the participants executed 10 overhand volleyball serves while being recorded. During the intervention phase, participants followed the same procedure except that they watched a 50 second clip of themselves serving the volleyball rather than watching an unrelated activity. Scores were assigned to participants based on five aspects of the serve: preparation, step, toss, ball contact, and follow-through. The overall results of this study demonstrated mixed findings in regard to performance outcome after implementing the intervention. Participants 1 and 3 originally showed declining outcome scores prior to the intervention; followed by increasing scores immediately following the intervention. Participant 2 showed a similar increasing trend, however, participants 4 and 5 did not show definitive increasing trends after the intervention was implemented. The results support the use of self-modeling as an intervention to be used when performance is declining.

It has been proposed that action observation facilitates performance through the activation of mirror neurons. Mirror neurons are brain cells that activate not only when the observer makes a specific movement, but also when the observer sees a model perform the same movement. These neurons were first discovered in a study looking at monkeys and their behavior. Rizzolatti et al. (1996) placed an electrode in the motor cortex of macaque monkeys and recorded neuron activation as the monkeys performed certain tasks and also when they observed other monkeys perform the same tasks. They found that the same neurons fired when the monkey performed the task and when they simply observed the task executed by another monkey. Similar neurons have been found in humans through electroencephalographic research (Calmels et al., 2006; Cochin, Bathelemy, Roux, Martineau, 1999) and through brain-imaging studies (Buccino et al., 2001; Grèzes, Armony, Rowe, & Passingham, 2003). These findings demonstrate support for an observation-execution matching system known as the motor resonance system. This system provides the explanatory mechanism of how perception of an action can form a brain representation similar to that used to perform the action. Later research conducted by Rizzolatti (2005) and Rizzolatti & Craighero (2004) looked at the link between mirror neurons and four main functional human roles: understanding of action, understanding of intention, imitation, and empathy.

In regards to sports performance understanding the action and imitation are two of the main functions necessary. Iacoboni (2005) found that imitation of an action includes activity in the neural circuitry of the superior temporal sulcus and the frontal and parietal mirror areas. These areas are activated when humans perform the action themselves and also when they observe these actions being carried out by others. Buccino et al. (2004) also found that imitation activates areas involved in motor preparation. These findings offer evidence for why action observation may enhance sports performance. Observation can positively affect how an athlete performs specific actions. The process of observing action activates mirror neurons within the individual which relate to the same activation achieved when the person is physically performing the task.

A theoretical basis for the effect of action observation of performance is provided by Prinz’s (1997) “common coding” principle. Common coding suggests that actions are planned and controlled by their intended effects. In other words, the perception of an action outcome engages the same neural systems involved in the planning of a future action. This link between perception of action outcome and action execution is of course consistent with the physiological studies of “mirror neurons” described above. Several studies have provided evidence consistent with this principle. Brass, Bekkering, & Prinz (2001) asked participants to perform a simple finger movement (either lifting or tapping) following observation of a compatible or incompatible finger movement. It was found that movement response times were faster when the inducing stimulus was compatible with the assigned action. In a study by Castiello, Lusher, Mari, Edwards, and Humphreys (2002), participants observed a grasp action directed to an object and then had to grasp either the same or a different object. Time to peak velocity occurred earlier and peak grasp aperture was smaller for valid (i.e., when the observed object was the same size as the object to be reached) than invalid prime trials. The faster reach and more precise grasp indicate that observation of a matching action facilitated subsequent execution.

Comparing Imagery and Action Observation

Which method of mental preparation is most effective? Holmes & Calmels (2008) reviewed various studies of both imagery and observation usage in sports presenting the pitfalls of each, and how they could best be applied to different fields. They defined imagery as a top-down knowledge-driven process whereas observation was defined as a bottom-up percept-driven process. Both processes were found to have activated areas of the brain associated with motor movement. However, Holmes & Calmels argued that there are far too many unknowns within the imagery area. The process itself creates more questions about what the person actually saw, how clear the image was, how the images are formed, etc. that remain unanswered. The authors argue that observation, on the other hand, is much more easily controlled and manipulated. The viewpoint can be altered along with the clarity, detail, and a myriad of other aspects to fit the needs of the observer. It was also noted that many athletes have difficulty generating, maintaining, and transforming mental images; which is not a problem with observation. Holmes & Calmels (2008) propose: “the ease of use, greater control over procedure, and more effective access to functional brain areas indicate that observations should be used in preference to imagery” (p. 442).

Nelson, et al. (2002) compared a video intervention and verbal imagery in the context of baseball throwing. This study examined 6 baseball pitchers at either the high school level or college level who were deemed either high-ability visualizers (n=3) or low-ability visualizers (n=3). The participants were classified as such based on their responses to the Movement Imagery Questionnaire-Revised. One athlete from the high-ability and one athlete from the low-ability group constituted the control group; where they did not take part in the imagery interventions. The control group participants were simply asked to throw to the best of their ability. The four athletes who made up the intervention group underwent a three week intervention involving video of representative models and verbal imagery (not simultaneously). A baseline assessment was taken for each player over the course of one week. Following this first week, two players in the intervention group underwent the video intervention while the other two underwent verbal imagery. After a week and a half, the first group switched to verbal imagery and the second group switched to the video intervention in order to account for order effects.

The results from this study provide a unique perspective on using different types of imagery and how they affect performance. Individuals with a high ability to visualize showed an increase in performance (throwing accuracy) during the intervention. Conversely, the individuals in the control group actually showed a decline in performance throughout the same time period. Individuals with a low ability to visualize demonstrated mixed results. In one scenario, the accuracy declined after the imagery session, but in another similar scenario the accuracy increased quite substantially. It was hypothesized that individuals with low ability to visualize may benefit more from the video intervention where they can actually see what they are trying to perform in as great of detail as possible. The results demonstrated that the individuals responded similarly regardless of whether they practiced visualization or were in the video intervention group. Regardless of whether the athletes were high-ability visualizers or not, all of the athletes who took part in the intervention marked on a post-study survey that they would like to use imagery more in the future and that they felt it could be beneficial to their performance. While this study provides useful information and an interesting comparison between a video intervention and verbal imagery, it has a very small sample size. The results shown in this study were taken from only 6 participants who were also all male. In order to get a clearer picture of the differences between imagery techniques, more participants would need to be involved, and females could be utilized to show any differences between the genders.

Ram, Riggs, Skaling, Landers and McCullagh (2007) conducted two experiments that examined how performance of a physical skill was affected by imagery or modeling (observation of oneself). The first experiment involved 41 female students that had no previous experience with the free-weight squat task that they were asked to perform during the experiment. Participants were randomly assigned to one of four conditions: imagery, modeling, combination of imagery and modeling, or control (neither imagery or modeling). The imagery group listened to an audiotape of 80 seconds of spoken dialogue. The speaker instructed the participant to visualize the correct form of the squat-lifting task, as well as how to execute the task according to the nine elements that they were going to later be rated on as they performed. There were silent portions of the audiotape which led the total length of the tape to be 105 seconds. The modeling group watched a 105 second videotape with forward, side, and back views of a 25 year old female performing the squat lift with ideal form. The combination group was shown the modeling video before the first trial, listened to the audiotape before the second trial, and then alternated between the two types of interventions for the rest of the trials (total of 4). The control group was asked to read during rest periods. The participants came back and carried out four more trials of squats without any intervention 48 hours after the first experiment. These trials were utilized to examine the retention of the skill. Overall, the participants were told to carryout body-weight squats for a 30 second interval and that they should reach about 14 squats. Participants were told to concentrate both on the quality of their squats and the number of squats performed during each trial. Researchers videotaped the participants as they performed the squats, and then judges later scored each participant based on nine characteristics of good form. Results demonstrated that there was a main effect for the modeling condition in that groups that received the modeling intervention performed closer to the criterion than those that did not see the model. Researchers also noted that “groups that received modeling improved their scores over the retention trials whereas the no-modeling groups remained relatively stable” (Ram et al., 2007, p. 591).

