

NO DIFFERENCE BETWEEN ATHLETE AND
NON-ATHLETE PERFORMANCE ON
A SPATIAL MEMORY TEST
by

Kaitlin J. Hill

An Abstract
of a thesis submitted in partial fulfillment
of the requirements for the degree of
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April, 2017

ABSTRACT

by

Kaitlin J. Hill

Spatial memory is the part of memory devoted to the storage and retrieval of spatial information such as location, distance, and orientation. A quasi-experimental study assessed the spatial memory ability of 26 undergraduate students who participated in a sport that runs plays in high school and 21 undergraduates who played no such sport. Participants completed the Rey Complex Figure Test (Meyers & Meyers, 1995; Rey, 1941) and a short sport history questionnaire. A *t*-test for independent measures revealed no significant differences between the performance of the athlete and non-athlete group on the Recall Trials of the Test, suggesting there may be no difference in spatial memory ability between the two groups.

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APPROVED:

Thesis Chair: Patrick Ament, Ph.D.

Thesis Committee Member: David Kreiner, Ph.D.

Thesis Committee Member: Aqualus Gordon, Ph.D.

ACCEPTED:

Chair, Department of Psychology: David Kreiner, Ph.D.

UNIVERSITY OF CENTRAL MISSOURI
WARRENSBURG, MISSOURI

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CHAPTER 1
NATURE AND SCOPE OF
THE STUDY

Definition of Terms

Cognitive ability: capability to complete complex mental functions such as decision-making, problem solving, paying attention, remembering

Corsi block tapping task: originally developed by Corsi (1972), this task requires participants to tap blocks, usually arranged in a 3x3 grid, in the same order that the experimenter tapped the block immediately beforehand

Emotional Regulation: ability to modulate one's emotions to a desirable or stable state

Mental control: "ability to influence our focus of attention" (Wegner, 1988, p. 683), by way of attending to or ignoring stimuli; "first step toward willpower" (Wegner, 1988, p. 683)

Mental rotation task: originally developed by Shepard and Metzler (1971), this task requires participants to rotate a figure in their mind to determine which two shapes are identical but turned in different directions

Play-running sport: any sport in which the players' memorization and execution of pre-planned actions (i.e., plays) is crucial to competitive success

Reaction time: the amount of time it takes to respond to a stimulus

Rey Complex Figure Test: originally developed by Rey (1941), this assessment of spatial memory requires participants to copy a complex figure and then draw it from memory after a 3 minute and 30 minute delay

Spatial memory: the part of memory devoted to the storage and retrieval of spatial information such as location, distance, and orientation

Purpose of the Study

The purpose of this study was to assess the spatial memory ability in student-athletes compared to student-non-athletes. Previous research (e.g. Voss, Kramer, Basak, Prakash, & Roberts, 2009) has suggested that athletes display stronger cognitive skills than non-athletes on tests of cognitive ability. However, there is little research on the spatial memory ability of athletes. This study explored the extent of spatial memory ability in athletes of play-running sports (i.e., football, basketball, soccer, and volleyball) specifically, because these athletes often work to memorize person or object locations. We assume non-athletes do not engage in such rigorous practice. Thus, this study was conducted to explore differences in spatial memory ability between the two groups.

Rationale

Many abilities of athletes, especially their physical and emotional ones, have been researched. In addition, there has been a recent increased interest in the cognitive abilities of athletes. However, little research has been conducted into the spatial memory ability of athletes, particularly in athletes of play-running sports. Football, basketball, soccer, and volleyball athletes repeatedly rehearse where to go during a game and how to get there. They must memorize their position in relation to boundaries and other players in order for their team's action to be successful.

A previous study (i.e., Moreau, Clerc, Mansy-Dannay, & Guerrien, 2012) has suggested that a sport training program can successfully improve performance on a spatial task. If this is true, then logic follows that repeatedly practicing spacing--as one would do in basketball, for example--could affect spatial memory. No research to date has sought to answer this question. Thus, this study fills a hole in the literature. Additionally, it may spark future research into use of

athletic participation in clinical settings or promote discussion about the generalizability of skills from sports to academia and how any generalization could help athletes or the general public have a successful life (Voss et al., 2009).

Hypothesis of the Study

It was hypothesized that athletes of play-running sports will show significantly better spatial memory ability than non-athlete controls, as measured by the Rey Complex Figure Test (Meyers & Meyers, 1995; Rey, 1941).

Procedural Overview

Participants entered a private lab for a 1-hr. one-on-one session with the experimenter. They completed the Rey Complex Figure Test ([RCFT]; Meyers & Meyers, 1995; Rey, 1941), a paper and pencil assessment of spatial memory, and a short personal history questionnaire. Participants were debriefed and thanked for their participation. A one-tailed *t*-test for independent samples was used to compare the mean raw scores from the RCFT Recall Trials of the two groups (i.e., athletes and non-athletes).

CHAPTER 2 REVIEW OF LITERATURE

Athletes possess skills beyond the ones visible to spectators. It is clear that athletes are often physically talented (e.g. Sands et al., 2005). However, athletes also possess the rarely considered ability to regulate their emotions (Boes, Harung, Travis, & Pensgaard, 2014), as well as greater cognitive prowess compared to non-athletes (Voss et al., 2009). Research to date has examined various cognitive abilities in athletes. One area that has received little attention thus far is spatial memory.

Spatial memory is the part of memory devoted to the storage and retrieval of spatial information such as location, distance, and orientation. It is critical to everyday life. Without spatial memory humans would be unable to efficiently travel between locations or even move easily about their own home (Johns Hopkins Center for Talented Youth, n.d.). We would wander around lost whenever we tried to travel. We have to know where to go and we depend on spatial memory to get us there (Morris & Mayes, 2004).

