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The Athlete Advantage: The impact of sport participation on auditory and visual reaction times

A Thesis

Presented to the Honors Program

of

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of the Requirements for Graduation Honors

Alexandra Lynn Carmichael

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Introduction

Perception and action are commonly linked and studied together in cognitive psychology. The detection and interpretation of changes of energy in the environment, such as light, sound, or neural activation are known as perception (Williams et al., 2000), while the action is the chosen behavior indicative of what was perceived (Rosenbaum et al., 2013). Psychologists have been fascinated with the study of perception-action and how humans are able to interact with changing environments for centuries (Warren, 2006). One such lens through which perception-action is investigated is reaction time research. Reaction time has been an element of psychological research since the mid-nineteenth century, with studies utilizing reaction times to measure cognitive function appearing in the 1890s (Deary et al., 2011). Reaction time in cognitive psychology is defined as the amount of time it takes for an individual to process information following a stimulus (Haen Whitmer, 2021). Visual and auditory stimuli are most frequently used in research investigating reaction time, and reaction times have been found to depend on the type of stimulus presented (Haen Whitmer, 2021). The auditory reaction time is one of the fastest reaction times in the body and is thought to be around 140-160 milliseconds while visual reaction times are around 180-200 milliseconds (Jain et al., 2015). However, auditory stimuli have also been found to degrade reaction time when the visual and auditory stimuli do not occur simultaneously, showing the interconnectedness of these pathways (Malpica et al., 2020).

In addition to the type of stimuli, other factors may influence reaction times. Deary and Der (2005) found that age and reaction time are positively correlated; as age increases so does reaction time. They also found that increased reaction time is often correlated with cognitive decline as humans age, which emphasizes how reaction times may be indicative of cognitive function. Gender also impacts reaction time and on average males have faster reaction times than females (Reimers & Maylor, 2005; Jain et al., 2015). Academic stress (Wright et al., 2022) and sleep deprivation (Taheri & Arabameri, 2012) also have been found to negatively impact reaction time. Another area of reaction time research that is highly studied is how physical activity level impacts reaction time. Regularly exercising can decrease reaction time in cognitive tasks (Jain et al., 2015). Incorporating exercise into rehabilitation programs can produce positive effects on reaction time in older adults, decreasing their fall risk (Rosado *et al*., 2021). Current research on reaction time demonstrates that there are many factors that can influence reaction time, and there is much to be learned about how reaction time may differ from person to person.

Because reaction time and physical activity are so interconnected, much research within sports psychology and sports performance have been focused on reaction time. Reaction time is one of the key parameters that allows elite athletes to succeed (Atan & Akyol, 2014). Improved reaction time can greatly benefit an athlete's performance; a track runner who reacts faster to a starting gun or a baseball player who can determine the curve or speed of an incoming ball more quickly both have an advantage over their competition. While these are two examples of reaction time at work in the realm of sports, the stimuli athletes are reacting to are very different. Because the differences in how stimuli are presented to athletes vary between sports like those previously mentioned, research has divided sports into two categories: open skill dominated (OSD) or closed skill dominated (CSD) (Nardello et al., 2021). As described in Nardello et al.

(2021), OSD sports, such as football, baseball, volleyball, tennis, and others take place in environments that are continually changing. Athletes must react to unpredictable stimuli and must make decisions on how to respond accordingly. CSD sports, such as swimming, track and field, rowing, and others take place in unchanging environments. Athletes must react to a single stimulus, such as a starting gun or buzzer, and much of their sport follows a stable and predictable pattern (Nardello et al., 2021).

In testing reaction time, research has also developed specific reaction time tests to accurately study the ways stimuli can be presented, and how the presentation of stimuli changes reaction time. While there are many different tests and methods to measure reaction time, two common, reliable, and useful tests used for reaction time testing are simple reaction time and choice reaction time (Deary et al., 2011). Simple reaction time (SRT) involves a single response while reacting to a single stimulus (i.e., pressing a button upon hearing a sound). Choice reaction time (CRT) involves the participant responding to one of several stimuli and deciding how to respond correctly (Deary et al., 2011).

To study how reaction time is affected by either OSD or CSD sport participation, Nardello et al. (2021) studied a group of young soccer players (OSD sport) and swimmers (CSD sport). These athletes engaged in a series of reaction time tests to evaluate the differences between the two sports. He found that there was no significant difference between swimmers and soccer players when it came down to simple reaction time tasks, which involved pressing a single button as soon as a light in the experimental set-up turned on. Nardello et al. (2021) also found that soccer players had faster reaction times in anticipatory tasks, which involved reacting to and maintaining balance as soon as another opponent pushed them. This research used simple reaction time (SRT) tests, however, instead of using choice reaction time (CRT) tests as well, they used anticipatory reaction time tests as a measure of choice reaction time, as anticipatory skill is an important component in decision-making in sports (Vaeyens et al., 2006). This study suggests that this group of soccer players, representing an open-skill-dominated sport, were faster at anticipatory reaction time than the swimmers due to the decision-making skills required of an open-skill-dominated sport. Similar research was done in 2013 by Nuri et al. looking at the differences in reaction time in volleyball players (OSD) and sprinters (CSD). The athlete's simple and choice reaction times were measured in a similar manor as in the study by Nardello et al. (2021). This study also incorporated a measure of auditory stimuli as well to investigate how the interconnectedness of the audio-visual pathway impacted reaction times. The results of the auditory reaction time tests indicated that sprinters had faster simple and choice auditory reaction times than volleyball players. Nuri et al. (2013) concluded that this heightened auditory reaction time is due to the way the stimulus in track is presented: a race begins with the sound of a starting gun. Interestingly, although the sprinters' auditory reaction time was faster, when asked in the choice reaction time task to discriminate a sound and respond accordingly, sprinters had significantly higher error rates than the volleyball players. The researchers concluded that the higher error rate was because for sprinters, it was more important for them to achieve a fast reaction time than it was to respond correctly, whereas for volleyball players, it was more important for them and their sport to evaluate and make a correct decision when reacting to gameplay. Like Nardello et al. (2021), Nuri et al. (2013) also found that the OSD athletes (volleyball players) had much faster anticipatory reaction times than the CSD athletes, indicating that the nature of their sport and the necessity to respond to changing environments improves their choice reaction times.

While these two studies are beneficial in tracing initial patterns of correlation between the type of sport and how it affects the type of reaction time, there is little research overall into how OSD sports and CSD sports compare; current research is limited to one sport versus another such as volleyball players versus sprinters (Nuri et al., 2013) or soccer players versus swimmers (Nardello et al., 2021). Sample populations in these studies were also very small, with 22 and 16 participants, respectively. No research has been done on multiple closed and multiple open sports at once, which provides an opportunity to increase the external validity of data and its ability to be generalized to larger athletic populations. Most research that does investigate closed and open sports differences do so using methods that may not be the best way to analyze reaction times objectively. For example, to analyze anticipatory reaction times, Nuri et al. (2013) had participants react to a ball's speed. This is a sport-specific movement that might favor volleyball players' skill sets, and therefore, more objective, non-specific stimuli might be better suited to analyze these variables. While these two studies are unique in that they are among the few to ask these questions, there are limitations to their research that can be addressed with the current study.

This research aims to look broadly at a university's athletic population and provide a general sense of OSD and CSD athletes and how they compare. This research will compare simple and choice reaction times of all athletes, with and without the addition of auditory stimuli. To do so, this research is adapting the Deary-Liewalk reaction time task (see *Methods*) to objectively measure reaction time in a manner that does not require any sport-specific movements to not create a bias. Lastly, research into the differences between closed and open sports rarely uses a control (non-athletic) population or mediates confounding variables such as sleep or academic stress levels. Because of the drastic impact that gender (Reimers & Maylor, 2005; Jain et al., 2015), academic stress levels (Wright et al., 2022), sleep deprivation (Taheri & Arabameri, 2012), and physical activity level (Jain et al., 2015) have on reaction time, these factors are important to control to produce a clear picture of how sport participation impacts reaction time. This study will control for these factors using a survey following data collection to ensure proper data analysis.