In the second experiment, 60 female students were randomly assigned to one of four groups: modeling, imagery, combination, or control. The task in this experiment was to balance on a stability platform for 20 seconds. Each participant carried out 4 blocks of 5 trials during the acquisition day, and then one block of 10 trials on the retention day (48 hours later). The conditions were setup much like those in the first experiment: the imagery group listened to an audiotape and the modeling group watched a videotape of the intended action. The combination group, however, watched the modeling video *and* listened to the audiotape during each intervention period. Participants were rated based on the amount of time that they stayed balanced on the platform as well as on the form they exhibited during the trials. Results from this experiment showed that the interaction between the block of trials and the modeling intervention were significant. This means that the effects of the modeling intervention alongside the effects of the block trial demonstrated statistically higher performance ratings for the time on balance ratings than the other groups. Overall, the results from these to experiments found that in 3 out of 4 measures of skill acquisition, the modeling intervention groups performed better than the control groups. They also noted that “in no case was imagery better than the modeling conditions” (p. 594). A possible reason for this outcome is that novices may not be able to create an appropriate image of the task that they are asked to perform. Without having experience or having previously viewed a model of the task, the person is unable to formulate an accurate image of what the task should look like. It is important to note that participants in all three of the intervention conditions performed better than individuals in the control group. This shows that imagery, modeling, and the combination groups did benefit somewhat from the intervention itself, yet the intervention that was the most beneficial was the modeling (self observation).

Aims of the Present Study

The aim of the proposed study was to perform a more rigorous comparison of the effects of imagery and action observation on sports performance using a baseball batting simulator. A further goal was to investigate how these effects are mediated by expertise.

Methods

Purpose

The goal of this study was to compare the effects of imagery and action observation on directional hitting (i.e., the ability to hit the ball to a particular location on the field) in a baseball batting simulator.

Participants

This study involved 48 participants: 24 novice participants and 24 expert participants. The 24 novice participants did not have any competitive baseball/softball experience, were recruited through the Applied Psychology subject pool and received 1 hour of class credit for their participation. The 24 expert participants were recruited from local recreational softball leagues.

Apparatus

Batting Simulation. The baseball batting simulation used in the present study has been used in several previous experiments (Gray, 2002a, 2002b, 2004; Castaneda & Gray, 2007; Gray, Beilock, & Carr, 2007; Gray, 2009). Participants swung a baseball bat at a simulated approaching baseball. The simulated ball was an off-white sphere texture mapped with red laces. The image of the ball, a pitcher and the playing field were projected on a 2.11m (h) x 1.47m (v) screen using a Proxima 6850+ LCD projector updated at a rate of 60 Hz. Batters stood beside a standard 0.45m x 0.45m home plate that was placed on the floor 2.5 m in front of the screen. The area around the plate and the area between the plate and the screen was covered with green indoor/outdoor carpet. Each batter stood on the side of the plate from which they most commonly batted during actual games. Mounted on the end of the bat [Rawlings Big Stick Professional Model; 84 cm (33")] was a sensor from a Fastrak (Polhemus) position tracker. The x, y, z position of the end of the bat was recorded at a rate of 120 Hz. The estimated static positional precision of our tracking system (<0.2 mm) was derived from the standard deviation of 50 samples with the receivers at a constant position. The dynamic precision of the system (<1mm) was estimated using the method described by Tresilian and Longergan (2002). Similar values were obtained for the x, y, and z coordinates.

A sensation of motion towards the batter was created by increasing the angular size of the ball. The angular size of the ball, pitcher and other objects was based on the visual angle subtended by these objects from the batter's perspective. The vertical position of the ball on the display was changed to simulate the drop of the ball as it approached the batter. The only force affecting the flight of the simulated ball was gravity (e.g., the effects of air resistance and spin on the ball's flight were ignored). The height of the simulated pitch Z(t) was changed according to

$$Z(t) = -1/2*g*t^2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots[3]$$

where g is acceleration of gravity ($9.8 m/s^{-2}$). Pitches ranges in speed between 39 m/s (87 mph) and 41 m/s (92 mph) and had under spin (i.e., rotated from the ground to the sky as it approached the plate). The height of the simulated ball was constant and such that all pitches crossed the plate at the batters waist level. The lateral location of the pitch when it crossed the plate varied randomly between 30 and 75 cm (measured from the participants' waist). These location values correspond to pitches that would cross the inside edge, center, and outside edges of the plate for a batter standing 30 cm from the plate.

Each trial began with a 10 s view of the playing field and the virtual pitcher. The simulated pitcher then executed a pitching delivery that lasts roughly 3 s before the virtual ball approached the batter. The position of the ball in the simulation was compared with the recording of bat position in real-time in order to detect collisions between the bat and ball.

Batters received auditory and visual feedback about the success of their swing. The timing of presentation of this feedback was as follows. If no contact between the bat and the ball occurred an audio file of an umpire saying strike was played over a loudspeaker. If contact between bat and ball was detected the sound of the "crack" of a bat was played at the instant contact is detected and the location of the bat, bat speed, ball speed and bat angle was used to visually simulate the ball flying off the bat (i.e., moving away from the batter) into the simulated playing field. For ball trajectories into foul territory (i.e., outside the simulated playing field), an audio file of an umpire saying "foul ball" was played. For homeruns [(fair balls that traveled further than 107 m (350ft)], an audio file of an announcer's home run call from an actual game was played.

Procedure

In separate experimental blocks, participants were asked to perform three different directional hitting tasks: (i) "pulling" the ball (e.g., attempting to hit the ball to right field for a batter standing on the right side of the plate as viewed from behind) , (ii) hitting to the opposite field (e.g., attempting to hit the ball to left field for a batter standing on the right side of the plate as viewed from behind), and (iii) hitting a sacrifice fly (i.e., attempting to hit the ball in the air to the outfield). These three tasks were chosen because they are skills called upon in many game situations (e.g., to advance a runner) but can often be difficult to master (Williams &Underwood, 1970).

