Effects of Arousal on Attention and Reaction Time in Collegiate Student-Athletes

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ABSTRACT

With athletic skills in sports requiring quick reaction times, accurate hand-eye coordination, and the ability to make decisions quickly, the cognitive side of athletic profile should be given attention. PURPOSE: To measure changes in reaction time (RT), hand-eye coordination (HEC), and decision-making (DM) when increasing an athlete's arousal (via increased heart rate and sound stimulus). METHODS: Eleven participants were recruited to participate in the study. All eleven of them were current competing student-athletes at the NCAA Division III level across a variety of sports. The participants reported to the lab on three separate occasions to have their RT, HEC, and DM measured with three different arousal conditions: low arousal (no sound or elevated heart rate), medium arousal (no sound but with elevated heart rate), and high arousal (sound and elevated heart rate). Heart rate was elevated to 75-85% of their age-predicted maximum using a standardized graded walking protocol on a treadmill. Sound was administered via noise-cancelling headphones that played simulated crowd noise. The three conditions were administered in a randomized order for each participant. RT, HEC, and DM were measured by completing tasks on a cognitive sensory station that consisted of a large touchscreen and tablet. RESULTS: Fourteen different metrics that quantified RT, HEC, and DM were recorded across the three different conditions. No statistical differences were reported across the metrics and the three arousal conditions ($p > 0.05$). CONCLUSION: The activities designed to increase arousal in this study did not appear to significantly change cognitive function within the collegiate student-athletes participants. This could possibly provide evidence that athletes have learned through practice and competition to not let changed arousal levels effect their reaction time, hand-eye coordination, and decision-making.

INTRODUCTION

Strength, speed, stamina, suppleness, skill, and strategy are the aspects that define athleticism. Most sports training focuses on physical metrics of strength, speed, stamina, skill, and suppleness. Yet, training rarely includes components related to an athlete's cognitive performance in these areas (strategy). Possibly, in-game performance could be enhanced if athletes trained BOTH physically *and* cognitively, like their decision-making, hand-eye-coordination, and reaction time. As research continues to grow around integration of technology into sport performance training, there is a significant chance athletes could improve their decision making, hand-eye-coordination, and reaction time through physical *and* cognitive training. This type research hopes to: (1) profile and benchmark reaction time, hand-eye coordination, and decision-making in athletes and (2) investigate how increased arousal (via increased heart rate and sound stimulus) will affect reaction time, hand-eye coordination, and decision-making in athletic performance. This will in turn aid sport coaches, strength and conditioning specialists, rehabilitation professionals, and athletes themselves to better understand training methods to improve athletic performance under cognitive pressure. By testing individual athletes on attention and reaction time, while being under a stimulated pressure similar to in-game arousal, this study can not only create a profile for athletes in the sport but also give training suggestions on how to train athletes under these stimulates

PURPOSE & HYPOTHESIS

The purpose of this study is to determine whether or not heart rate arousal and sound stimuli negatively or positively impacts an athlete's reaction time, accuracy, and decision making to better understand how arousal and stimuli affect athletes' decision making during physical activity in game. The hypotheses are that if subjects are placed where arousal is increased through increased heart rate and/or sound stimuli, their cognitive abilities will decrease.

METHODS

Subjects
- 11 NCAA Division III varsity athletes
  - 7 females (20.7 ± 0.82 years; 164.25 ± 2.62 cm; 71.4 ± 14.54 kg)
  - 4 males (20.5 ± 1.02 years; 178.25 ± 7.32 cm; 81.45 ± 8.49 kg)
- Read and signed an informed consent approved by institution IRB prior to participation
- Approval of utilizing humans as subjects was approved by the IRB prior to any data collection

Instruments
- Senaptec Cognitive Sensory Station (Beaverton, OR) – Figures 1 and 2
- Wahoo TICKER Heart Rate Monitor (Atlanta, GA) – used to ensure subjects reached a specific level of physical arousal (at least 75% of age-predicted maximum heart rate on treadmill).
- Bose Noise-Cancelling Headphones (Framingham, MA) – Subjects listened to mock crowd noise.
- Trackmaster Treadmill (Newton, KS) – incremental exercise to induce physical arousal of at least 75% of age-predicted maximum heart rate.

Testing Procedures
- Cognitive Tests on Senaptec Cognitive Sensory Station (See Table 1 and Figures 1 and 2)
  - Split Attention
  - Go/No-Go
  - Reaction Time

Conditions
- Three different arousal conditions:
  - Condition 1 - medium arousal (no sound but with elevated heart rate)
  - Condition 2 - high arousal (sound and elevated heart rate)
  - Condition 3 - low arousal (no sound or elevated heart rate)

Data Analyses
- Repeated measures Analysis of Variance to find statistical differences in cognitive performance across arousal conditions.
- Bonferonni post-hoc analysis was conducted to find specific differences between means.
- *p*-value set to ≤ 0.05

TEST	DESCRIPTION
Split Attention	Split Attention is a training module on the Sensory Station that combines a central cognitive task with a peripheral motor task. The participant responds to a constantly changing task at the center of the screen and at the same time using their peripheral vision, reaching to touch targets that appear in the rest of the screen. When the condition is over, the results screen will display the condition's accuracy, precision, and response time.
Go/No-Go	Go/No Go training is designed to train quickness and accuracy of decision making in pressure situations. When targets appear, the participant must hit the target as quickly as possible until the end of condition. There are two types of images. The participant must hit the Go target images, but not hit the No Go target images.
Reaction Time	Reaction Time will test how quickly an individual's hands react in response to visual stimulus. The participant will place both index fingers on the touchscreen that will have an image of two circles. Once one of the circle's turns red the participant will take that index finger off that circle and then place their finger back once the red disappears.