Similarly, athletes of some sports must rely on their spatial memory to be successful. For example, football players need to remember where they need to be on every play. If a receiver forgets to which spot on the field he needs to run and in which direction he must go to get there (i.e., forgets his route), it might lead to an interception, which would be counterproductive. It is crucial that athletes in play-running sports remember where they need to be. Therefore, they practice these plays nearly every day. Between studying the playbook and physically rehearsing the plays, athletes get a lot of practice studying where people and objects should be (J. Svoboda, personal communication, October 19, 2015). However, little research has explored the spatial memory ability of athletes from play-running sports.

In contrast, the physical abilities of athletes are well-documented. Kusy and Zielinski (2014) found that “speed-power” athletes (p. 68) have a greater aerobic capacity than non-athlete controls. Compared to non-athletes, athletes had higher scores on the VO₂ max test, an assessment of how much oxygen can be provided to the muscles during physical activity. This suggests that they can send more oxygen to their muscles and produce more energy units. This increase in available energy units results in the athletes’ ability to run faster or farther.

Athletes are physically strong, as well. A descriptive study of the US National Skeleton Team showed that the most successful skeleton athletes were the ones who had the highest lower extremity power (Sands et al., 2005). Olympic Skeleton racing involves athletes pushing and then jumping on a small sled, which is raced down a track made of ice. A powerful skeleton athlete could push the sled better than a weaker athlete, resulting in a faster start to the race. The study’s authors mention that a fast start is considered crucial to skeleton race winning (Sands et al., 2005). Another study compared the upper extremity power of professional athletes versus recreational athletes (Gasic et al., 2011). While professional athletes did show a slightly greater amount of upper extremity power, as measured by a wireless accelerometer, the difference was not statistically significant (Gasic et al., 2011). The professional athletes were shown to be strong, but not stronger than the recreational athletes.

In addition to their physical abilities, athletes are also able to manage their emotions in order to be successful (Boes et al., 2014). Coaching experience indicated that the most successful athletes are the ones who can best engage in emotional regulation. One collegiate football coach stated that “mental toughness” is the number one quality he and his staff look for in potential recruits, outside of their physical abilities (J. Svoboda, personal communication, October 19, 2015). His comments suggested that, in order to be mentally tough, a player must regulate his

emotions. Boes et al. (2014) also proposed mental toughness as a mental ability essential for success. One intercollegiate women's basketball coach commented that the greatest athlete he had ever coached was able to forget what just happened on the court and keep playing unaffected (D. Slifer, personal communication, October 12, 2015). In this way, she was acting mentally tough.

Part of this emotional regulation is most likely due to the athletes' use of self-talk. Hardy, Gammage, and Hall (2001) suggested the use of Hackfort and Schwenkmezger's (1993) definition of self-talk: "a dialogue [in which] the individual interprets feelings and perceptions, regulates and changes evaluations and convictions, and gives him/herself instructions and reinforcement" (Hackfort & Schwenkmezger, 1993, p. 355, as cited in Hardy et al., 2001). Hardy et al. (2001) found athletes used self-talk to remain focused, boost their self-confidence, and to cope in difficult situations. It was also reported that athletes use self-talk to "psych themselves up" (p. 315) or to keep calm as the situation requires.

Analysis of table tennis players' competitions in a separate study revealed that these athletes also used self-talk to focus and manage their emotions (Martinent, Ledos, Ferrand, Campo, & Nicolas, 2015). Players were asked to describe the emotions that they were feeling during different parts of their match. Martinent et al. (2015) found that athletes who self-reported that they managed their emotions well turned out to be the ones who won more points in the matches observed in this study.

Furthermore, through an analysis of 28 semi-structured interviews, Boes et al. (2014) found that "world-class" Norwegian athletes (p. 423) exert mental control to stay calm and focused during their respective athletic competitions. Additionally, Boes et al. concluded the existence of a drive they called "growth orientation" (p. 425) within the athlete that strives for

continual improvement. This orientation keeps the athletes motivated to keep pushing themselves to be more and more successful. This drive did not appear to be regulated by any outside force. In fact, Boes et al. (2014) concluded that a fundamental attribute of the athletes was self-reliance. The athletes reported a lack of heavy dependence upon coaches or teammates. They relied mostly on themselves. The world-class athletes managed their own emotional and physical abilities to become among the best in the world.

The strength of athletes' cognitive abilities has also been explored. Akarsu, Caliskan, and Dane (2009) found that simple visual reaction time was lower in high school athletes than non-athlete controls. Participants were 138 high school athletes from soccer, basketball, volleyball, track, and skiing teams, and 145 age-matched non-athletes. They were given instruction to press the "A" key whenever a flash of light appeared on the computer screen. Akarsu et al. (2009) found not only that visual reaction time was lower in athletes but also that there was a negative correlation between total number of years playing sports and reaction time. Thus, as length of time participating in sports increased, the quicker the athletes were at responding. Further, it should be noted that as the total number of years playing sports increased so did visuospatial intelligence.

Alves et al. (2013) administered a comprehensive cognitive abilities battery to groups of adult and junior athletes and their respective age-matched control groups. All athletes were volleyball players. Alves et al. (2013) used a computer to administer, in this order: task switching, Useful Field of View (UFOV), Visual Short Term Memory (VSTM), Stopping, Flanker, and Change Detection tasks. These tasks were grouped into the cognitive ability they assess. Thus, executive control activities were task switching and Stopping tasks, visuo-spatial attentional processing activities were Flanker and Change Detection tasks, and Useful Field of

View (a measure of breadth of visual attention). The Visual Short Term Memory task stood alone in its own group, ergo needing no group label.