Each participant was assigned to one of three different mental preparation conditions: *Imagery, Observation,* and *Control.* In the *Imagery condition,* participants were read a dialogue which will lead them through a visualization script prior to hitting in the simulation. The imagery scripts for each hitting task are shown in Appendix A. In the *Observation* condition, participants viewed video clips prior to hitting in a batting simulation. The video clips (described in detail in Appendix B) showed baseball batters successfully performing the hitting tasks that the participants were asked to perform. In the *Control* condition participants were asked to read a general article about baseball prior to hitting in the simulation. Each of the 3 experimental conditions (directional hitting tasks) were comprised of 15 pitches. All participants performed the three hitting tasks in the same order: opposite field hit, pull hit, and then sacrifice fly. Participants will be given a 5 minute break between each condition. Prior to completing these experimental trials, participants completed a 15-pitch practice run (with no mental preparation technique or directional hitting task). They then completed a practice session of 15 pitches for each of the 3 hitting tasks; again with no mental preparation. Once the practice session was finished, participants completed 15 pitches for each directional hitting task with the mental preparation technique before each trial. Each participant completed only one of the mental preparation techniques. Therefore there will be 8 novice players and 8 expert players in each mental preparation condition (control, imagery, and action observation).

Data Analysis

Performance Measures

The primary dependent variable that was used is the number of successful hits (scored out of 15) for each condition. For "pulling" the ball and opposite field hitting success was defined as hitting a fair ball anywhere on the desired half of the field. For sacrifice fly hitting, success was defined as hitting a fly ball or line drive in fair play that travels more than 200 ft. The number of successful hits was analyzed using 2x3 Mixed Factor ANOVAs with Skill Level (Expert, Novice) and Preparation Method (Control, Imagery, Observation) as factors. Separate ANOVAs will be completed for each of three hitting tasks.

Kinematic Measures

For the pull-hit and the opposite-field scenarios, the longitudinal position of the bat at the instant of bat-ball contact was examined. This position was measured (in cm) relative to the front edge of home plate with positive values indicating contact made in front of the plate (i.e., closer to the pitcher) and negative values indicating contact made behind the front edge of the plate (i.e., closer to the back catcher) . This kinematic variable was chosen because one strategy that can be for directional hitting is to alter the location as at which the ball is contacted (Williams & Underwood, 1970), where a "pull" hit is achieved by hitting the ball in front of the plate and an “opposite field” hit is achieved by hitting the ball behind the front edge of the plate. This is discussed in more detail below.

For the sacrifice fly hitting task, the vertical angle of that bat (relative to the ground plane) at the instant of bat-ball contact used as a dependent variable with positive values representing an upward angle. This kinematic variable was chosen because one of the main strategies that is used to hit a “sacrifice fly” is to use an “uppercut swing” (i.e., a more positive vertical angle).

The three kinematic variables were analyzed using 2x3 Mixed Factor ANOVAs with Skill Level (Expert, Novice) and Preparation Method (Control, Imagery, Observation) as factors

Predictions

Based on the previous research described above I expected to find the following:

1) Expert players should have more success at achieving their hitting goals than novice players as evidenced by a main effect of skill level.

2) The number of successful hits should be greater when a preparation technique is used (either imagery or observation) as compared to the control conditions as evidenced by a significant main effect of preparation method. Based on the proposal made by Holmes and Calmels (2008), I also expected to find that the number of successful hits is significantly higher for the observation condition that for the imagery condition.

3) The effect of mental preparation on the number of hits (as compared to the control condition) would be significantly larger for experts than for novices as evidenced by a significant Skill Level x Preparation Method interaction. I expected this to occur because presumably expert players have more well-developed robust representations (that may be activated by the imagery and observation techniques) for each of the three hitting skills than novice players.

Results

Performance Measures

Pull Hits

Figure 1 shows the mean number of successful “pull hits” in each condition. As shown in Table 1, the ANOVA performed on these data revealed a significant main effect of skill level [$F(1,42) = 154.1$, $p < .001$], and a significant main effect of condition [$F(2,42) = 77.4$, $p <.001$]. The main effect of skill level occurred because experts successfully pulled the ball more than novices. The main effect of condition occurred because participants in the visualization and observation conditions successfully pulled the ball more than participants in the control condition (participants in the observation condition had the most successful hits). There was also a significant skill level x condition interaction [$F(2,42) = 13.7$, $p < .001$] due to the fact that experts demonstrated more of an effect of the different preparation methods than novices. To further analyze these effects post-hoc pair wise comparisons were made between all conditions using two-tailed t-tests with a Bonferroni correction for Type I error. For experts, the observation group yielded significantly more pull hits than the visualization group [$t(14) = -6.8$, $p <.001$], and significantly more pull hits than the control group [$t(14) = 11.4$, $p<.001$]. The visualization group also yielded significantly more pull hits than the control group [$t(14) = 5.9$, $p < .001$]. The novice participants pulled the ball significantly more in the visualization condition [$t(14) = 3.2$, $p<.01$] and observation condition [$t(14) = 4.8$, $p <.001$] as compared to the control condition. All other comparisons were not significant ($p>0.1$).

Opposite-Field Hits

Figure 2 shows the mean number of successful “opposite field hits” in each condition. As shown in Table 2, the ANOVA performed on these data revealed a significant main effect of skill level [F(1,42) = 146.6, p < .001], and a significant main effect of condition [F(2,42) = 19.1, p <.001]. The main effect of skill level occurred because experts successfully hit the ball to the opposite field more than novices. The main effect of condition occurred because participants in the visualization and observation conditions successfully hit the ball to the opposite field more than participants in the control condition (participants in the observation condition had the most successful hits). There was also a significant level x condition interaction [F(2,42) = 4.2, p < .05] due to the fact that experts demonstrated more of an effect of the preparation condition than novices. To further analyze these effects post-hoc pair wise comparisons were made between all conditions using two-tailed t-tests with a Bonferroni correction for Type I error. Experts demonstrated significantly more opposite-field hits in the observation condition than in the control condition [t(14) = 5.2, p<.001]. All other comparisons were not significant (p>0.1).

Sacrifice Fly Hits

Figure 3 shows the mean number of successful “sacrifice fly hits” in each condition. As shown in Table 3, the ANOVA performed on this data revealed a significant main effect of skill level [F(1,42) = 80.5, p < .001], and a significant main effect of condition [F(2,42) = 16.0, p <.001]. The main effect of skill level occurred because experts successfully hit more sacrifice fly balls more than novices. The main effect of condition occurred because participants in the visualization and observation conditions successfully hit more sacrifice fly balls than participants in the control condition (participants in the observation condition had the most successful hits). The skill level x condition interaction was not significant. Post-hoc comparisons revealed that the expert participants hit significantly more sacrifice fly hits in both the observation condition [$t(14) = 4.8$, $p < .001$] and visualization conditions [$t(14) = 4.8$, $p < .001$] as compared to the control condition. All other comparisons were not significant ($p>0.1$).