Based on this sport-specific data and background information, the hypothesis is that overall, participation in athletics or exercise programs will be positively correlated with faster reaction times. In addition, OSD athletes will have faster reaction times than CSD athletes on choice reaction time tasks because fast decision-making is a highly valued skill in their sports. This research hypothesizes that the opposite may be true for the simple reaction time tasks; CSD athletes will have faster reaction times because of the nature of the sports that require fast and precise reactions to simple stimuli. Lastly, based on previous research on how auditory and visual stimuli work together, the additional auditory stimulus is hypothesized to improve reaction times in all participants as opposed to just the visual stimuli.

Methods

Participants

22 undergraduate and graduate students (17 females and 5 males, age *M*= 20.3, *SD* = 1.42) from Butler University participated in this experiment. This study was approved by the Institutional Review Board at Butler University (Appendix A), and any undergraduate or graduate student was eligible for participation in this experiment. Participants were recruited through the Butler University SONA system, an online psychology research participation system. Participants were also recruited through email solicitation among the athletic department at Butler University (Appendix B), and through word-of-mouth solicitation across campus. Participants who were enrolled in a psychology course were provided with extra credit in their course for their participation. Participants who were not enrolled in a psychology course were notified that they would not be receiving any compensation for their participation, but their time and participation was greatly appreciated. The study was conducted in-person, either in a designated psychology research lab in Levinson Family Hall, or in a private study room in the Academic Center of Hinkle Fieldhouse. All participants were greeted with an overview of the experiment and what it entailed and were given an informed consent document to sign before their participation in the research (Appendix C). Participants were randomly assigned to either complete the visual reaction time tests or combined reaction time tests first and completed the other condition second. Every participant completed all four testing conditions.

Design

The entire experiment consisted of an experimental portion followed by a survey given to participants. The experimental portion was conducted on a laptop computer and utilized a 2 (Test type: simple or choice) by 2 (Stimulus type: visual stimulus or combined (auditory and visual) stimulus) repeated measures design. Test type and stimulus type were both manipulated within participants, as every participant received both visual and visual/ auditory, and simple and choice tests. A simple test involved participants reacting to a single stimulus with only one way of reacting. For example, a stimulus may be presented, and participants are expected to press a singular button whenever they see a stimulus. A choice stimulus involved participants reacting to a stimulus and making a decision on how to respond. For example, participants may be presented with multiple stimuli, and are instructed to press a button that correctly corresponds to the stimuli being presented, and therefore, must make a choice as to how to respond correctly. Stimulus type was also presented as either visual or combined (auditory and visual). A visual stimulus was one that could be viewed visually, such as an image appearing on a screen. A combined stimulus was one that was visual, such as an image appearing on a screen, and was also accompanied by an auditory stimulus. In this research, the auditory stimulus was a short, 800 Hz tone emitted from a speaker system. A survey administered after the experiment was to gather more demographic information about the participant and their activity level, as well as other factors that have been found to influence reaction time and was used in data analysis to determine correlation between reaction times and demographic factors.

Participants were categorized into three different groups regarding collegiate sports participation in this analysis. Participants were categorized as being a closed skill-dominated (CSD) athlete if they participated in swimming (*N* = 2), track and field (*N* = 1), golf (*N* = 1), or competitive dance (*N* = 1). There was a total of five CSD athletes in this study. Participants were categorized as being an open skill-dominated (OSD) athlete if they participated in open skill-dominated sports such as lacrosse (*N* = 3), baseball (*N* = 3), softball (*N* = 1), tennis (*N* = 2), or football (*N* = 1). There was a total of ten OSD athletes in this study. Participants were categorized as "no sport" if they did not participate in collegiate athletics (*N* = 7).

Materials and Apparatus

The entirety of experiments was conducted seated at a desk located in either a psychology lab space in Levinson Family Hall or seated at a table in a private study room in Hinkle Fieldhouse. The entirety of the experiment was conducted on a MacBook Air laptop sitting at the desk or table. Participants were instructed to make themselves comfortable and sit with their hands on the laptop as they normally would.

The software PsyToolkit was used to develop and administer the experiment (Stoet, 2010, 2017). The test that was run on PsyToolkit was the Deary-Liewald reaction time task, which is a previously developed and reliable test cognitive psychologists use to test simple and choice reaction times (Deary & Der, 2005). Figure 1 depicts the instructions given to participants for the simple reaction time task. Figure 2 depicts what the simple reaction time task looked like, which involved participants pressing the spacebar on the keyboard whenever a black "X" appeared within the box on the screen as fast as they can. Figure 3 depicts the instructions the software gave participants for the choice reaction time test. The software instructed participants to line up their fingers on the corresponding keys: z, x, "," (comma), and "." (period) which correspond to each of the white boxes (Figure 3c). Participants were instructed to press the correct key when a black "x" appears in the box corresponding to a specific key. For example, if a black "x" appeared in the leftmost box, participants would press the "z" key on the keyboard. Figure 4 depicts what the choice reaction time task looked like, with four white boxes aligned horizontally on the screen, and what the test would look like when a stimulus was presented. This was the standard Deary-Liewald task used for the visual stimulus. Further details of this experiment and its usage in reaction time testing can be found in Deary and Der (2005). The same Deary-Liewald task was then modified for this experiment to create the auditory-visual stimulus, which involved the addition of an 800 Hz tone played as soon as the black "x" appeared on any screen.

Participants received 20 trials of simple reaction time tasks, once with only visual stimuli and once with combined stimuli. Participants received 40 trials of choice reaction time tasks, once with only visual stimuli and once with combined stimuli. During the data collection process, the PsyToolkit's software's auditory stimulus was rendered non-functioning for a period, however, data collection continued. Therefore, only eight participants received both visual and combined stimuli. The other 14 participants included in this trial only received the simple and choice reaction time tests under the visual condition. All analyses comparing all four conditions utilized the eight participants who received all four conditions. Analyses comparing generalized means for all participant's reaction times were pooled from all participants so a larger sample size could be generated (see *Results: Data management*).

Following the reaction time task trials, participants were given a survey created on Google Forms to gather demographic information and other details such as athletic history, activity levels, and factors such as age, academic class, and amount of sleep participants received in the past week, all of which have been found to impact reaction time.

Procedure

Upon entering the experiment location, participants sat at a desk in a private room with a laptop on top of the desk. Participants were asked to sit at the desk comfortably as they would naturally sit. Participants were asked to read and sign an informed consent page prior to participation in the study. The informed consent that was given to all participants is included in the appendix (Appendix C). Participants were given the information that they were participating in a psychological study measuring reaction time, which gave them as much information as possible without giving them knowledge of the various conditions to ensure validity of the experiment. Following their signature on the informed consent page, informed consent was stored in a private folder until data collection was completed. Upon completion of the entire experiment, the informed consent was transferred and stored in a locked file cabinet kept in the locked psychology lab, Levinson Family Hall room 163.

The PsyToolkit Deary-Liewald reaction time task software was opened on the laptop computer. The researcher instructed the participants to follow the instructions on the screen which took them through the entire experiment. The program included all the necessary instructions and practice trials, so participants could follow along at their own pace. Upon opening the experiment, the program directed participants to practice trials of the simple reaction time first, and then proceed with the real trials of simple reaction time. The program then directed participants to the choice reaction time practice trials, which were then followed by the choice reaction time real trials. Participants completed 20 trials of the simple reaction time task, and the software measured participant's reaction times. Participants completed 40 trials of the choice reaction time task, and the software measured participant's reaction times, as well as if they pressed the correct key.