Alves et al. (2013) found athletes to be superior to non-athletes on three of the tasks. Two of these, task switching and Stopping, were executive control tasks and the other one, Change Detection, was a visuo-spatial attentional processing task. Athletes “showed greater inhibitory control” (Alves et al., 2003, p. 7) and were faster to detect changes in stimuli. Alves et al. (2003) concluded that it appears sport may have a positive impact on at least some cognitive abilities.

McAuliffe (2004) looked into possible differences between athletes and non-athletes in the ability to set attention. He used a cuing task to test 11 female college volleyball athletes and 11 non-athletes. McAuliffe (2004) set up a computer-based study in which participants were to press the “z” key when the “+” symbol appeared on the screen and “/” key when the “=” symbol came on the screen. The two symbols would appear on-screen in one of four boxes. In each trial, a cue appeared. This cue, colored either bright white or red, would appear either in the box about to be filled with a target symbol or an empty one. The participants’ task was to respond to the presentation of the “+” and “=” symbols as quickly as possible, disregarding the color of the symbols and any possible cuing targets. McAuliffe (2004) wanted to see if athletes were better able to shut out distractions and respond more quickly than non-athletes.

McAuliffe (2004) found that the athletes did show greater control of their attention in some cases. In the trials where the cue symbol and the target symbol were the same color (i.e., either both red or both white) the athletes were quicker to respond to the on-screen target. The athletes were also faster at responding to the target when the cue correctly foreshadowed its location. The athletes took longer to respond on the trials where the cue appeared in a different location than the target ultimately did. While at first this finding seems counterintuitive,

McAuliffe (2004) pointed out that this reaction may be due to the sport training. Sports often involve deception. For example, Team A, who currently has the ball is trying to mislead the other team so that they (Team A) can score. This author postulates that athletes must be aware of and respond to this feinting in order to succeed. Therefore, the athlete participants in this study may have taken longer to respond in said trials because they practice taking seemingly misleading information into account.

Overall, Voss et al. (2009) determined, in a quantitative meta-analysis, that cognitive prowess lends itself to the athlete. Voss et al. (2009) reviewed 20 studies that examined a variety of cognitive abilities within the athlete compared to the non-athlete. The abilities were grouped into three broad categories: attentional cuing, processing speed, and “a category of varied attention tasks” (p. 814). The data were collected from literature found through a search of six online databases: PsychInfo, Medline, Current Contents, Education Research in Completion (ERIC), Sport Discus, and Dissertation Abstracts Online. Articles included in the analysis also came from the references listed in the articles found through the online search. The sports included in the analysis were either of the static (i.e., long distance running, swimming), interceptive (i.e., tennis, fencing, boxing), or strategic type (i.e., volleyball, basketball, soccer, hockey, field hockey, water polo; Voss et al., 2009).

Voss et al. (2009) found that each group of athletes was better than non-athletes during some attentional cuing tasks but not by a significantly wide margin. For example, the athletes showed a greater amount of attentional flexibility but this amount was not greater than that of the non-athletes. Both interceptive and strategic sport athletes displayed a significantly quicker processing speed than controls. The data from the processing speed trials showed a medium effect size. According to Voss et al. (2009), the effect size for “the overall athlete effect” was

“small-to medium” (p. 821). The authors conclude that, while the effect sizes were often modest, the overall trend is that athletes have stronger cognitive abilities than non-athletes. The sport cognition literature may sometimes conflict, but this meta-analysis shows that, overall, athletes outperform non-athletes on tests of cognitive ability.

The meta-analysis offered by Voss et al. (2009) reviewed research studying a variety of cognitive abilities. However, studies of athletes’ spatial ability are noticeably absent. Only within a subdivision of miscellaneous tasks category can one find mention of “spatial attention” (p. 814), which is hardly an adequate representation of spatial abilities. This absence is noted here to underline a theme in the sport cognition literature: There is not much research available on the spatial abilities of athletes.

With regard to studies that have addressed spatial abilities, Ozel, Larue, and Molinaro (2004) used the mental rotation task (Shepard & Metzler, 1971) to test the spatial abilities of “athletes engaged in open-skills activities” (p. 53; i.e., handball, rugby, basketball, soccer, badminton, wrestling, judo, and table tennis) and of those “engaged in closed-skills activities” (p. 53; i.e., running, cycling, swimming, gymnastics, archery, javelin throwing, and body building) and non-athlete controls. An analysis of variance (ANOVA) showed a significant effect of group on discrimination time and mental rotation time. Both groups of athletes were quicker to discriminate the stimuli and to begin making on-screen rotations compared to the non-athletes. Additionally, the open-skills activities group rotated the stimuli significantly faster than the non-athletes. Ozel et al. (2004) concluded that athletes can perform better than non-athletes on a spatial ability task regardless of the sport in which they participate.

Other studies, such as that by Furley and Memmert (2010) have used the Corsi Block Tapping Task (Corsi, 1972) to assess spatial ability. Furley and Memmert (2010) were looking to

evaluate spatial working memory in male college basketball players compared to male non-athletes. Interestingly, the researchers found no significant difference between the performance of the athletes and the non-athletes on the Corsi Block Tapping Task (Corsi, 1972; Furley et al., 2010). They concluded that spatial working memory does not differ between the two groups and that possibly basketball does not help improve spatial working memory as originally thought. However, in the discussion of their work, Furley and Memmert (2010) mentioned that the reason for this lack of difference may be due to the instrument used to measure spatial working memory and to Type II error. The researchers admitted that the assessment may not be sensitive enough to detect differences between healthy individuals because “it lacks sufficient discriminant validity” (Furley et al., 2010, p. 806).