Kinematic Measures

Pull Hits

Figure 4 shows the mean point of contact relative to the front edge of the plate (FOP) for each condition. Positive values in this figure indicate contacts made closer to the pitcher while negative values indicate contacts closer to the back-catcher. As shown in Table 4, the ANOVA performed on this data demonstrated a significant main effect of skill level [$F(1,42) = 263.2$, $p < .001$], and a main effect of condition [$F(2,42) = 40.5$, $p <.001$]. The main effect of level is due to the fact that experts made contact farther in front of the plate than novices did; which is consistent with successful pull hitting. The main effect of condition is due to the fact that participants in the observation and visualization conditions made contact farther in front of the plate than the participants in the control condition (the observation condition made contact farther out front of the plate than participants in the other two conditions). A significant interaction was also found between skill level and condition [$F(2, 42) = 3.5$, $p < .05$]. This significant interaction occurred because the point of contact varied more as a function of preparation condition for experts than for novices. For experts, all of the pair wise comparisons between conditions were significant: experts in the observation condition hit the ball significantly farther in front of the plate than in the visualization condition [t(14) = -4.1, p<..01] and the control condition [t(14) = 7.8, p < .001]. Experts in the visualization condition also hit the ball significantly farther in front of the plate than experts in the control condition [t(14) = 4.7, p < .001]. Novices hit the ball significantly farther in front of the plate in the observation condition than in the control condition [t(14) = 4.0, p < .01]. The other pair wise comparisons were not significant (p>0.1).

Opposite-Field Hits

Figure 5 shows the mean point of contact relative to the front edge of the plate (FOP) for each condition. As shown in Table 5, the ANOVA performed on this data demonstrated a significant main effect of condition [F(2,42) = 3.4, p < .05]. The main effect of condition was due to the fact that participants in the observation and visualization conditions made contact farther behind the front of the plate than the participants in the control condition (The main effect of skill level and the level x condition interaction were not significant). Pair wise comparisons revealed that the experts in the observation condition hit the ball significantly farther behind the FOP than in the control condition [t(14) = -3.0, p < .01]. The other pair wise comparisons were not significant (p>0.1).

Sacrifice Fly Hits

Figure 6 shows the mean bat angle during the follow-through portion of the swing for each condition. Positive values in this figure indicate the bat was moving away from the ground. As shown in Table 6, the ANOVA revealed a significant main effect of condition [$F(2,42) = 3.8$, $p < .05$]. This effect appeared to occur because bat angle was larger (consistent with an “uppercut” swing) in the visualization and observation conditions than in the control condition. The main effect of skill level and the level x condition interaction were not significant. None of the pair wise comparisons were significant ($p>0.1$).

Discussion

The main focus of this study was to examine the relationship between different mental preparation methods and performance and movement kinematics in baseball batting. The two preparation methods investigated were visualization and observation. Both preparation methods have been utilized by athletes with the aim of improving sports performance. By knowing which preparation method is related to more successes, athletes can focus their time and attention on that one method, and increase performance. Following the proposal of Holmes and Calmels (2008) that observation is easier to use and control than visualization, I predicted that hitting performance would be significantly better following observation than following visualization. An additional goal of this study was to examine how the effects of different mental preparation techniques vary as a function of expertise. I predicted that the mental preparation techniques would have larger effects on batting performance for experts than for novices because expert batters presumably have more robust representations of directional hitting than novices. Overall, the results of the present study were consistent with these predictions, however the effects of the different preparation techniques also depended on the specific hitting task. I next discuss each of the three hitting tasks separately.

Pull Hits

For “pull-hitting,” the use of observation and visualization benefited both novice and expert batters in the present study. For experts, the mean number of successful pull-hits increased by 140% in the observation condition and by 59%

in the visualization condition compared to the control condition in which no preparation technique was used. For novices, the mean number of successful pull-hits increased by 106% in the observation condition and by 56% in the imagery condition compared to the control condition.

As predicted, the effect of mental preparation on batting performance was larger for expert batters as evidenced by a significant Skill Level x Condition interaction (see Figure 1). As discussed above, this effect was most likely due to the fact that through practice experts have developed more robust motor programs and mental models (Langheim, Callicott, Mattey, Duyn & Weinberger, 2002) for pull-hitting that can be readily activated by imagery and observation..

Consistent with the proposal of Holmes and Calmels (2008) that observation should be a superior preparation technique to visualization, expert batters in the present study had significantly more successful pull-hits in the observation condition than in the visualization condition (mean difference of 52%). However, this difference was not statistically significant for novices (mean difference of 31%). This is somewhat surprising given that imagery techniques are often difficult to learn and control for novices.

The results of the kinematic analyses for the pull-hitting task were highly consistent with the performance measures. One of the most effective ways a batter can “pull” a ball is to attempt to make contact in front of the plate (Williams & Underwood, 1970). At this point in the swing the bat is angled toward the “pull field”. Therefore, it would be expected that an increase in the number of pull hits is associated with contact made further in front of the plate.

As shown in Figure 4, this is exactly what was found in the present study. All of the significant effects and comparisons that were found for the number of successful hits were also found for this kinematic variable. Therefore, it would seem that the mechanism by which observation and imagery improve batting performance in this task is by causing the batter to hit the ball further in front of the plate.

Opposite Hits

Similar to pull hits, experts and novices benefited from the imagery and observation conditions. For experts, the mean number of successful opposite field hits increased by 81% in the observation condition and by 38 % in the imagery condition compared to the control condition. For novices, the mean number of successful opposite field hits increased by 100 % for the observation condition and by 88 % for the imagery condition compared to the control condition.

Consistent with my predictions and the results from the "pull-hitting" task, the effect of preparation on "opposite field" performance depending on skill level was evidenced by the significant skill level x condition interaction. This interaction was again due to the fact that the preparation condition had a larger effect for expert batters: post-hoc comparisons revealed that the only significant difference was between the observation and control condition for experts. Unlike the results from the "pull hitting" task, the post hoc comparisons revealed that there were no significant differences between conditions for novices. I would argue that this occurred because the "opposite field" task was much more difficult than the "pull-hitting" and thus it was less influenced by the mental preparation techniques (i.e., novices' mental models for this task may not be sufficiently well developed to be activated by mental preparation). As discussed below, "opposite field" hitting is a more complex motor task than "pull-hitting" (Williams & Underwood, 1970).

The results of the kinematic measures were somewhat consistent with the performance measures. Much like pull hitting, the point of contact from the front of the plate (FOP) plays a role in which direction the batter will hit the ball (Williams & Underwood, 1970). In this situation, players attempt to hit the ball farther back (toward the catcher) in order to hit the ball to the opposite field. Therefore it would be expected that the number of opposite field hits would be associated with contact made further back on the plate (in this case it is represented by a negative number). Figure 5 shows that this was found in the present study. A significant main effect of condition for the point of contact was found. The main effect of condition indicates that participants in the observation and visualization conditions hit the ball significantly farther back than participants in the control condition.

There was no main effect of skill level for this measure. The lack of significance of level may be attributed to a few things. First, the task of hitting to the opposite field is arguably more difficult than hitting to the pull-side. Second, in order to hit the ball to the opposite field, more factors come into play than simply point of contact. Timing issues occur due to the extra time it takes the ball to travel farther, making eye movements for a longer period of time, and many other factors contribute to a person's ability to successfully hit the ball to the opposite field. Even though this factor is not the sole contributor, it is still associated with successfully hitting the ball to the opposite side of the field. Post hoc comparisons show that experts in the observation condition hit the ball significantly farther back on the plate than in the control condition. This result exemplifies how observation activates experts' previously established mental models in order to create the desired outcome (Langheim, Callicott, Mattey, Duyn & Weinberger, 2002).