Participants performed this experiment (consisting of one simple and one choice reaction time task) twice. One of the two experiments was administered with auditory cues, while one of them did not have auditory cues. The auditory cue administered was an 800 Hz tone from the computer speakers. The auditory cue started as soon as the black "x" appeared on the screen and stopped as soon as the participant pressed a key. The order participants complete the two experiments will alternate between participants to avoid any order effects, meaning the first participant performed the experiment with auditory cues first, but the second participant performed the experiment with auditory cues second, and the pattern continued throughout all participant trials. Following each experiment, the researcher paused to store the data produced by PsyToolKit. The data being recorded was the time it took participants to press the corresponding keyboard button after a stimulus was presented (in milliseconds), as well as if participants pressed the correct key when prompted in the choice reaction time test. For data storage, each participant was given a number (1, 2, 3, etc.) and the researchers only stored their data in terms of their number. No names of participants were ever recorded. This data was stored on Google Drive in a Google Sheets document which was password protected. Only those included in the IRB submission had access to the data.

Upon completion of both experiments, participants were asked to take a short survey on Google Forms. The researcher administered the survey on the same device that was used to conduct the experiment (Appendix D). This survey asked participants to indicate their gender, current level of academic stress, physical activity level (according to physical activity standards), previous experience with sports (any sport they played or are currently playing at a competitive level), and on average, how much sleep they have gotten per night for the past week. These surveys were used to control for possible mediating variables that have been shown to impact reaction time (Reimers & Maylor, 2005; Rosado et al., 2021; Wright et al., 2022; Taheri & Arabameri, 2012). None of these questions were required and participants were told they may skip questions without penalty. This survey was administered after the study to avoid participants gathering any information that could potentially impact their performance and reaction times in the trials. All information gathered from the survey was also only stored in Google Drive with the participants' number; no names or identifying information other than what is asked in the survey were recorded or saved.

Data Analysis

This research utilized a 2 (test type: simple or choice) by 2 (stimulus type: visual stimulus or combined (auditory and visual) stimulus) by 2 (sport participation: open or closed) repeated measures design. A three-way ANOVA was used to assess the effect of stimulus type, test type, and sport type on reaction time and their impact on one another. The interactions between stimulus type and test type, test type and sport type, and sport type and stimulus type were compared using this analysis, as well as generally, which stimulus type, test type, and sport type produced statistically significant differences in reaction times. Gender, academic stress levels, and sleep deprivation were also used to control for confounding variables and test if significant differences were the effect of the three independent treatment variables (stimulus type, test type, and sport type).

Figures

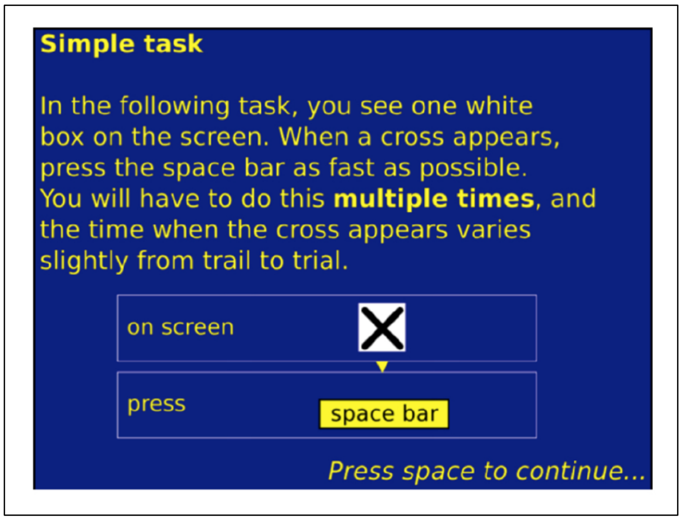

Figure 1. Simple reaction time task instructions from the PsyToolKit Deary-Liewald program. The screen reads: "In the following task, you can see one white box on the screen. When a cross appears, press the space bar as fast as possible. You will have to do this **multiple times**, and the time when the cross appears varies slightly from trial to trial".

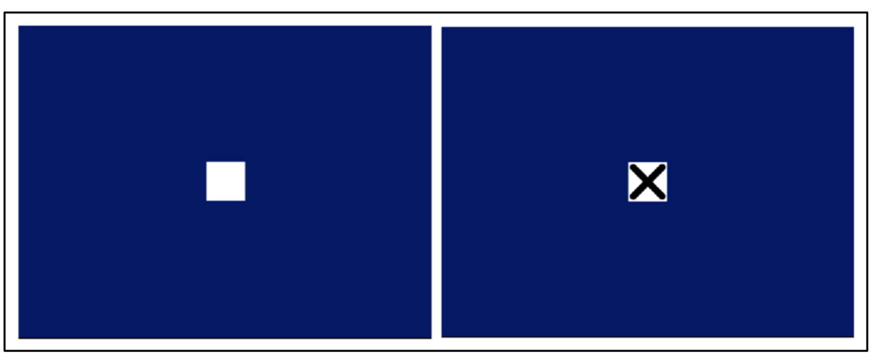

Figure 2. Simple reaction time test screen. Each simple reaction time task involved participants looking at the white box (left). At random times, a black "X" appeared within the white box (right). Participants were instructed to press the space bar as soon as the black "X" appeared.

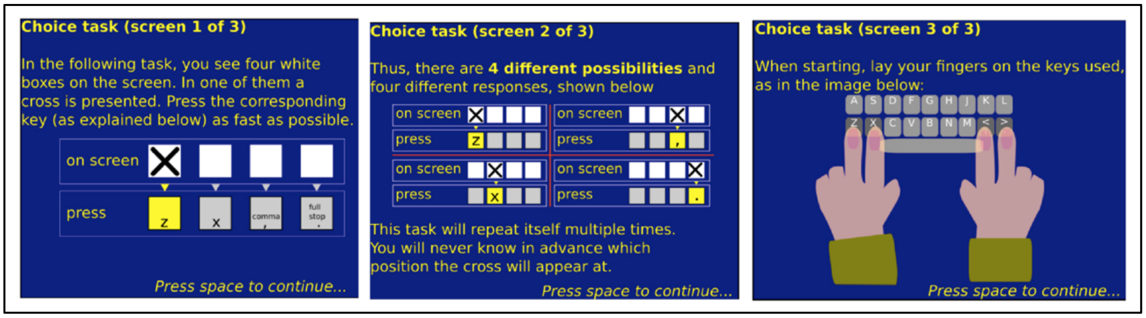

Figure 3. Choice reaction time task instructions. Participants were given three instructional screens prior to completing the choice reaction task instructions. Left: The first instructional screen instructed participants that there were four white boxes, and each time a black "X" appeared in one of them, they had to select a specific key on the keyboard. Middle: The second instructional screen showed each of the four possible responses to the black "X" appearing in each box, and which key to press when that box was selected. Right: Participants were instructed to use their pointer and middle fingers on both hands to select the corresponding keys: z, x, "," (comma), and "." (period) which correspond to each of the white boxes.

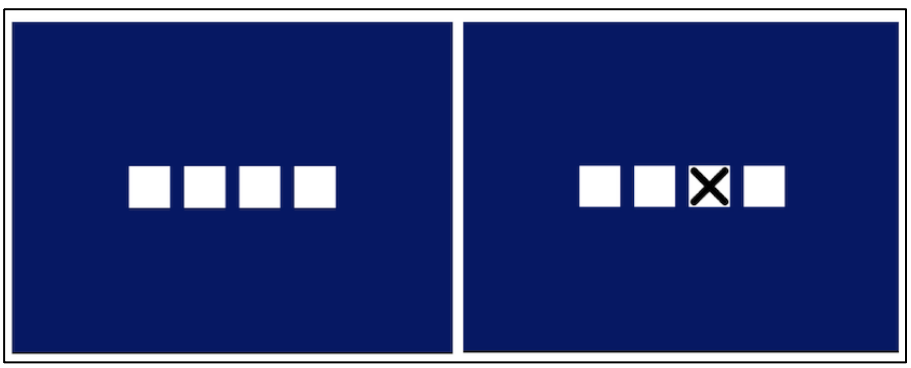

Figure 4. Choice reaction time task test screen. Each choice reaction time task involved participants looking at four white boxes (left). At random times, a black "X" appeared within one of the white boxes (right). Participants were instructed to press the corresponding key to the box with the "X" in it as soon as the black "X" appeared.