Allen, Fioratou, and McGeorge (2011), offered a comment on Furley and Memmert (2010). Allen et al. (2011) suggested that the findings of the Furley and Memmert (2010) were not “evidence of absence” (p. 244). Rather, they suggested that the results showed an “absence of evidence” (Allen et al., 2011, p. 244) that falls in opposition to previous research stating otherwise. Or, Allen et al. (2011) postulated, maybe there was no difference because the control group’s skills were elevated by a means other than sports. The authors suggested that video games could be one such method, especially in a group made entirely of college-aged men. It is clear from their comment that Allen et al. (2011) had large doubts about the truth in Furley and Memmert’s (2010) findings. Indeed, they appear to believe the opposite of the former’s findings is true.

The findings of Notarnicola et al. (2014) seem to support Allen et al.’s (2011) argument. Notarnicola et al. (2014) found two groups of athletes to perform better than non-athletes on a test of spatial ability. Notarnicola et al. (2014) used the Terzi test to assess two parts of spatial

ability: spatial orientation and memory. The Terzi test is administered in two phases. First, blindfolded participants are instructed to follow a series of vocal commands (e.g. “Take a lateral left step”, “Take two steps forward”; p. 2). The final instruction is to return to the starting point. In this way, spatial orientation is tested. Following the commands correctly earns points. A maximum of 20 points may be earned. In the second stage, the participants must reproduce, on paper, the route they followed earlier. Again, correct movements earn points and a maximum of 20 points can be earned. By requiring reproduction, the second stage assesses spatial memory. Notarnicola et al. (2014) found that the volleyball players and tennis players outperformed the non-athletes on both assessments. The athletes displayed a superior spatial orientation and spatial memory. The researchers state that their results support the idea that the practice of volleyball- and tennis-specific activities can develop spatial ability.

Critics may argue that the studies previously discussed are merely correlational and as such they cannot confirm causal effects from sport participation. Such an argument would be a valid one. However, this does not mean that correlational studies are not important. Correlational studies, including the present research, are often the precursors to experimental studies.

Moreover, there has been experimental research conducted into the spatial abilities of athletes. In a study performed by Moreau, Clerc, Mansy-Dannay, and Guerrien (2012), participants--who were not athletes prior to this study--underwent a 10-month training program in either wrestling or running. At intake, all participants had comparable scores on the mental rotation task. However, after the 10-month program, the wrestling group produced higher scores than the running group. The running group produced scores that were not significantly different from pre-test scores. Thus, it appears that participating in wrestling, a sport that requires spatial manipulation, improved performance on a test of spatial ability.

Further, since a wrestling training program affected mental rotation task scores while running did not, Moreau et al.'s (2012) results support the idea that the cognitive processes used in the motor activity of wrestling transferred to a novel task (i.e., the mental rotation task). Running regularly may not have affected mental rotation task performance because it does not require motor rotations. Wrestling practice, on the other hand, requires motor rotations almost constantly. Hence, it appears as though motor rotations in real life serve as practice from the mental task.

If we consider this logic with respect to spatial memory, it seems possible then that repeatedly rehearsing sports plays might affect spatial memory. Just as wrestlers must rotate their bodies, learn, and practice these moves in order to win, so must football, basketball, volleyball, and soccer players remember and move to their designated locations in order to succeed. If cognitive processes from motor activity do generalize, as Moreau et al. (2012) suggest, then, in this study, I expect the scores from athletes of play-running sports to be significantly better than non-athlete controls on the Rey Complex Figure Test (Meyers & Meyers, 1995; Rey, 1941), an assessment of spatial memory.

CHAPTER 3 METHODOLOGY

Participants

A power analysis using a large effect size revealed the need for two groups of 32 participants to achieve significant results in this study. The power analysis was performed using the program G*power. Since no research using the RCFT (Meyers & Meyers, 1995; Rey, 1941) to study athletes was available at the time, this researcher used a study of cognitive abilities to frame the power analysis. Voss et al.'s (2009) meta-analysis provided Hedge's g values for each of the studies reviewed in their work. Anzeneder and Bosel's (1998) research was of particular interest in this study due to its work with volleyball players (i.e., athletes from a play-running sport) and visuospatial attention (i.e., an ability related to spatial memory). The effect size in Anzeneder and Bosel's (1998) work, as reported by Voss et al. (2009), was 0.84. According to Cohen's (1992) widely accepted suggestion on effect size interpretation, an effect size greater than 0.70 is considered large. Therefore, 0.84 was believed to be an acceptable value to use when calculating how many participants would be necessary to achieve significant results in the present study.

The alpha level was set at .05 during the power analysis, as is standard convention. The G*power program also calls for an input of Cohen's d before it can calculate. However, the Hedge's g value was used instead because "effect sizes are interchangeable" (Field, 2000, p. 1). Therefore, the number of participants needed in each group to achieve significant results using a one-tailed, independent t -test is 32 participants.

Participants were 63 undergraduate student volunteers, aged 18-32 years ($M= 20$), enrolled at the University of Central Missouri at the time of the study. The data from 16 participants were discarded due to experimenter error, visual impairment, a fundamental

misunderstanding of the task, or an extreme outlying score resulting in a final sample size of 47. Extreme outlying score was defined as any participant who scored in the first or lower than the first percentile on the Delayed Recall Trial. Those who received such a score in a clinical setting would be assumed to have a severe spatial memory impairment. However, since participants were drawn from a non-clinical population and they navigated their way to the research room successfully, something else must have occurred to cause their scores to be extreme. Thus, scores from their data were no longer considered in future analyses. Failure to recruit the full subject pool of 64 participants as determined by the power analysis may have inflated the Type II error rate in the present study.