Sacrifice Fly

Yet again, experts and novices, alike gained benefits from the imagery and observation conditions. Experts saw a 31 % increase in successful sacrifice fly hits in the observation condition and a 26 % increase in the imagery condition compared to the control condition. Novices saw a 20 % increase in successful fly hits in the observation condition and a 29 % increase in the imagery condition compared to the control condition.

Unlike the pull-hit and the opposite hit, there was no main effect of skill level. Novices and experts showed no significant difference in the amount of sacrifice fly hits across conditions. This finding is not consistent with expectations. Experts were expected to have more success at the various hitting tasks than novices based on their skill level. An explanation for this result is that the criterion for a successful sacrifice fly was set broadly. Any ball that traveled in the air more than 200 ft was considered a successful sacrifice fly. With this criterion, novices and experts alike were able to complete the task successfully. This task, overall, was considered easier based on the fact that the ball could go anywhere on the field (rather than a specific side). Post-hoc pair wise comparisons demonstrated that there was not a significant difference in the amount of successful hits carried out by participants in the observation condition compared to those in the visualization condition. This result is contrary to the predictions made at the beginning of this study. One explanation for this result is based on the ease of the task at hand. In order to complete the task, a simple uppercut swing at the correct time would create a successful outcome.

The kinematic variable measured was the bat angle during the follow through of the swing. Consistent with the performance data, a main effect of condition for swing angle was found. Experts saw a 14% increase in swing angle in the imagery condition and a 20 % increase in the observation condition compared to the control condition. Novices saw a 21 % increase in the imagery condition and a 38 % increase in the observation condition compared to the control condition. The post hoc pair-wise comparisons were not significant for this condition. The lack of significance can be attributed to the ease of the task. Novices and experts, alike, were able to utilize an uppercut swing in order to successfully hit sacrifice fly balls. Another explanation for the lack of significance is the measurement, itself. The bat angle does play a major role in where the ball will end up, however, it is not the sole contributing factor. For example, a participant can have a nice level swing, hit the bottom half of the ball, and hit a sacrifice fly. In this instance, the swing angle would not be indicative of a sacrifice fly even though that was the end result.

Overall, significant results were found which indicate a few very important points. First, for all measurements (performance and kinematic), there were significant main effects of condition. This result indicates that the participants in the preparation conditions had significantly better results than those in the control conditions. These results were expected based on previous research. Second, pair-wise comparisons demonstrated significantly higher measures for the observation condition compared to the visualization condition on three different measurements (performance pull hit, performance opposite hit, and kinematic pull hit). Third, novices and experts can benefit from preparation techniques as evidenced by the main effect of condition.

Limitations and Future Research

There a few important limitations to this study. The participants in this study were asked to perform in a simulated batting environment. While the task simulates actual hitting, there are drastic differences which include visual lighting, hitting a virtual ball rather than actually making contact with a ball, and distance to the pitcher. The screen in the simulator is set up a few feet away from the participant, whereas a normal playing field places the pitcher around 60 ft from the plate. Another aspect that is different is the bat. The bat is smaller and lighter than a regulation bat. The bat had a sensor taped to it in order to track its position, which may have caused the batters to adjust how they would normally prefer to hold the bat. Performance measures were based on how the participant did during each “at bat” in the simulation. In a normal baseball game, a player only gets up to bat between 4 and 6 times. In the simulation, the batter was asked to hit 15 in a row with a small break between pitches.

Another limitation to the study is the defining characteristics between novices and experts. Novices had no previous experience hitting, while the experts had a wide range of experience. All of the experts had played either baseball or softball at some point competitively. Some experts were actively playing while others hadn’t played in a few years. Future studies may want to be more selective as to who qualifies as an expert in order to get more accurate results.

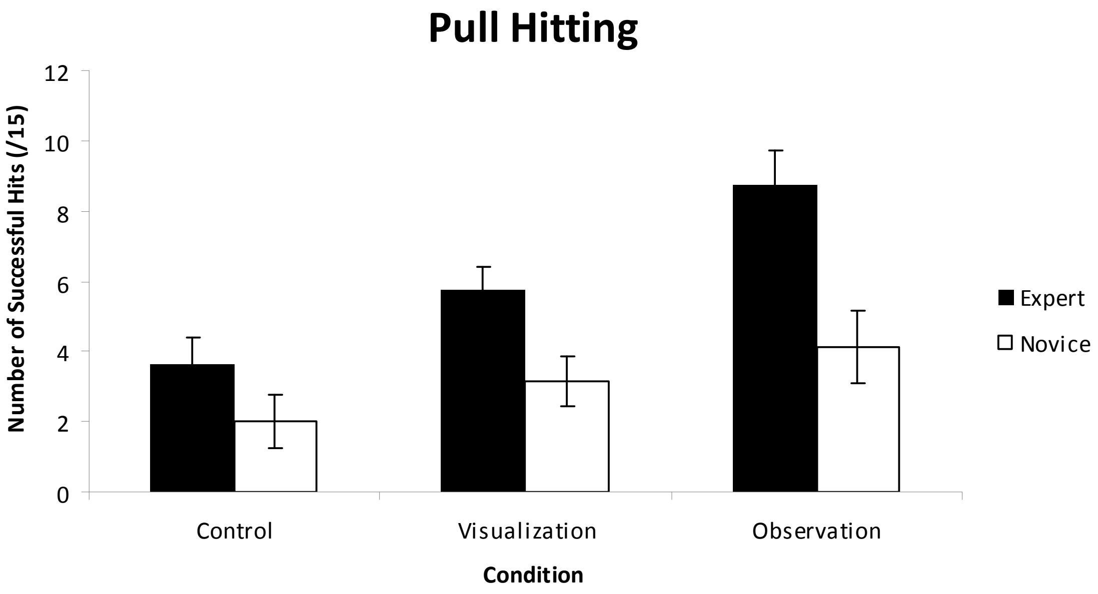
The length of the preparation methods may be considered a limitation as well. Each visualization and observation clip was less than a minute in duration.

Future research may delve into providing individuals with a more in depth clip or a longer visualization practice. For example, each scenario could involve a 5 minute long exercise before the task was to be completed. The observation clips are also limited. Each of the hitting videos was from an extended view to encompass the pitcher and part of the field. In the future, clips zoomed in on the batter would provide better modeling. The batter could even show the hit in slow motion in order to break down the steps involved. The visualization clip could then be more in depth to include step by step instructions for the person to visualize. In the present study I did not measure the ability of participants to use imagery – it would be interesting to see if this was related to the batting results like in other studies. For instance, the Sport Imagery Questionnaire (imagery use) and the Movement Imagery Questionnaire-Revised (imagery ability) could be given to participants before measuring performance on the batting simulator. Short, Tenute, and Feltz (2005) utilized these questionnaires, and they can be utilized in a future study to compare ability to visualize with batting performance.

Future research possibilities on the topic of visualization and observation are endless. Other hitting tasks could be examined, the duration or depth of the description could be altered in the observation and visualization clips, time lengths for the preparation methods could be varied and tested, and so much more. Observation and visualization can be taken into other sports such as golf, basketball, volleyball, or to any type of action that can be observed or thought about. In order to generalize the results of this study, the effects would need to be studied in a number of other areas. It would be interesting to see if the same results were found for golfers or other athletes as well.