Table 1: Description of cognitive assessments on sensory station.

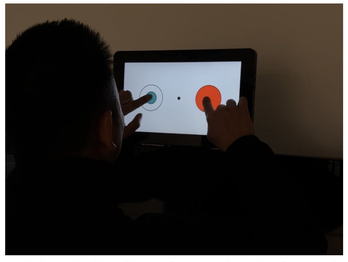

Figure 1: Reaction Time Test on Senaptec Cognitive Sensory Station

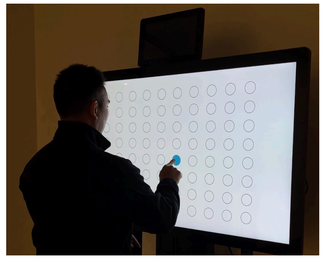

Figure 2: Go/No-Go Test on Senaptec Cognitive Sensory Station

RESULTS

TESTS	LOW AROUSAL	MEDIUM AROUSAL	HIGH AROUSAL
GNG GO HIT	16.09 ± 5.00	16.27 ± 5.37	15.18 ± 7.16
GNG LATE	11.09 ± 5.07	9.91 ± 5.68	10.00 ± 6.42
GNG NO HIT	0.55 ± 0.69	0.36 ± 0.81	0.27 ± 0.65
GNG OVAL ACC %	0.50 ± 0.17	0.54 ± 0.18	0.52 ± 0.23
GNG OVAL PREC. MM	2.68 ± 0.50	2.44 ± 0.37	2.37 ± 0.57
GNG OVAL SPEED	0.54 ± 0.02	0.53 ± 0.02	0.53 ± 0.02
SPLT CENTER HITS	41.55 ± 4.55	45.64 ± 5.48	46.82 ± 8.73
SPLT PERIPH. HITS	7.82 ± 2.96	7.27 ± 2.33	7.73 ± 2.49
SPLT CENTER FALR	0.36 ± 0.50	0.09 ± 0.30	0.36 ± 0.67
RT AVG	305.73 ± 22.81	307.73 ± 30.09	306.09 ± 23.24
RT AVG DOMINANT	316.55 ± 26.63	311.45 ± 32.53	311.00 ± 26.34
RT AVG NONDOMINANT	21.32 ± 21.32	304.55 ± 29.86	301.45 ± 22.47

TESTS	DESCRIPTION
GNG GO HITS	Go/No-Go Go Hits is the number of times the participant hits a correct target.
GNG LATE HITS	Go/No-Go Late Hits is the number of times the participant hits a correct target, but late.
GNG NO HITS	Go/No-Go No Hits is the number of times the participant hits an incorrect target.
GNG OVAL ACC %	Go/No-Go Overall Accuracy % is the percentage of the participant's overall accuracy hitting the Go targets.
GNG OVAL PREC. MM	Go/No-Go Overall Precision Millimeters is how close the participant was to hitting the targets in millimeters.
GNG OVAL SPEED	Go/No-Go Overall Speed shows the overall speed of how fast the participant hit targets.
SPLT CENTER HITS	Split Attention Center Hits is the number of times the participant hits the correct center image
SPLT PERIPH. HITS	Split Attention Peripheral Center Hits is the number of hits along the outer screen.
SPLT CENTER FALR	Split Attention Center False Alarm is the number of times the participant hits an incorrect center image.
RT AVG	Reaction Time Average is the average reaction time of how quickly the participant react to the visual stimulus.
RT AVG DOMINANT	Reaction Time Average Dominant is the average reaction time of how quickly the participant's dominant hand reacts to the visual stimulus.
RT AVG NONDOMINANT	Reaction Time Average Dominant is the average reaction time of how quickly the participant's nondominant hand reacts to the visual stimulus.

CONCLUSIONS & PRACTICAL APPLICATIONS

While this study's results appeared showed no significant differences in between elevated arousal and cognitive performance, this could be due to the study's limitations. 1) One limitation is the number of participants and the variety of sports. 2) The second limitation could be the sensitivity of the games. The games could have been set on harder levels as the intensity of the arousal increased, but instead it stayed the same throughout the study. 3) The levels of HR could have been harder. As some of the athletes involved were at their peak performance, the medium and high arousal conditions did not seem to affect those athletes any differently than the low arousal condition. Increasing the speed of the HR condition and for a longer period of time may have a different impact.

As research continues to grow around integration of technology into sport performance and training, there is a significant chance athletes could improve their decision making, hand-eye-coordination and reaction time through physical *and* cognitive training.

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