Results

Data management

A 2 (test type: simple or choice) x 2 (stimulus type: visual or combined) by 2 (sport participation: open or closed) repeated measures design was used, and therefore, participants received all four conditions in a single experimental trial (simple x visual, choice x visual, simple x combined, choice x combined). The reaction times from each participant for each condition were recorded in milliseconds (ms). These reaction times were pooled and averaged, giving the eight participants who completed all four conditions, four averages. The averages for each condition per participant were used when comparing the differences in reaction time across the four conditions. For further analysis, the average completed across all trials by the participant were averaged, giving each participant a single, average measure of reaction time. This averaged reaction time was also used in specific analyses within this study, in combination with the average reaction times per condition.

To study reaction time as it relates to sports participation, participants were categorized into three different groups regarding collegiate sports participation: closed (closed skill-dominated athletes), open (open skill-dominated athletes), and “no sport” (participants who do not participate in a sport at the collegiate level. These categories were used for the duration of the analysis. This analysis lists the main effects of each condition, then two-way interactions, and ends with the analysis of the three-way interaction of all conditions.

Main effects of test type, stimuli type, and sport participation on reaction time

To measure the individual effects of test type, stimuli type, and sport participation on reaction time, a three-way ANOVA was used. In this three-way ANOVA analysis, only the eight participants who received all four conditions were included and significance is reported at $p < 0.05$. Participant's average reaction time for all four conditions were used in this analysis. There was a significant main effect of test type (simple or choice) ($F(1, 5) = 442.162$, $p < 0.001$), with simple reaction time tasks generating faster reaction times than choice reaction time tasks. There was also a significant main effect of stimulus type ($F(1, 5) = 24.218$, $p = 0.004$), with combined (visual and auditory stimuli) resulting in faster reaction times than when only visual stimuli are presented. Lastly, the main effect of sport participation was not found to be significant ($F(2, 5) = 2.180$, $p = 0.209$). This indicates that there was no significant difference found between reaction times across the closed, open, and no sports groups.

Two-way interactions

The same three-way ANOVA used to determine main effects of test type, stimulus type, and collegiate sports participation was used to investigate the two-way interactions between these variables. Conditions included simple reaction time test and visual stimuli ($M = 279.83$ ms, SD = 20.5397 ms), choice reaction time test and visual stimuli ($M = 411.95$ ms, SD= 47.207 ms), simple reaction time test and combined stimuli ($M = 247.76$ ms, $SD = 24.588$ ms), and choice reaction time test and combined stimuli ($M = 393.193$ ms, SD = 41.069 ms). There was not a significant interaction effect between test type and stimulus type ($F(1, 5) = 1.592$, $p = 0.263$). This indicates that the addition of auditory stimuli does not impact the effects seen due to test type, and vice versa. These two factors influence reaction time independent of one another (Figure 5).

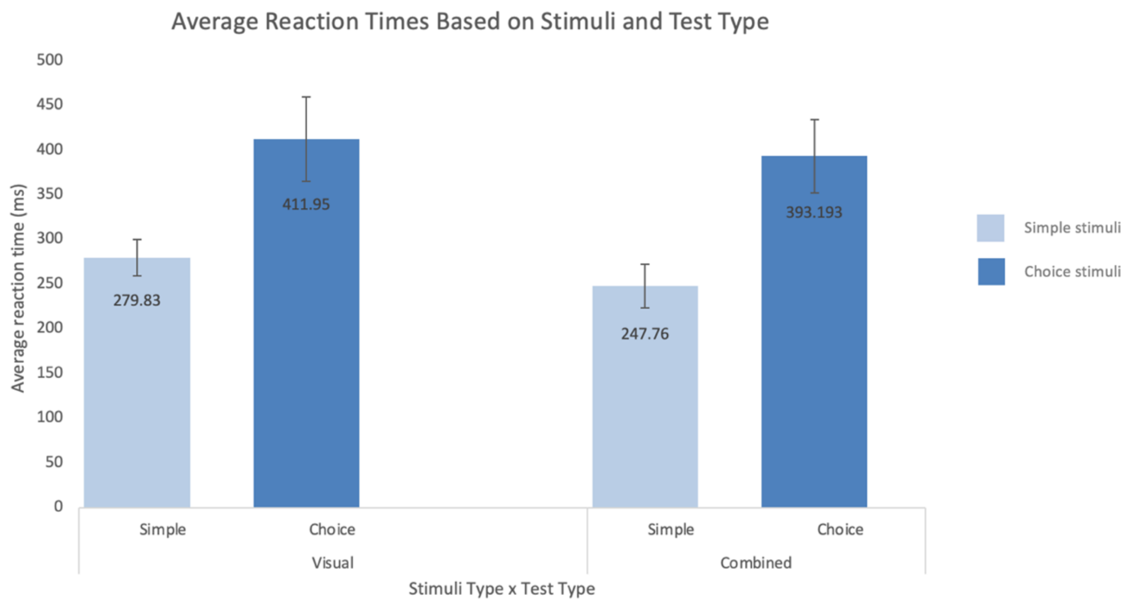

Figure 5. Average reaction times based on stimuli and test type. Reaction times from each condition were averaged to generate four reaction times for each participant who received all four experimental conditions ($N = 8$). Bar graph depiction shows average reaction times along the y-axis, and conditions plotted aloing the x-axis. Conditions are grouped by visual reaction time tests to the left (simple = light blue, choice = dark blue) and combined reaction times on the right (simple = light blue, choice = dark blue). Error bars represent standard deviations.

In investigating the interaction between test type and college sport participation, no significant interaction was found ($F(2, 5) = 3.869$, $p = 0.097$). This indicates that collegiate sport participation was not a predictor for how fast or slow an individual reacted to a particular stimuli type, either simple or choice.

A similar result was found when analyzing the interaction between stimuli type and collegiate sport participation. No significant interaction was found between the two ($F(2, 5) = 1.098$, $p = 0.402$). This demonstrates that collegiate sport participation does not predict whether a given participant will have faster or slower reaction times when presented with a given stimulus.

Three-way interactions between test type, stimuli type, and sport participation

Finally, the three-way ANOVA was used to determine the interaction between test type, stimuli type, and collegiate sport participation. Averages for closed skill-dominated athletes in each of the four conditions were as follows: simple test and visual stimuli (M = 282.267 ms, SD = 12.02 ms), choice test and visual stimuli (M = 405.617 ms, SD= 21.282 ms), simple test and combined stimuli (M = 256.733 ms, SD = 13.353 ms), and choice test and combined stimuli (M = 399.242 ms, SD = 21.11 ms). Averages for open skill-dominated athletes in each of the four conditions were as follows: simple test and visual stimuli (M = 268.3 ms, SD = 12.012 ms), choice test and visual stimuli (M = 381.867 ms, SD = 21.282 ms), simple test and combined stimuli (M = 229.883 ms, SD = 13.535 ms), and choice test and combined stimuli (M = 393.193 ms, SD = 21.11 ms). Averages for non-athletes in each of the four conditions were as follows: simple test and visual stimuli (M = 293.4750 ms, SD = 32.915 ms), choice test and visual stimuli (M = 466.587 ms, SD = 65.354 ms), simple test and combined stimuli (M = 261.125 ms, SD = 39.774 ms), and choice test and combined stimuli (M = 428.075 ms, SD = 63.339 ms). There was no statistically significant three-way interaction between these variables ($F(2, 5) = 0.841$, $p = 0.484$). This indicates that the variables analyzed in this study act independently of one another to influence reaction time (Figure 6).