Of those 47 participants whose data were analyzed (age $M= 20$; $SD= 3.07$), 14 were male, 32 were female, and one participant identified as gender fluid. Twenty-six of the participants played on one of the following athletic teams during their time in high school: men's basketball, women's basketball, volleyball, soccer, or football. The remaining 21 participants did not play on a play-running athletic team during the same period.

Participants were recruited through undergraduate class announcements and the online program Sona, the Department of Psychological Science's research participant recruitment system. Participants may have received course credit or extra credit for their participation.

Design and Materials

This quasi-experimental study included two groups of participants in a between subjects design: undergraduate students who were once high school student-athletes (athlete group) and high school non-athletes (non-athlete group). Participants completed the RCFT (Meyers & Meyers, 1995; Rey, 1941) and a short personal history questionnaire. The RCFT (Meyers &

Meyers, 1995; Rey, 1941) is a paper and pencil assessment administered individually to adults aged 6 to 89 years.

Historically, this assessment has been called the Rey-Osterrieth Complex Figure Task. The complex figure was originally developed by Rey (1941) and the scoring standardized by Osterrieth in 1944. However, despite Osterrieth's (1994) effort, a wide variability in scoring developed over the next 50 years. Meyers and Meyers (1995), realizing this, developed a new, more precise scoring system that is used today. Ergo, since Osterrieth's (1944) contributions were no longer utilized, this assessment is now called the Rey Complex Figure Test.

It was chosen for this study because of its ability to test a range of cognitive abilities related to spatial memory including: visuospatial recall memory, visuospatial recognition memory, response bias, processing speed, and visuospatial constructional ability (Meyers & Meyers, 1995). In addition, the assessment has been found to be reliable. The test-retest reliability coefficient ranges from .76 to .89 and the interrater reliability ranges from .93 to .99. While this assessment is widely considered valid, no specific statistics were reported by Meyer and Meyers (1995) at this time.

To ensure confidentiality, a different and random three-digit alphanumeric string was written on more than seventy 3x5 in. index cards. Random strings were created using the Random String Generator at random.org. These strings served as participant codes throughout the study. Such codes were necessary so that questionnaire data could be matched with RCFT results without using names. Participants drew one card during the procedure to determine their participant code.

Procedure

Participants entered a private room for a 1-hr. one-on-one session with the experimenter. Participants were seated at a table directly across from the experimenter. After receiving informed consent from the participant, the researcher placed ten of the previously coded 3x5 inch index cards face down in front of the participant. The participant was instructed to choose any one card, look at the card but lay it face down off to the side until it would be needed later. The researcher never looked at the code written on the card selected by the participant.

Next the researcher completed the procedure for the Copy, Immediate Recall, and Delayed Recall Trials of the RCFT as outlined in the professional manual (Meyers & Meyers, 1995). Participants were presented with a complex line figure, as part of the RCFT (Meyers & Meyers, 1995.; Rey, 1941). The stimulus card was placed in front of the participant and he or she was asked to reproduce the image, freehand, using the pencil and paper provided by the experimenter. Any hesitation or discomfort expressed by the participant was met with verbal reassurance by the researcher. For example, if a participant said “I’m not great at drawing!”, the researcher would respond “Just do the best you can and it will be okay.”

After the Copy Trial (CT) was completed, the researcher engaged the participant in light conversation for three min to fulfill the instruction of conducting “a verbal task” (Meyers & Meyers, 1995, p. 8) before administering the Immediate Recall Trial (IRT). Light conversation involved the researcher asking the participant how his or her day going, if he or she was taking a psychology class, how was college going, and similar questions. During the IRT, participants were asked to reproduce the figure from memory, again using the pencil and paper provided.

To fill the remaining time before the Delayed Recall Trial (DRT) administration, participants listened to a portion of an audiobook via the online application Audible. Participants

were given adjustable headphones which were attached to an iPod Touch. Participants were instructed to “Just listen until I tell you to stop.” The researcher asked the participants if the audiobook was at a comfortable volume and, if not, adjusted the volume at the participants’ direction. The audiobook, titled “Writing Tools: 50 Essential Strategies for Every Writer”, was written and read by Roy Peter Clark (2011). The audiobook was started 36 s from the beginning, after the title and author name had been spoken. The participants listened from the start of the book’s introduction until the DRT was scheduled to begin. The DRT is administered 30 min after the CT is completed. Therefore, if a participant takes 3 min to complete the IRT, he or she listened to about 27 min of the audiobook.

Participants were asked to draw the figure from memory again during the DRT. Finally, participants completed a short questionnaire regarding their demographic information, sport participation history, and head injury history (see Appendix). The researcher ensured each participant wrote his or her participant code on the top of the questionnaire before leaving. Personal histories were also collected to ensure possible evaluation of any covariates in future analysis beyond those central to this study. Then participants were debriefed, invited to ask clarifying questions, and thanked for their participation.

CHAPTER FOUR RESULTS

Scores on the RCFT (Meyers & Meyers, 1995; Rey, 1941) were calculated using the standard scoring technique. There are 18 components to the figure, with one point awarded for each correct placement and accurate depiction (Meyers & Meyers, 1995). An element can earn 0.5 points if it is incorrectly placed and malformed but shaped well enough that it is recognizable. The same scoring criteria apply to all three trials. The maximum score possible is 36 points. The final raw score for each trial is the simple total of points from each element. Using the normative data provided by Meyers and Meyers (1995), *T* scores and percentile rankings for each participant were obtained. However, since those two pieces of information are typically used for diagnostic purposes, they were not used in the comparison of means done in this study. Therefore, it was the raw score from each Recall Trial that were used in analysis. Data were analyzed using Version 24 of the Statistical Package for the Social Sciences (SPSS) for Windows.