Summary

The purpose of this study was to compare the effects of imagery and observation on batting performance, and also to investigate how these effects are mediated by expertise. As in past research, the results for the observation and visualization conditions revealed significantly greater results in performance and kinematic measures than control conditions. This shows that both imagery and observation techniques can improve directional hitting performance. In general, observation results in more benefits to performance than imagery. Experts demonstrated greater effects from the mental preparation techniques compared to novices, however these depend on task difficulty. These findings concur with Holmes and Calmels proposal (2008) that observation should be used in preference to visualization. Although the observation condition did not outperform the visualization condition in all measurements, results on three separate measures did indicate significance. The difference between experts and novices, as well as the difference between the observation and imagery conditions becomes greater as task difficulty increases (e.g. opposite field hitting vs. pull hitting). The effects of mental preparation can be seen both at the level of performance outcome measures (# of successful hits) and at the level of kinematic variables such as the direction of bat movement and point of contact. Overall, results indicate that preparation through visualization and observation yields the best performance, and that observation is significantly better in some instances.



<u>Figure 1</u> Mean number of successful hits for the "pull-hit" task

Error bars are standard errors

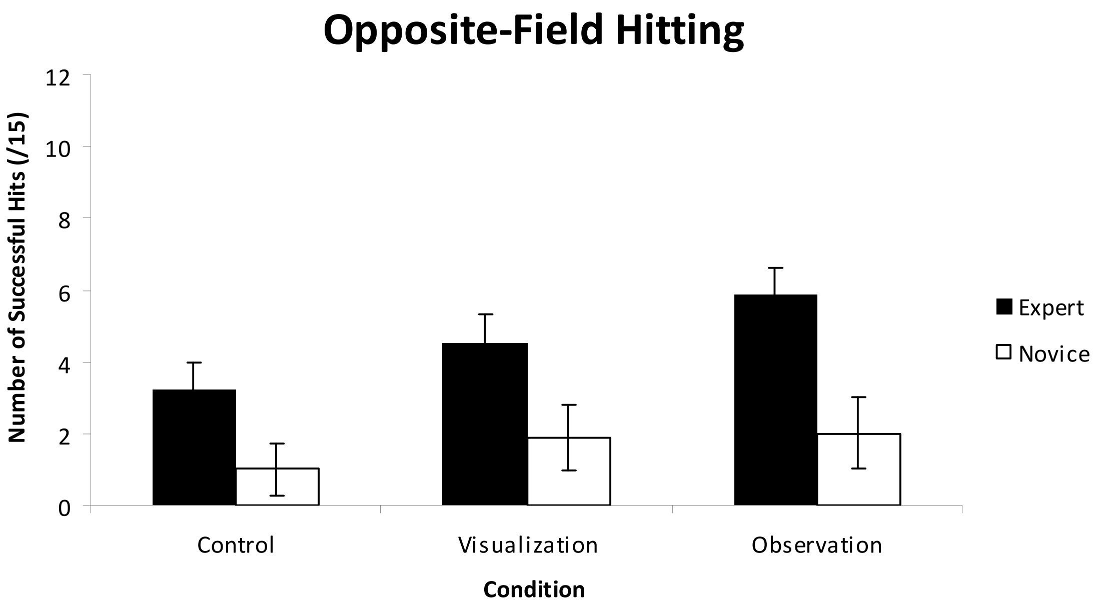


Figure 2 Mean number of successful hits for the “opposite-field” hitting task

Error bars are standard errors

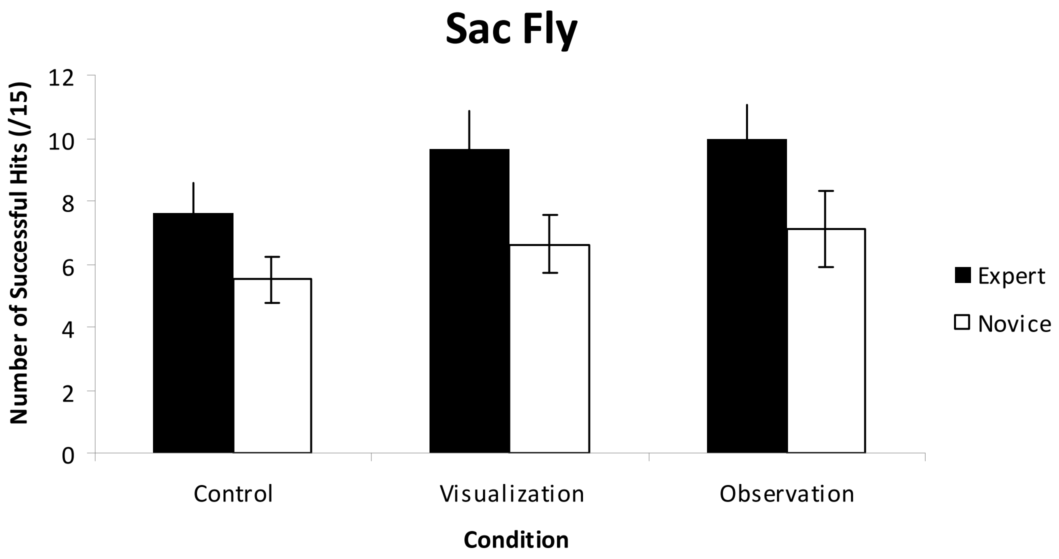


Figure 3 Mean number of successful hits in the "sacrifice fly" hitting task

Error bars are standard errors

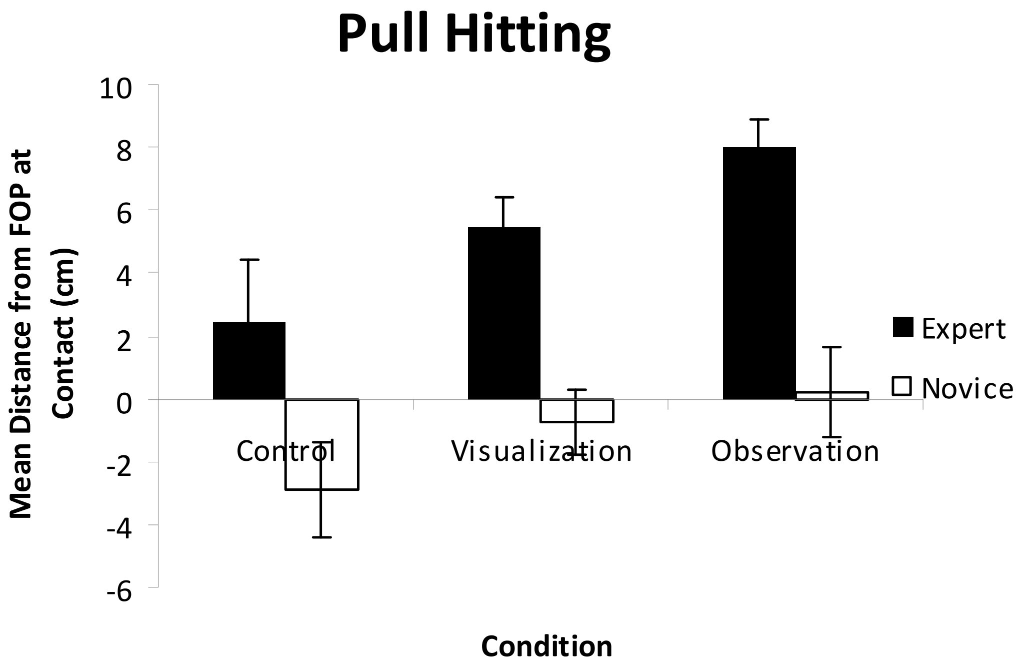