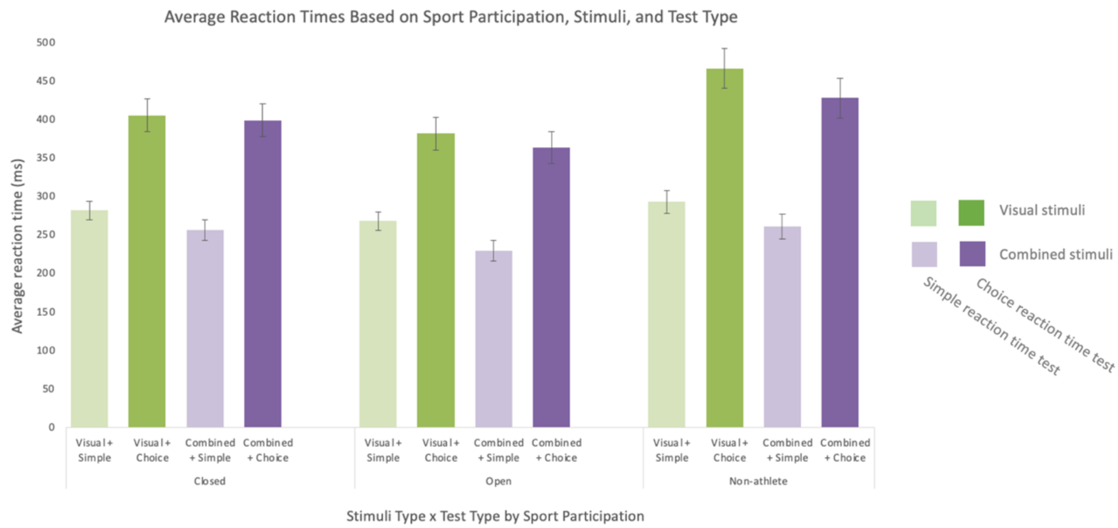

Figure 6. Average reaction times based on sport participation, stimuli, and test type. Average reaction times for each participant were generated for each condition, and conditions were averaged across the study ($N = 8$). Participant's participation in a collegiate sport was deemed closed ($N = 3$), open ($N = 3$), or non-athletes ($N = 2$). The y-axis of the bar graph depicts average reaction time (ms), while the x-axis displays the various reaction time tests by athlete type (CSD = left, OSD = middle, non-athlete = right). Each group of athlete types has four bars, each representing a test type. Green represents visual stimuli conditions and purple represents combined stimuli conditions. Light colors represent simple test types while opaque colors represent choice test types. Therefore, light green is visual x simple, green is visual x choice, light purple is combined x simple, and purple is combined x choice. Error bars represent standard deviation.

Athletes versus non-athletes

Following analysis by ANOVA, further investigations were performed to analyze the athletic participation in contrast to non-athletes. In this analysis, each participant's reaction time across all trials completed were pooled and averaged. This generated a singular, average reaction time for each participant, and the entire participant pool was used ($N = 22$). Participants were then grouped into two groups: either athletes (consisting of both CSD and OSD athletes, $N = 15$) or non-athletes (participants who do not participate in a collegiate sport, $N = 7$). A Pearson correlation was run on participation in collegiate athletics and average reaction time across all trials. Participation in any collegiate sport, regardless of open or closed skill-dominated classification, was correlated with faster reaction times ($N = 22$, $r = -0.559$, $p = 0.007$) (Figure 7). The average reaction time for collegiate athletes was 331.424 ms ($N = 15$, $SD = 19.257$ ms). The average reaction time for non-collegiate athletes was 364.840 ms ($N = 7$, $SD = 32.971$ ms). This indicates there was a significant correlation between being a college athlete and decreased reaction time, indicating athletes have faster reaction times than non-athletes.

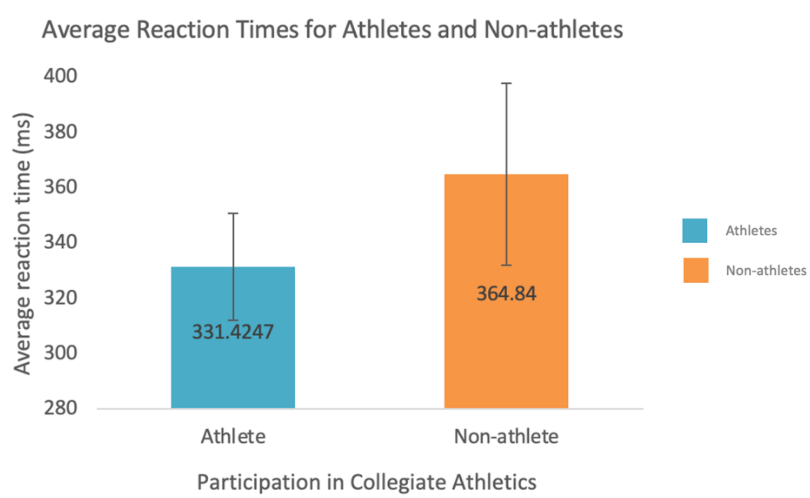

Figure 7. Average reaction times for athletes and non-athletes. Bar graph depicting the differences between athletes ($N = 15$) and non-athletes ($N = 7$) and their averaged reaction times. Y-axis represents the average reaction time in milliseconds, and the x-axis displays athletes (blue) and non-athletes (orange). Error bars represent standard deviations.

Following the Pearson correlation, a one-way ANOVA was used to determine which test type and stimuli type generated these significant differences between athletes and non-athletes. This ANOVA used the four averages for each participant generated from the four conditions to determine which conditions specifically contributed to the athlete's decreased overall reaction time. The only stimuli type and test type that contributed to the significant difference between athletes and non-athletes was the choice reaction time task under visual stimuli ($F(1, 21) = 18.588$, $p < 0.001$). All other stimuli and test types resulted in non-significant differences (all p's > 0.05).

Effect of gender on reaction time differences

A one-way ANOVA was run to compare the average reaction times between males and females. The average reaction time for each participant was used in this ANOVA. There was a significant difference found between the overall reaction time average across all four conditions between males and females ($F(1, 20) = 6.168$, $p = 0.022$). The average reaction time for males was significantly faster than females.

For further analysis, another one-way ANOVA was used to determine which test type and stimulus type conditions resulted in these gendered differences. The only condition that yielded a significant difference was the simple reaction time test and visual stimuli ($F(1, 20) = 4.772$, $p = 0.041$). All other conditions resulted in p-values > 0.05 and were not deemed significant.

Effect of age and academic class on reaction time

To investigate if the age of participants impacted participant's reaction time, a one-way ANOVA was run. This ANOVA utilized the average reaction time for all participants across all trials ($N = 22$) in comparison to the participant's reported age. The age ranges of participants in this study was between 18-22 years-old, and the average age of students was 20.3 years. There was no statistically significant difference in average reaction time in all four conditions based on participant's age (all p's > 0.05).

Similarly, a one-way ANOVA was run on each participant's averaged reaction time across all trials and academic class ($N = 22$). There was no statistically significant difference in average reaction time in all four conditions based on participant's academic class (all p's > 0.05).

Effect of academic stress level and average hours of sleep

The sample size was not large enough in this study to examine the potential confounding effects of the level of academic stress on reaction time differences in each of this study's conditions. Similarly, the sample size was not large enough to examine the effect of the amount of sleep participants received in the last week on reaction times.

Analysis of incorrect answers in choice reaction time tasks

In all choice reaction time tasks, the number of times participants answered incorrectly was recorded. An incorrect question was defined by a participating pressing the wrong key during a choice reaction time test. A one-way ANOVA was used to determine if the number of times answered incorrectly was affected by sport participation under both visual and combined stimuli (Figure 8). Under visual stimuli, the average number of incorrect responses for CSD athletes was 1.400 ($N = 3$, $SD = 0.548$), the average number of incorrect responses for OSD athletes was 1.000 ($N = 3$, $SD = 0.817$), and the average number of incorrect responses for non-athletes was 1.143 ($N = 2$, $SD = 0.690$). Under combined stimuli, the average number of incorrect responses for CSD athletes was 0.667 ($N = 3$, $SD = 1.154$), the average number of incorrect responses for OSD athletes was 3.000 ($N = 3$, $SD = 2.646$), and the average number of incorrect responses for non-athletes was 3.500 ($N = 2$, $SD = 0.707$). There was no significant differences found between the number of incorrect responses and college sport participation, regardless of if it was under visual ($F(2, 19) = 0.504$, $p = 0.612$) or combined ($F(2, 5) = 1.796$, $p = 0.258$) stimuli.