A one-tailed *t*-test for independent samples revealed no significant difference between the athlete ($M= 24.58, SD= 3.80$) and non-athlete group ($M= 24.24, SD= 4.49$) on the IRT; $t(45)= 0.28, p= 0.39$. Levene's Test for Equality of Variances was not violated ($F= 1.06, p= 0.31$) and so equal variances were assumed. An evaluation of the skewness and kurtosis levels did not show a violation of normality. The athlete group data showed skewness of $-0.26 (SE= 0.46)$ and the non-athlete group data showed skewness of $-0.83 (SE= 0.50)$. The athlete group showed kurtosis of $-0.73 (SE= 0.89)$ and the non-athlete group showed kurtosis of $-0.45 (SE= 0.97)$. The effect size was extremely small (Cohen's $d= 0.082$).

Nor was there a significant difference between the athlete ($M= 24.48, SD= 4.03$) and non-athlete group ($M= 24.62, SD= 3.58$) on the DRT; $t(45)= -0.12, p= 0.45$, one-tailed. Again

Levene's Test for Equality of Variances was not violated ($F= 0.24, p= 0.63$) and so again equal variances were assumed. These data also did not violate normality assumptions. The skewness of the athlete group data was -0.39 ($SE= 0.46$) while the skewness of the non-athlete group was -0.48 ($SE= 0.50$). The kurtosis of the athlete group data was -0.86 ($SE= 0.89$) while the kurtosis of the non-athlete group was -1.29 ($SE= 0.97$). The effect size was extremely small on the DRT, as well (Cohen's $d= 0.036$).

CHAPTER FIVE DISCUSSION

These results did not support the hypothesis. The athletes did not produce a significantly higher raw score on either Recall Trial of the RCFT (Meyers & Meyers, 1995; Rey, 1941). The positive t statistic resulting from the IRT raw score comparison indicates that the athletes scored higher than the non-athletes as hypothesized. However, the p value was not significant. These results would also seem at odds with the work of Moreau et al. (2012) among others. However, several points need to be remembered.

First, in this study, participants in the athlete group were those that played a play-running sport in high school. Other studies that have found significant results used data from college or even professional athletes (e.g. Moreau et al., 2012; Ozel et al., 2004). It is worth noting that the rigor of high school athletic team participation is typically much lower than that of college athletes. A high school team usually requires a lower time commitment. This means the athletes would spend less time working on memorizing plays and thus, hypothetically, less time sharpening their spatial memory. Furthermore, a high school team playbook would be expected to be simpler and shorter than one belonging to a college or professional team. Therefore, the high school athlete would not be expected to perform to the level of the collegiate or professional athletes observed in previous literature. Without repeated expectation of high performance pushing athletes to utilize their memory well, they may remain no different than their non-athlete counterparts. Thus, it may be that practicing running plays helps to improve spatial memory but a greater rigor than that required of high school athletes is necessary to facilitate such an improvement. If this is indeed the case, this may help explain why the athletes in this study were not significantly different than the non-athletes. The negligible effect size in each trial may support this idea.

Secondly, as Furley et al. (2010) discussed, the lack of significance found could be due to the instrument used. Furley et al. (2010) found no significant difference between the college basketball athletes and non-athlete controls on the Corsi Block Tapping Task (Corsi, 1972). It could be true that the present research supports what Furley et al. (2010) found.

Or, it could be that the instruments used could lack the sensitivity needed to detect such differences. The RCFT (Meyers & Meyers, 1995; Rey, 1941) allows scoring down to only half-points. Other psychological assessments can be much more precise. For example, a simple reaction time task, when administered on a computer, often provides data down to the thousandth of a second. The RCFT (Meyers & Meyers, 1995; Rey, 1941) does not allow for such precision. The raw score a participant receives is either a full point or half-point value. There is no room to detect more subtle differences that may exist. It may be true that subtle differences between athletes and non-athletes exist but the RCFT (Meyers & Meyers, 1995; Rey, 1941) is not sensitive enough to detect them.

It must also be remembered that the RCFT (Meyers & Meyers, 1995; Rey, 1941) is primarily a visuospatial memory test. Perhaps play-running requires a type of spatial memory other than the visual kind. For example, it may be that motor spatial memory is the type of spatial memory affected by play-running. If this were true, any differences between athletes and non-athletes would not be seen here because the RCFT (Meyers & Meyers, 1995; Rey, 1941) does not measure motor spatial memory. Participants are asked only to look at a figure, draw it, and then draw it again from memory. They are not asked to look at a figure and then use that information to guide the movement of their bodies, as they likely would be expected to do in play execution. The RCFT (Meyers & Meyers, 1995; Rey, 1941) procedure may not be close enough to play execution to find meaningful results.

This idea may be supported by the findings of Notarnicola et al. (2014). When these researchers used a spatial memory assessment that incorporates body movement (i.e., the Terzi test), they found that the volleyball players scored higher than the non-athletes on the test. Granted, Notarnicola et al.'s (2014) study was measuring more spatial working memory than the delayed recall that would be expected of play-running sport athletes. Still, the procedure used in their research may contribute to the incongruent results between their study and the present research. Notarnicola et al.'s (2014) procedure required body movement and the RCFT (Meyers & Meyers, 1995; Rey, 1941) did not. An assessment which incorporates the body movement requirements of the Terzi test (Notarnicola et al., 2014) and the DRT part of the RCFT (Meyers & Meyers, 1995; Rey, 1941) may be closer to measuring what abilities the athletes are using when they practice running plays and to finding significant results.