Figure 4 Mean Distance from FOP at contact for the “pull-hit” task

Error bars are standard errors

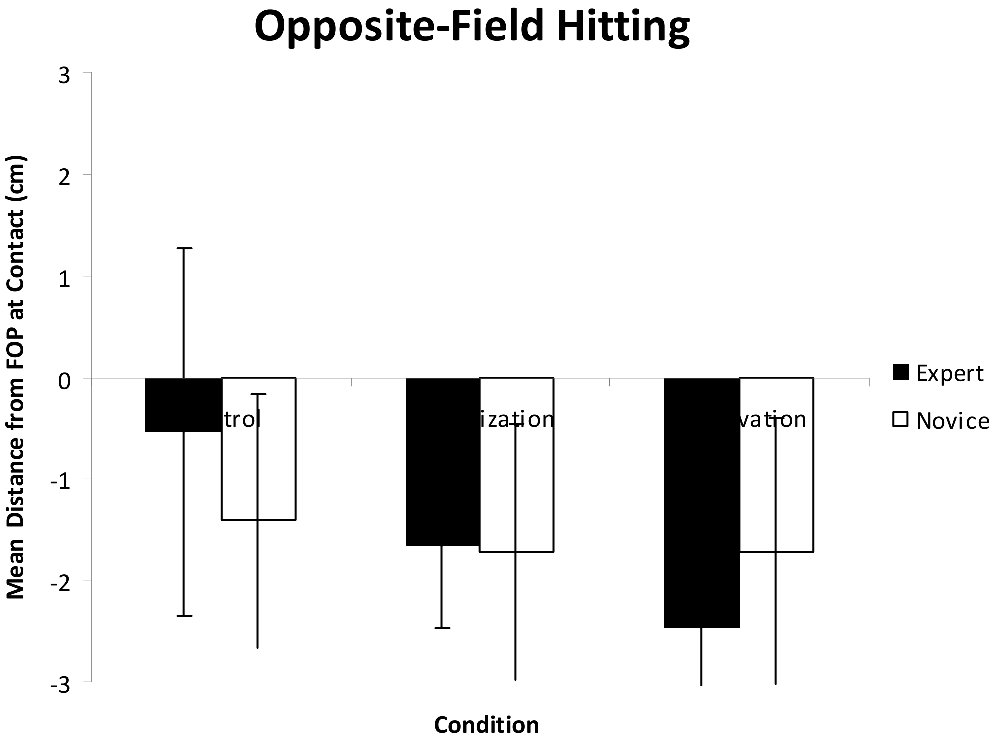


Figure 5 Mean distance from FOP at contact for the "opposite-field" hitting task

Error bars are standard errors

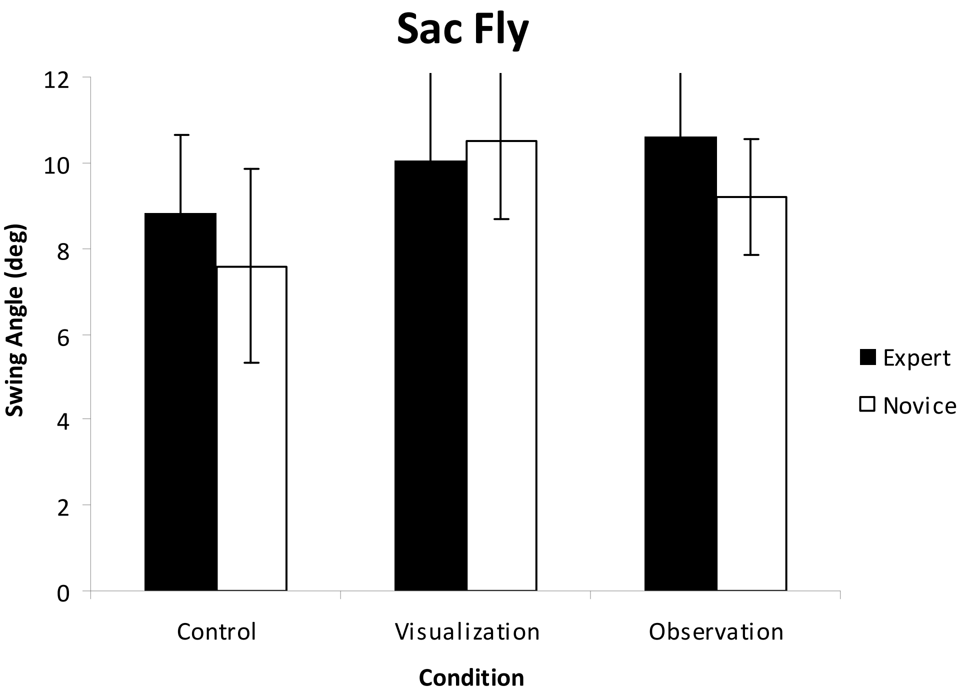


Figure 6 Mean Swing Angle during follow through for the “sacrifice fly” hitting task

Error bars are standard errors

Table 1

Omnibus ANOVA for Successful Hits in the "pull-hit" task

Tests of Between-Subjects Effects

Dependent Variable:PULL hits

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	229.188[a]	5	45.838	67.255	.000	.889
Intercept	999.187	1	999.187	1466.057	.000	.972
Level	105.021	1	105.021	154.092	.000	.786
Condition	105.500	2	52.750	77.397	.000	.787
Level * Condition	18.667	2	9.333	13.694	.000	.395
Error	28.625	42	.682			
Total	1257.000	48				
Corrected Total	257.813	47				

a. R Squared = .889 (Adjusted R Squared = .876)

Table 2

Omnibus ANOVA for Successful Hits in the “opposite-field” hitting task

Tests of Between-Subjects Effects

Dependent Variable:OPP hits

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	134.417[a]	5	26.883	38.602	.000	.821
Intercept	456.333	1	456.333	655.248	.000	.940
Level	102.083	1	102.083	146.581	.000	.777
Condition	26.542	2	13.271	19.056	.000	.476
Level * Condition	5.792	2	2.896	4.158	.023	.165
Error	29.250	42	.696			
Total	620.000	48				
Corrected Total	163.667	47				

a. R Squared = .821 (Adjusted R Squared = .800)

Table 3

Omnibus ANOVA for Successful Hits in the “sacrifice fly” hitting task

Tests of Between-Subjects Effects

Dependent Variable:SAChits

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	122.500[a]	5	24.500	23.124	.000	.734
Intercept	2883.000	1	2883.000	2721.034	.000	.985
Level	85.333	1	85.333	80.539	.000	.657
Condition	33.875	2	16.937	15.986	.000	.432
Level * Condition	3.292	2	1.646	1.553	.223	.069
Error	44.500	42	1.060			
Total	3050.000	48				
Corrected Total	167.000	47				

a. R Squared = .734 (Adjusted R Squared = .702)