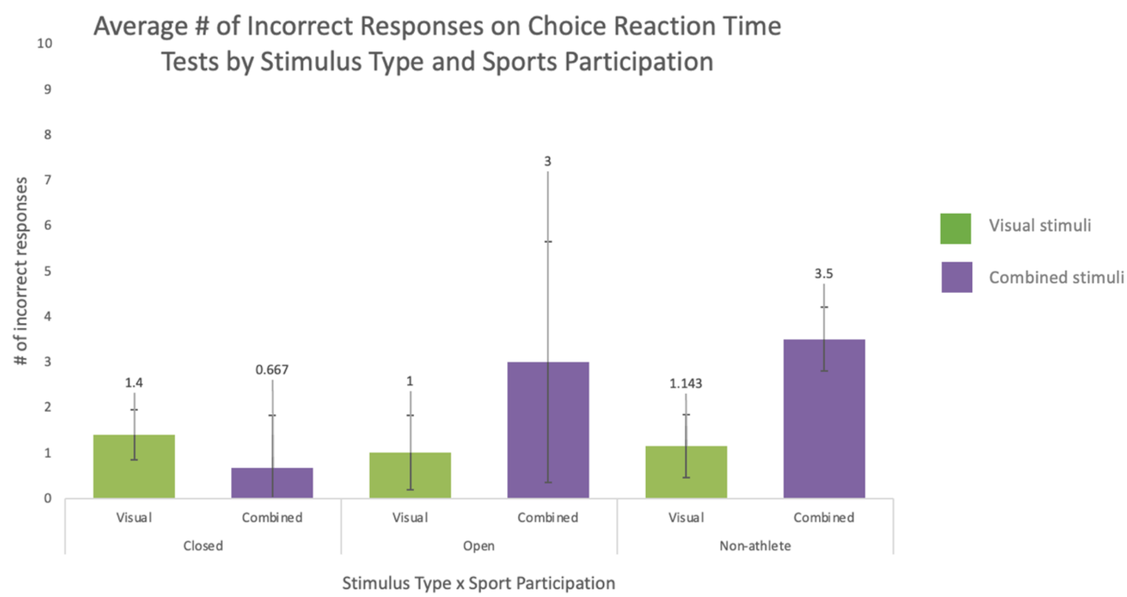

Figure 8. The number of incorrect responses on choice reaction time tests based on stimulus type and sports participation. The number of incorrect responses during choice reaction time tests was recorded for each participant, and the average number of incorrect responses was generated for each stimulus type. The average number of incorrect responses for each sport participation type (closed, open, or non-athlete) for each stimulus type were averaged and are plotted on the y-axis. The x-axis displays the results grouped by sport type and test type, with CSD athletes grouped to the left, OSD athletes in the middle, and non-athletes on the right. Green represents the visual stimuli conditions and purple represents the combined stimuli conditions. Error bars represent standard deviations.

Discussion

This research aimed to analyze differences in reaction times based on different stimulus types, test types, and the intersection of sports participation. The results of the three-way ANOVA demonstrated that the stimuli type and test type had significant main effects on reaction time. This was expected as previous literature demonstrates that the human reaction time to simple stimuli is faster than when humans are required to make a decision, such as in choice reaction time tasks (Deary et al., 2011). Additionally, previous literature demonstrates that the auditory reaction time is faster than the visual reaction time (Jain et al., 2015)., which was also confirmed by this analysis. In both simple and choice reaction time tasks, participants had a significantly faster reaction time with the addition of an auditory stimulus (Figure 5). This supported the hypothesis that the auditory stimuli will improve reaction times in all participants. Additionally, using the same three-way ANOVA, there was not a significant interaction between stimuli type and those belonging to the OSD, CSD, or non-athlete groups. This demonstrates that the addition of the auditory stimulus reduced reaction times in participants across all groups and did not have a greater impact on one sport type over another.

This was surprising, as previous research analyzed the auditory reaction times of sprinters compared to volleyball players and demonstrated that regardless of test type, sprinters (CSD) had significantly faster reaction times as opposed to volleyball players (OSD) (Nuri et al., 2013). Previous research suggests that closed skill-dominated athletes generate more improved reaction times than open skill-dominated athletes when they are presented with an additional auditory stimulus. This has been assumed to be because athletes in these sports are accustomed to reacting quickly to an auditory stimulus, such as the sound of a starting gun (Nuri et al., 2013).

Additionally, it was hypothesized that participation in collegiate athletics is positively correlated with faster reaction times. This was based on previous research that exercise improves reaction time; regularly exercising adults demonstrate faster reaction times than adults who do not regularly exercise (Jain et al., 2015). The three-way ANOVA found no significant effect of sport participation on reaction time when looking across all three groups: OSD, CSD, and non-athletes. However, when combining athletes into a singular, larger group, and comparing them to the non-athletes, there was a statistically significant correlation between participating in an athletic team at Butler University and decreased reaction times (Figure 7). Athletes at Butler University demonstrated significantly faster reaction times than non-athletes in every condition presented to them. This was expected based on prior research that exercise positively impacts cognition (Etnier et al., 1997), and reaction time is a common and reliable proxy for the measurement of cognition (Deary & Der, 2005). Overall, participation in a collegiate athletic program is correlated with decreased reaction times across all reaction time conditions used.

To further investigate how sport participation effected reaction time on particular tasks, the same ANOVA was used to find interactions between sport participation and test type. It was hypothesized that athletes participating in closed skill-dominated sports would have faster reaction times in simple reaction time tasks than open skill-dominated athletes due to the importance placed on fast reaction times to simple stimuli in CSD sports. Similarly, it was also hypothesized that the opposite is true; OSD athletes would have faster reaction times in choice reaction time tasks than CSD athletes due to the importance placed on fast decision-making in their sports. Both hypotheses were generated because it has been concluded by previous research that the most effective form of training for elite athletes is deliberate practice of skill-sets (Baker et al., 2003). Therefore, it would be expected that a CSD athlete would have deliberate practice and training to responding to simple, quick stimuli, as this is how many of their sports are started (i.e. a starting gun). The opposite is true for OSD athletes based on this logic as well, as deliberate practice in their sport requires skill sets to enable these athletes to respond to multiple stimuli and make quick decisions. However, neither hypothesis proved to be significant in this study. There was no statistically significant difference found between OSD and CSD athletes and their performance on simple or choice reaction time tests (Figure 6). Research is currently divided in this area of reaction time research, specifically reaction times to simple stimuli. This study supports the findings from Nardello et al. (2021), which found no statistically significant difference when comparing simple reaction times between swimmers and soccer players. However, Nuri et al (2013), found that sprinters reacted significantly faster than volleyball players to simple stimuli. Little research has been done to determine if athletes from open and closed skill-dominated sports have statistically different reaction times to simple stimuli, and more research is needed in this area of sports performance.

Additionally, there was also not a significant difference found between OSD and CSD athletes responding to choice reaction time tasks. This is contrary to previous research, as both of the studies comparing soccer players to swimmers, and volleyball players to track athletes, demonstrated that athletes participating in open skill-dominated sports tended to have faster reaction times to choice reaction time tasks than closed skill-dominated athletes (Nardello et al., 2021; Nuri et al., 2013). While this finding is contrary to previous findings, there is little other research currently analyzing the difference between sport types and their reaction times to choice stimuli. In terms of analyzing the differences between the sport types, all known previous research analyzing the differences between open skill-dominated athletes and closed skill-dominated athletes and their participation on both simple and choice reaction time tests to date utilizes data from two separate sports populations (soccer vs. swimming, or volleyball vs. sprinting). However, this research looked broadly at multiple sports within the open and closed skill-dominated groups. Therefore, more research and a larger sample size is needed to further illuminate the differences between open and closed skill-dominated athletes and their reaction times to different reaction time tests, and the implications that has for sport performance.