The present findings also may not support Moreau et al. (2012) or Notarnicola et al. (2014) because of Type II error. A *t*-test is not robust to low sample sizes, such as the ones seen in this study. Thus, as was also mentioned by Furley et al. (2010), the lack of significant results could be due to Type II error rather than genuinely little difference between the two groups.

Lastly, it must be remembered that, even if there is an effect from play-running sport participation, it is not known how long that effect may last. It may be that participating in a play-running sport helps improve spatial memory during the sport's season but wanes in the off season. Or, an effect might be seen until the end of the year but begin to decline 3 months or 6 months afterward. Recall that every participant was at least 10 months removed from high school education at the time of this study. If the athletes in this study were given the RCFT immediately after their high school graduation, we may have seen a difference between the two groups. It simply cannot be determined from this study design. Thus, future research is necessary.

Future research should consider reproducing this study but with current collegiate student-athletes (and non-athletes) instead of previous high school athletes for the reasons outlined above. A replication using professional athletes would be useful, as well. Regardless of that outcome, a true experimental design, with a treatment and control group, is necessary. It needs to be established whether play-running sport participation has an effect on spatial memory. Then future research should attempt to delineate which aspect of spatial memory, if any, is affected by play-running sport participation. This may require the development of a new valid assessment which would surely be a benefit to the field.

The results an experimental study would contribute to this literature's real world application. If play-running sport participation is shown to help improve spatial memory, future researchers may be able to use that knowledge to explore clinical benefits. Results from research using older adults facing cognitive decline, for example, could support the use of play-running sport in a rehabilitation or clinical treatment setting.

This current study cannot answer those questions. However, it serves to open the door so that others may address them.

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ADDENDUM

Figure 1. Average Immediate Recall Trial Raw Scores for Athletes and Non-athletes with Error Bars

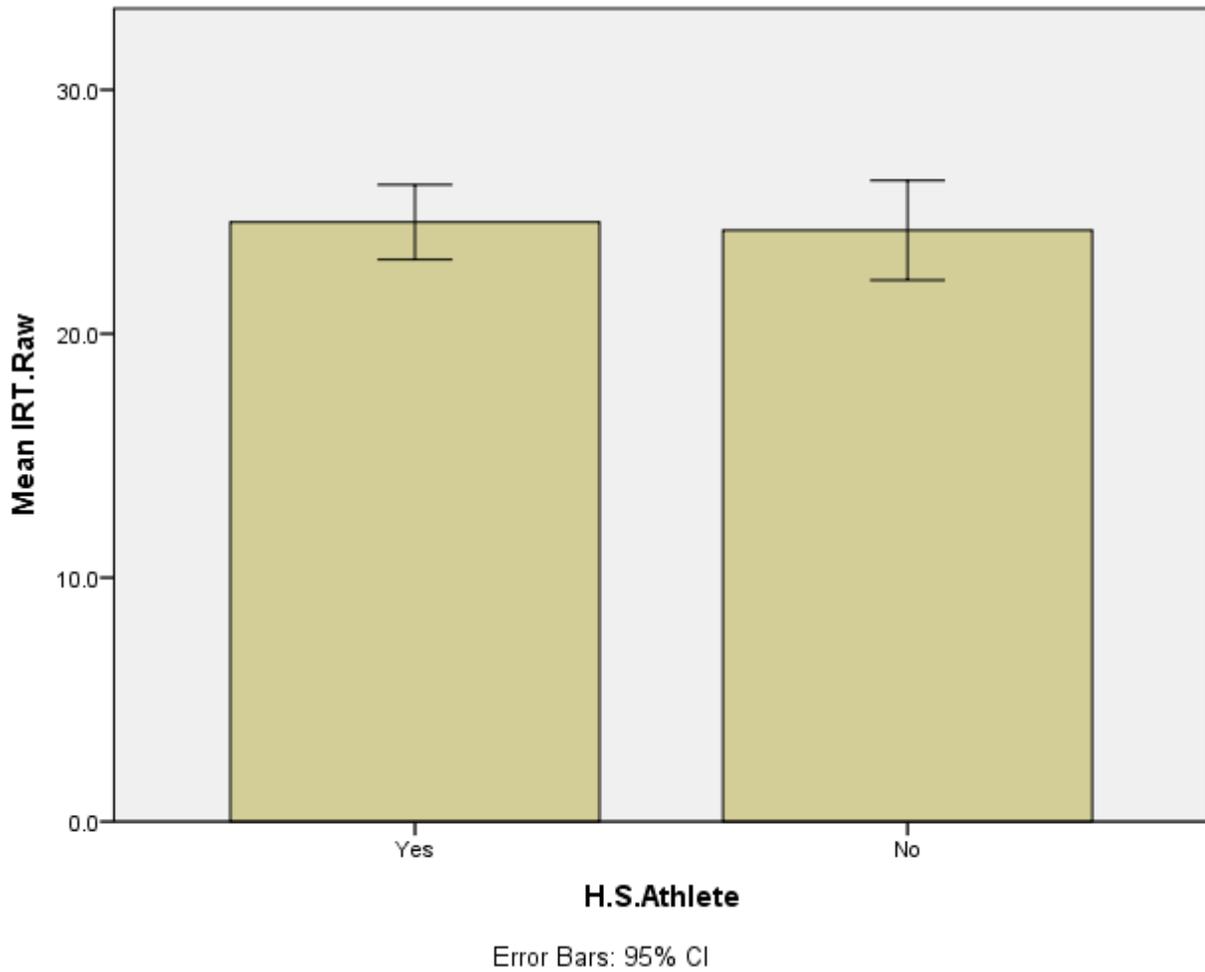


Figure 1. This figure displays the average Immediate Recall Trial raw scores for each group of participants.