Table 4

Omnibus ANOVA for Distance from FOP at contact for the "pull-hit" task

Tests of Between-Subjects Effects

Dependent Variable:KIN pull

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	660.412[a]	5	132.082	70.220	.000	.893
Intercept	205.220	1	205.220	109.103	.000	.722
Level	495.046	1	495.046	263.186	.000	.862
Condition	152.299	2	76.149	40.484	.000	.658
Level * Condition	13.066	2	6.533	3.473	.040	.142
Error	79.001	42	1.881			
Total	944.632	48				
Corrected Total	739.412	47				

a. R Squared = .893 (Adjusted R Squared = .880)

Table 5

Omnibus ANOVA for Distance from FOP at contact for the "opposite-field" hitting task

Tests of Between-Subjects Effects

Dependent Variable:KINopp

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	15.687[a]	5	3.137	2.056	.090	.197
Intercept	120.967	1	120.967	79.255	.000	.654
Level	.041	1	.041	.027	.871	.001
Condition	10.284	2	5.142	3.369	.044	.138
Level * Condition	5.363	2	2.681	1.757	.185	.077
Error	64.105	42	1.526			
Total	200.760	48				
Corrected Total	79.792	47				

a. R Squared = .197 (Adjusted R Squared = .101)

Table 6

Omnibus ANOVA for Swing Angle during follow through for the "sacrifice fly" task

Tests of Between-Subjects Effects

Dependent Variable:KIN sac

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	53.579[a]	5	10.716	1.861	.122	.181
Intercept	4295.975	1	4295.975	745.902	.000	.947
Level	6.527	1	6.527	1.133	.293	.026
Condition	44.313	2	22.156	3.847	.029	.155
Level * Condition	2.739	2	1.369	.238	.789	.011
Error	241.896	42	5.759			
Total	4591.450	48				
Corrected Total	295.475	47				

a. R Squared = .181 (Adjusted R Squared = .084)

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APPENDIX A

VISUALIZATION SCRIPTS

LEFTY PULL HIT

Relax. Close your eyes. See yourself holding the bat in your hands. You are in the batter’s box. The bases are loaded. Take a deep breath in…and exhale. You pick the bat up off your shoulder. The pitcher winds up and releases the ball. You see the ball clearly. As the ball gets closer to you, you start your swing. You see the ball all the way into the zone until it meets your bat. The ball takes off on a low line drive between the first baseman and the second baseman. You release the bat and take off towards first. The runner from third scores easily, as you reach first base.

RIGHTY PULL HIT

Relax. Close your eyes. See yourself holding the bat in your hands. You are in the batter’s box. There are runners on first and second base. Take a deep breath in…and exhale. You pick the bat up off your shoulder. The pitcher winds up and releases the ball. You see the ball clearly. As the ball gets closer to you, you start your swing. You see the ball all the way into the zone until it meets your bat. The ball takes off on a line drive down the left field line. You release the bat and take off towards first. The runner from second base scores easily, the runner from first makes it safely to third and you make it easily into second base.

LEFTY OPPOSITE HIT

Relax. Close your eyes. See yourself holding the bat in your hands. You are in the batter’s box. There is a runner at third base. Take a deep breath in…and exhale. You pick the bat up off your shoulder. The pitcher winds up and releases the ball. You see the ball clearly. As the ball gets closer to you, you start your swing. You see the ball all the way into the zone until it meets your bat. The ball flies off your bat on a line drive into left field. You release the bat and take off towards first. The runner from third scores easily and you make it to first base.

RIGHTY OPPOSITE HIT

Relax. Close your eyes. See yourself holding the bat in your hands. You are in the batter’s box. There is a runner at third base. Take a deep breath in…and exhale. You pick the bat up off your shoulder. The pitcher winds up and releases the ball. You see the ball clearly. As the ball gets closer to you, you start your swing. You see the ball all the way into the zone until it meets your bat. The ball flies of your bat high and hard towards the right field wall. You release the bat and take off towards first. The ball ricochets off the wall and you make it all the way to third. The runner from third scores easily.

LEFTY SACRIFICE FLY

Relax. Close your eyes. See yourself holding the bat in your hands. You are in the batter's box. There is a runner on third base and first base. Take a deep breath in…and exhale. You pick the bat up off your shoulder. The pitcher winds up and releases the ball. You see the ball clearly. As the ball gets closer to you, you start your swing. You see the ball travel deep into the zone. You see the bat hit the ball. The ball sails off the bat and travels high and deep into the outfield. You release the bat and take off towards first. The right fielder makes the catch and the runner at third base tags up. The runner makes it safely home.

RIGHTY SACRIFICE FLY

Relax. Close your eyes. See yourself holding the bat in your hands. You are in the batter's box. There is a runner on third base and first base. Take a deep breath in…and exhale. You pick the bat up off your shoulder. The pitcher winds up and releases the ball. You see the ball clearly. As the ball gets closer to you, you start your swing. You see the ball travel deep into the zone. You see the bat hit the ball. The ball sails off the bat and travels high and deep into the outfield. You release the bat and take off towards first. The right fielder runs towards center and makes the catch. The runner at third base tags up and makes it safely home.

APPENDIX B

VIDEO CLIP DESCRIPTIONS: ALL CLIPS FROM MLB.COM

RIGHTY PULL HIT

The right-handed batter is at the plate preparing for the pitch. The pitch comes in and the batter hits a hard line drive through the infield towards left field. The left fielder fields the ball and the runner from third base scores easily while the runner from second makes it easily into third base. The batter ends up on second base. The clip lasts about 19 seconds.

LEFTY PULL HIT

The runner at first base is shown. The left-handed batter is at the plate with bases loaded. The pitch comes in and the batter hits a hard ground ball through the gap between the first and second baseman. The right fielder fields the ball and throws it into the cutoff. One run scores and the runners all advance to the next base safely. The at-bat is then replayed twice in slow-motion. The clip lasts about 34 seconds.

RIGHTY OPPOSITE HIT

The right-handed batter is in the box. The pitch comes in and the batter hits a hard line drive out between the right fielder and the center fielder. The ball hits the ground once and bounces up onto the fence. The center fielder gets the ball and throws it in to home. The runner from third base scores easily, then the runner from second base gets tagged out at home plate. The batter makes it to the third base. The clip lasts about 30 seconds.

LEFTY OPPOSITE HIT

The left-handed batter is in the box. The pitch comes in and the batter hits the ball over the short stop and third baseman into shallow left field. The runner from third base scores easily and the batter makes it to first. The at-bat is then replayed in slow motion three times. The clip lasts about 43 seconds.

RIGHTY SACRIFICE FLY

A right-handed batter is in the box. The pitch comes in and the batter hits a fly ball to right field. The fielder makes the catch and the runner from third base tags up and scores easily. The clip lasts about 27 seconds.

LEFTY SACRIFICE FLY

A left-handed batter is at the plate. The pitch comes in and the batter hits a high fly ball to deep right field. The fielder makes the catch and the runner from third base tags up and scores easily. The clip lasts about 13 seconds