A one-way ANOVA was also used to examine the differences in average reaction times across genders. Males had statistically faster reaction times than females, which has been demonstrated in previous literature (Reimers & Maylor, 2005; Jain et al., 2015). Previous studies have explained these differences in reaction time across gender because male's motor responses are quicker than females (Jain et al., 2015). In a meta-analysis looking at the reaction time differences in males and females across a 73-year period, Silverman (2006) saw the "male advantage" shrinking. Silverman (2006) suggested this may be due to the increase in female participation in sports, or the prevalence of more females driving. While previous research suggests the gender differences in reaction time are shrinking, there are still some remaining effects of these gender differences present among college students today.

A one-way ANOVA was run to investigate if age of participants impacted reaction time. Academic class was also used as an additional measure of age, and data analyzed if academic class impacted reaction time of participants using a one-way ANOVA as well. Neither age of participants nor academic class was a factor in a participant's reaction time on any task. While age has been found in previous research to increase with age (Era et al., 1986), much of this research has focused on participants from wider age ranges (Deary & Der, 2005). Participants in this research, as it was focused on college-aged students, were between 18-22 years old, as opposed to research that has investigated participants ranging from 16-63 years old (Deary & Der, 2005). Previous research found the biggest increase in reaction time due to age is between 30-60 years old (Deary & Der, 2005), and no participants in this research were within that age range. Therefore, we can conclude that age and academic class did not contribute to any reaction time changes in this study of college-aged students.

This research also sought to analyze how academic stress and sleep deprivation may have impacted the data generated in this study. However, the sample size was not large enough to conduct the necessary analyses to confirm the impact of stress or sleep deprivation. Previously, both stress and sleep deprivation has been shown to affect performance on cognitive tasks (Dorenkamp & Vik, 2018; Taheri & Arabameri, 2012). Specifically, within reaction time research, chronic or academic stress has implications on performance in reaction time; more stressed individuals exhibit slower simple and choice reaction times on cognitive assessments (Wright et al., 2022). Sleep deprivation is also known to impair reaction time on cognitive assessments and reaction time tasks (Taheri & Arabameri, 2012). Because participants in this research were college students, who are known to both not receive adequate sleep (Mbous et al., 2022) and have an overall high stress level across populations (Baghurst & Kelley, 2014), both of these variables would be important factors to control in future research.

Lastly, a one-way ANOVA was used to determine if sport participation impacted how often participants selected incorrect answers on the choice reaction time test. This research showed that there was no statistically significant difference in the number of incorrect answers between participants who were OSD athletes, CSD athletes, and non-athletes (Figure 8). This finding is contrary to previous research, which demonstrated that in choice reaction time tasks, sprinters (CSD) had statistically higher error rates than volleyball players (OSD) (Nuri et al., 2013). The research concluded that the higher number of errors for sprinters was because in their sport, the most valued reaction time ability is responding to a single stimulus, such as the starting gun, rather than responding correctly to many stimuli. This research, however, found no difference in the error rates in choice reaction time tasks. This insignificant difference may be due to the large standard deviations found in the data, and future research is needed with a larger sample size to fully understand the effects of sport type on choice reaction time error rates.

This research provides an additional lens to investigate sport performance, specifically through reaction time. A key factor that distinguishes elite athletes are their enhanced reaction times (Atan & Akyol, 2014). This research corroborates this, as athletes were found to have faster reaction times than non-athletes at a college campus. However, due to this finding among others, this may have implications regarding competition regulations. Specifically, the international regulating body for athletics, World Athletics, formally known as the International Association of Athletics Federations (IAAF), upholds reaction time criteria that should be updated to reflect current research in this field. Currently, World Athletics holds that in running and sprinting events, any athlete who produces a reaction time of less than 0.01 seconds (100 milliseconds) will be disqualified from competition (World Athletics, 2016). That is, any athlete who still starts after the start of the race, but before 100 milliseconds has passed, will be assumed to have left early. While it has been documented that reaction times of less than 100 milliseconds are rare (Komi et al., 2009), there are instances where reaction times less than this have been achieved, specifically for simple, auditory reaction times (Pain & Hibbs, 2007; Komi et al., 2009), which is the type of stimuli track athletes respond to in races.

World Athletics (IAAF at the time) commissioned a research project to assess the fastest possible reaction times elite track athletes could generate to reevaluate their assumed 100 millisecond false-start criteria. In 2009, research was conducted on national-level Finnish track runners to assess the minimum reaction time possible to simple, auditory stimuli. This research found that some elite track athletes could generate reaction times between 60-80-milliseconds, far below the 100-millisecond cut-off set by World Athletics (Komi et al., 2009). However, World Athletics has made no effort to adjust their false-start criteria since this commissioned research.

The ability of these athletes, and many athletes across the globe, to generate such fast reaction times is due to many factors as discussed in this paper and other literature. However, while research such as the one commissioned by World Athletics demonstrates increased understanding of closed skill-dominated sports and their reaction time, little research has been conducted on the differences between closed and open skill-dominated sports. The lack of research in this field may hinder the ability for scientists, psychologists, athletes, and coaches alike to tap into the magnificence of the human body. More research in this area of sports performance and psychology provides an opportunity for increased knowledge of what the human body is capable of under different circumstances and stimuli, and how science can aid in bringing innovation to the improvement of athletes.

Limitations and Future Directions

While this study provides another lens by which to investigate reaction time, there are many further adjustments to this study for future research on sport type and reaction time. First, the software used in this study was a helpful tool, however, the software underwent a period during data collection in which the audio in the combined stimulus condition was non-functional. This generated a smaller sample size than originally intended. Future research undertaking a similar approach should recognize this limitation to this research and seek to recruit a larger pool of participants.

Additionally, there are many factors involved in the experimental portion which may not have mirrored conditions athletes face during competition. First, finger movements like the ones that are used in this study require fine motor control, and the precision and practiced movement of pressing a key with a finger may not accurately quantify reaction time in an athletic setting. However, this study was simply investigating the comparison of reaction times between individuals with different demographics, and therefore, the simple finger movement allows for the use of a controlled environment for this study. In future research, investigating the true reaction time limit, it would be beneficial for empirical evidence if a more sports-specific or gross motor function was performed, such as a sprint start or entire body movement (Pain & Hibbs, 2007; Komi *et al.*, 2009).

Additionally, competition in sports is known to evoke stress responses in athletes due to the various demands placed upon participants, such as physical, physiological, environmental demands as well as pressure from coaches and peers to perform well (Gould *et al.*, 1993). The reaction time tests were not designed to evoke stressful conditions, nor was the research performed in a competitive environment such as the conditions athletes face in competition, and therefore, this reaction time test may not mirror exact conditions of sports participation. Therefore, more research should be done in conditions that can more accurately mimic the demands athletes experience while participating in sports to best understand how reaction times differ between sport types and different stimuli.

While reaction time is a measure of how humans detect changes in their environment (perception) and respond accordingly (action) and is relevant to sports performance, as demonstrated in this research, it is also useful in determining how humans interact with changes that occur within their environment (Warren, 2006). This is known as perception-action within psychology and is an important element of psychological research (Deary et al., 2011). This study adds to the overall knowledge base of percpetion-action, which has applications far beyond sports. The relationship between perception and action is essential for daily human activity such as walking, driving, or waving to a friend (Warren, 2006). Therefore, this research, along with past and future research, contributes to a growing field of psychology that aims to better understand how humans perceive and interact with their environment.

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Appendices

Appendix A: IRB Approval

BUTLER
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4600 Sunset Avenue | Indianapolis, Indiana 46208 | www.butler.edu

INSTITUTIONAL REVIEW BOARD

DATE: October 7, 2022

TO: Dr. Brian Day
Miss Allie Carmichael
College of Liberal Arts and Sciences

FROM: Joel M. Martin, Ph.D.
Chair, Butler University IRB

RE: Notice of IRB Protocol Approval

TITLE: The effect of athletic participation and auditory stimuli on simple and choice reaction times

SUBMISSION TYPE: New Study - Exempt

On behalf of Butler's Institutional Review Board (IRB), I am pleased to inform you that your research has been registered as exempt as of the date of this memo. This research is approved under Exempt Category 3. As such, there will be no further review of your protocol, and you are cleared to begin the procedures outlined in your protocol.