Figure 2. Average Delayed Recall Trial Raw Scores for Athletes and Non-athletes with Error Bars

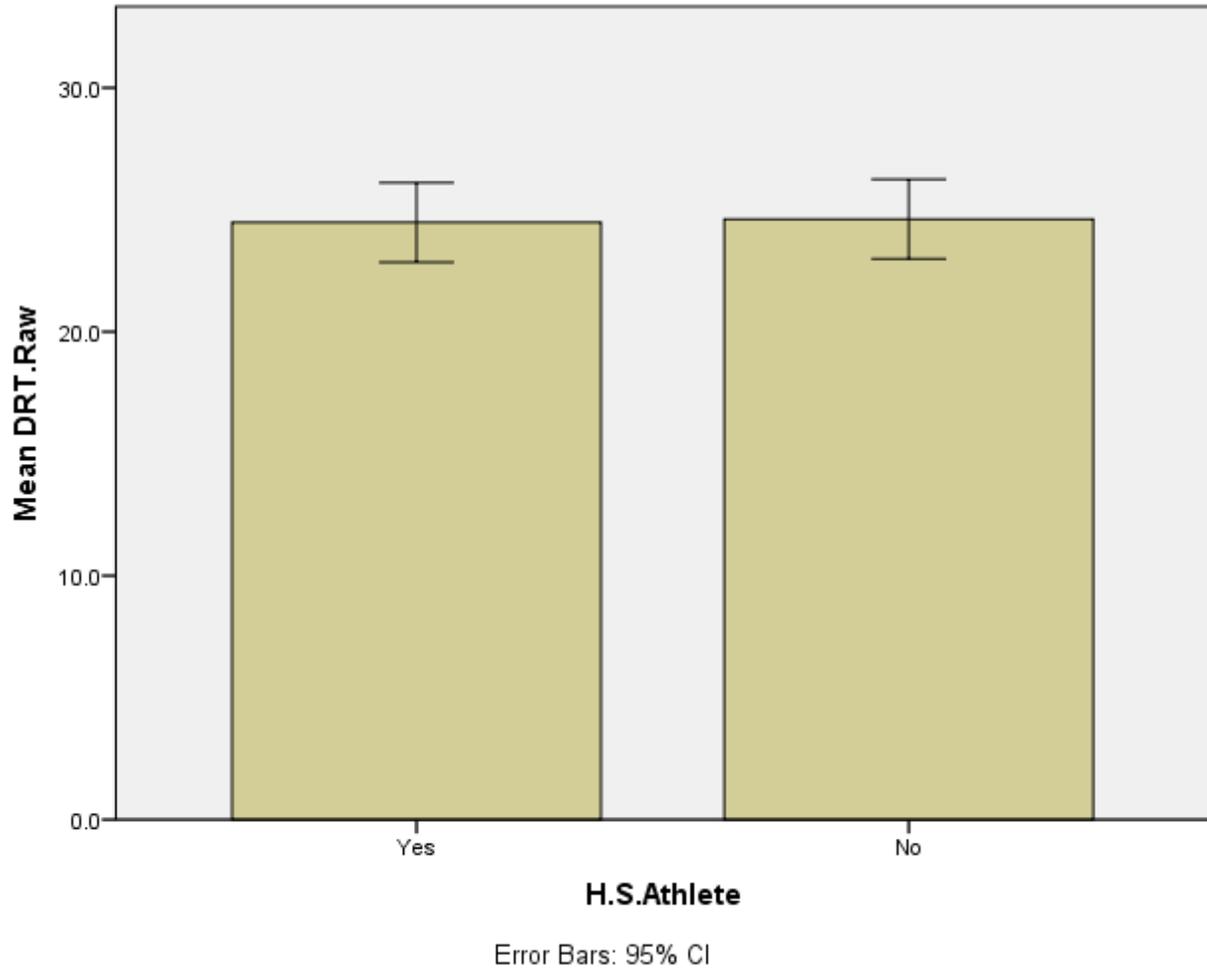


Figure 2. This figure displays the average Delayed Recall Trial raw scores for each group of participants.

APPENDIX

Personal History Questionnaire

Participant Code: _____

Please answer the following questions.

What is your primary language? _____

How old are you? _____ years

I identify as: (Please check all that apply.)

_____ Female _____ Male

_____ Other. Please explain: _____

Do you or will you play on an intercollegiate athletic team at University of Central Missouri during the 2016-2017 academic year?

_____ Yes _____ No

If yes, which athletic team are or will you be a part of? Please list all that apply.

How many years have you been a part of this intercollegiate athletic team(s)? (Please list the duration of each team membership separately.)

Do you or will you participate in any other organized athletic teams (e.g. intramural teams, community leagues) during the 2015-2016 academic year?

_____ Yes _____ No

If yes, which athletic team are or will you be a part of? Please list all that apply.

How many years have you been a part of this otherwise organized athletic team(s)? (Please list the duration of each team membership separately.)

Have you ever played on an organized athletic team before coming to the University of Central Missouri?

_____ Yes _____ No

If yes, which athletic team were you a part of? Please list all that apply.

How many years were you a part of this organized athletic team(s)? (Please list the duration of each team membership separately.)

Approximately how many hours do you spend exercising per week?

_____ hours

Approximately how many hours do you spend playing video games per week?

_____ hours

Have you ever had a serious head injury (e.g. concussion)?

_____ Yes _____ No

If yes:

How many of these head injuries have you had? _____

How long ago was/were the injury/injuries? _____

Do you wear contacts or glasses?

_____ Yes _____ No