As an exempt study, there is no requirement for continuing review. Your protocol will remain on file with the IRB as a matter of record. Although your study is exempt from continuing review, you and your research team are not exempt from ethical research practices and should therefore employ all protections for your participants and their data which are appropriate to your project.

Please note the following conditions apply to all IRB approvals:
1. No subjects may be involved in any study procedure prior to the IRB approval date.

2. All unanticipated or serious adverse events must be reported to the Office of Sponsored Programs within five (5) business days of the investigators becoming aware of the event.

3. All protocol modifications must be IRB approved prior to implementation unless they are intended to reduce risk. This includes any change of investigator, or site address.

4. All protocol deviations must be reported to the IRB within five (5) business days of the investigators becoming aware of the event.

5. All recruitment materials and methods must be approved by the IRB prior to being used.

I offer my congratulations on your approval and wish you success on your research. Should you desire additional assistance or clarification, please email irb@butler.edu
Additional information is also available on our website at
https://www.butler.edu/academics/sponsored-programs/research-compliance/irb/

Appendix B: Email Solicitation

Subject: Student Athlete Research Request & Psych Credit!
Date: Thursday, January 26, 2023 at 9:17:24 AM Eastern Standard Time
From: Reiff, Ralph
To: Student Athlete Listserv
CC: Carmichael, Allie

Hello! My name is Allie Carmichael, and I am a senior swimmer at Butler. I am currently working on psychology research for my honors thesis and would love to have athletes participate. I am specifically looking at connections between athletics and reaction time. The research will take less than 15 minutes and only require you to interact with computer software that measures reaction time, and then take a short survey.

If you are currently enrolled in a Psychology class at Butler, you will be eligible for extra credit in that class for participating!

If you are interested, you can either contact me at (317) 504-3239 or email me at alcarmic@butler.edu to coordinate a time to participate, or you can fill out the Google Form attached here: https://forms.gle/rJUVLDUoRmBGqM3V9

Thank you!
Allie Carmichael

Emailed by
Ralph Reiff, MEd ATC LAT
Sr. Associate Athletic Director for Student Athlete Health, Performance & Well-Being
Health Care Administrator | Head Athletic Trainer, Men's Basketball | Butler University

Appendix C: Informed Consent

BUTLER UNIVERSITY
CONSENT FORM

CONSENT BY SUBJECT FOR PARTICIPATION IN RESEARCH PROTOCOL

Reaction Time

I, ____________________, hereby consent to participation as a subject in the above-named research project, conducted under the direction of Dr. Brian Day's lab Butler University. My consent is given of my own free choice without undue inducement and after the following things have been explained to me. I have been informed that I will be one of approximately 60 subjects participating in this study.

1. Nature and Duration of Procedures.

You are invited to participate in a research study conducted by Dr. Brian Day. The purpose of this research is to investigate reaction times of college-aged students across various groups. We are interested in investigating the components that may play into reaction time. Previous research has shown many factors that contribute to increasing or decreasing reaction times.

You will be asked to participate in a 30-minute study that will first ask you to use computer software that will measure your reaction time pressing keyboard keys in response to visual or auditory stimuli. Following four experiments, you will be asked to complete a survey produced on Google Forms about various demographic data that may play a role in reaction times. The entirety of this experiment will be performed in this room, and you will not be asked to participate in a follow-up experiment. The only information that will be saved or stored will be your reaction times and your survey answers.

2. Potential Risks and Benefits

By participating in this study, you may exhibit symptoms of digital eye strain, such as a headache or eye irritation/ dryness due to viewing a digital screen for approximately 30 minutes. These symptoms will go away when you are no longer viewing a digital screen. If you continue to feel badly after this study, please contact Health Services at the HRC at 317-940-9385.

There are no known benefits to you that would result from your participation in this research. Information that is obtained from this study may be used scientifically and may be helpful to others. Possible benefits you attain may include extra credit towards a course grade for students and may include the satisfaction of contributing to the advance of science.

3. Voluntary Participation

Your participation in this project is entirely voluntary. You are free to decide not to participate in this study or to withdraw at any time without adversely affecting your relationship with any faculty at Butler University. Your decision will not result in any loss of benefits to which you are otherwise entitled. If you choose to participate, you may withdraw at any time by notifying the person administering the research session. Upon your request to withdraw, all information pertaining to you will be destroyed. If you choose to participate, all information will be held in strict confidence and will have no bearing on your academic standing or services you receive from the University. The information obtained in the study may be published in scientific journals or presented at scientific meetings but your identity will be kept strictly confidential.

4. Contact Information

If you have any questions or concerns about this study or if any problems arise, please contact Brian Day at Butler University at 317-940-2007. For questions about your rights as a research participant or to discuss problems, complaints or concerns about a research study, or to obtain information, or offer input, contact the Butler Office of Sponsored Programs (OSP) at (317) 940-9766 or by emailing IRB@butler.edu.

Consent:

I have had the opportunity to ask questions concerning any and all aspects of the project and my questions have been answered. I understand that participation is voluntary and that I may withdraw my consent at any time without prejudice to me. Confidentiality of records concerning my involvement in this project will be maintained in an appropriate manner.

I understand that if I have any questions concerning this research, I can contact the Investigator stated below or the supervising faculty member at Butler University.

Participant's signature: ________________________________ Date: ______________

Participant's name printed: ____________________________

Investigator's signature: _______________________________ Date: ______________

Appendix D: Survey Questions

End of Cognitive Psychology Research Survey

Thank you for taking the time to complete my cognitive psychology research. Please answer the following questions for the end of research survey. Thank you!

1. Participant Number (number assigned to you by the researcher)

   ____

2. Gender

   Mark only one oval.

   ◯ Male
   ◯ Female
   ◯ Prefer not to say
   ◯ Other: ______________________________

3. Age

   ____

4. Class

   Mark only one oval.

   ◯ First year
   ◯ Second year
   ◯ Third year
   ◯ Fourth year
   ◯ Fifth year or graduate student

7. Throughout high school, did you participate in any club or high school junior varsity or varsity athletic teams?

Mark only one oval.

- Yes
- No

8. If yes to the above question, what sport(s) did you participate in and for how many years?

____

9. If yes to the above question, how many HOURS a week did you spend participating in your sport(s)? This includes weight training, regular practices, games, etc. If you DID NOT participa in high school athletics, leave this question blank

Mark only one oval.

- 1-5 hours
- 6-10 hours
- 11-15 hours
- 16-20 hours
- 20+ hours

Current Activity Level

10. Select the choice that best describes you.

Check all that apply.

- [ ] I am a member of a Butler University athletics team.
- [ ] I am a member of a Butler University club athletics team.
- [ ] I am neither

11. If yes to the above question, what sport(s) do you currently participate in? If you DO NOT participate in varsity or club athletics at Butler, leave this question blank.

____

12. If yes to the above question, how many HOURS a week do you currently spend participating your varsity or club sport(s)? This includes weight training, regular practices, games, etc. If y DO NOT participate in varsity or club athletics at Butler, leave this question blank.

Mark only one oval.

- ( ) 1-5 hours
- ( ) 6-10 hours
- ( ) 11-15 hours
- ( ) 16-20 hours
- ( ) 20 + hours

13. How many days a week do you participate in at least 30 minutes of moderate physical activity that may not make you sweat or breathe hard such as fast walking, slow bicycling, etc.

Mark only one oval.

	0	1	2	3	4	5	6	7	
No (	( )	( )	( )	( )	( )	( )	( )	( )	7 days a week

14. How many days a week do you participate in at least 20 minutes of vigorous physical activity that makes you sweat or breathe hard, such as basketball, soccer, running, swimming, fast bicycling, fast dancing etc.

Mark only one oval.

	0	1	2	3	4	5	6	7	
No (	( )	( )	( )	( )	( )	( )	( )	( )	7 days a week