Reaction Time After Exercise Versus After Consumption of Caffeine

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Introduction

Reaction time is the time that elapses between the onset of a stimulus and the occurrence of a specific response to that stimulus.

Sensory neurons convert a stimulus into an electrochemical signal, which flows the length of the sensory neuron(s), then through a neuron or neurons of the central nervous system, and then through the length of the motor neuron(s). Reactions that involve only the receptor, the spinal cord, and the effector, are faster than those which involve processing in the brain.

Stimulus → Sensory Neuron → Spinal Cord or Brain → Motor Neuron → Response

Reaction Time depends on various factors:

- Perception
- Processing
- Response

Influence of physical exercise on Reaction Time

- The speed of cognition, or processing information, carries a lot of weight in regards to how quickly you react to external stimuli
- Quality of cognition can be improved and maintained by a healthy circulatory system.
- Exercise helps to increase heart rate and improve circulation to the brain.
- Brain benefits from increased circulation, and processes information faster and more accurately, which leads to faster reaction times.
- Exercise is known to increase blood flow and oxygen to the skeletal muscles and brain. It also affects an individual’s reaction time, since both skeletal muscle and the brain separately associated with reaction time.

Influence of caffeine on Reaction Time

Caffeine is a stimulant that increases activity of brain and nervous system. It also increases the circulation of chemicals such as cortisol and adrenaline in the body.

Short term effects like increased breathing and heart rate, and increased mental alertness and physical energy are experienced between 5 and 30 minutes after consuming caffeine.

A relatively high dose of caffeine may deliver as much benefit in increasing alertness and improving reaction times similar to drugs like methamphetamine or modafinil.

Caffeine stimulates the production of adrenaline, which causes the following changes:

- Breathing tubes to expand, increasing oxygen supply
- Heat rate increases
- More blood is supplied to big muscles and blood flow to the skin and stomach is reduced, to avoid wasting energy on digestion
- Sugar is released into the bloodstream
- Muscles tense up to prepare for action

These changes are designed to help the individual be alert.

Caffeine improves reaction time, vigilance and logical reasoning during extended periods with restricted opportunities for sleep.

Hypotheses

Inquiry	Null Hypothesis	Alternative Hypothesis
1	There will be no significant difference in the reaction time before and after consuming caffeine.	There is a significant difference in the reaction time of subjects before versus after consuming caffeine.
2	There is no significant difference in the reaction time of subjects after performing adrenaline pumping exercise for a minute.	There is a significant difference in the reaction time of subjects after performing adrenaline pumping exercise for a minute.

Materials

- BIOPAC Hand Switch
- BIOPAC Headphones
- Biopac Student Lab System: BSL 4 software, MP36/35 hardware
- Operating System (Windows 8, 7, Vista, or XP)
- Coffee
- Timer

Procedure

A. Setup
   a. Turn your computer ON.
   b. Plug the Hand Switch into CH 1 and the Headphones into OUT1 or OUT1A of the MP36/35 unit.
   c. Turn ON the MP36/35 unit.
   d. Start the BIOPAC Student Lab Program.
   e. Select the ‘Reaction Time’ lesson and click OK.
   f. Create a filename and click OK.

B. Calibration
   a. Prepare the Subject to start the calibration recording.
      i. Put headphones on.
      ii. Get in a seated and relaxed position.
      iii. Hold hand switch in dominant hand, with thumb is ready to press the button.
   b. Click Calibrate.
   c. Subject must press hand switch button after click is heard, and then release.
   d. Wait for Calibration to stop.
   e. Verify recording resembles example data.
      i. If similar, click Continue and proceed to Data Recording.
      ii. If necessary, click Redo Calibration and follow previous instructions again.

Procedure

C. Data Recording

a. Prepare for the recordings.
   i. Subject is seated with back turned to monitor.
   ii. Subject holds switch in dominant hand, with thumb ready to press the button.

Baseline Recording

b. Click Record to begin random interval test.
c. Subject must press hand switch button immediately after each click is heard, and then release.
d. Wait for recording to stop.
e. Verify recording resembles example data.
   i. If similar, click Continue and proceed to the next recording.
   ii. If necessary, click Redo and repeat steps above.
f. Perform test again for fixed interval recording.
g. If all required recordings have been completed, click Done.

Exercise Recording

h. Subject must perform one minute of exercise. (Jumping Jacks, Push-Ups, or High Knees)
i. Once exercise is completed, immediately prepare for the recordings.
   i. Subject is seated with back turned to monitor.
   ii. Subject holds switch in dominant hand, with thumb ready to press the button.
j. Click Record to begin random interval test.
k. Subject must press hand switch button immediately after each click is heard, and then release.
l. Wait for recording to stop.
m. Verify recording resembles example data.
   i. If similar, click Continue and proceed to the next recording.
   ii. If necessary, click Redo and repeat steps starting at letter point i.
n. Perform test again for fixed interval recording.
o. If all required recordings have been completed, click Done.

Procedure

Caffeine Recording

p. Subject must drink at least one cup of coffee.
q. Subject will wait five minutes before continuing the experiment.
r. Once coffee has been consumed and five minutes have passed, prepare for the recordings.
    i. Subject is seated with back turned to monitor.
    ii. Subject holds switch in dominant hand, with thumb ready to press the button.
s. Click Record to begin random interval test.
t. Subject must press hand switch button immediately after each click is heard, and then release.
u. Wait for recording to stop.
v. Verify recording resembles example data.
    i. If similar, click Continue and proceed to the next recording.
    ii. If necessary, click Redo and repeat steps starting at letter point r.
w. Perform test again for fixed interval recording.
x. If all required recordings have been completed, click Done.
y. Save the data file and quit the program.

Results

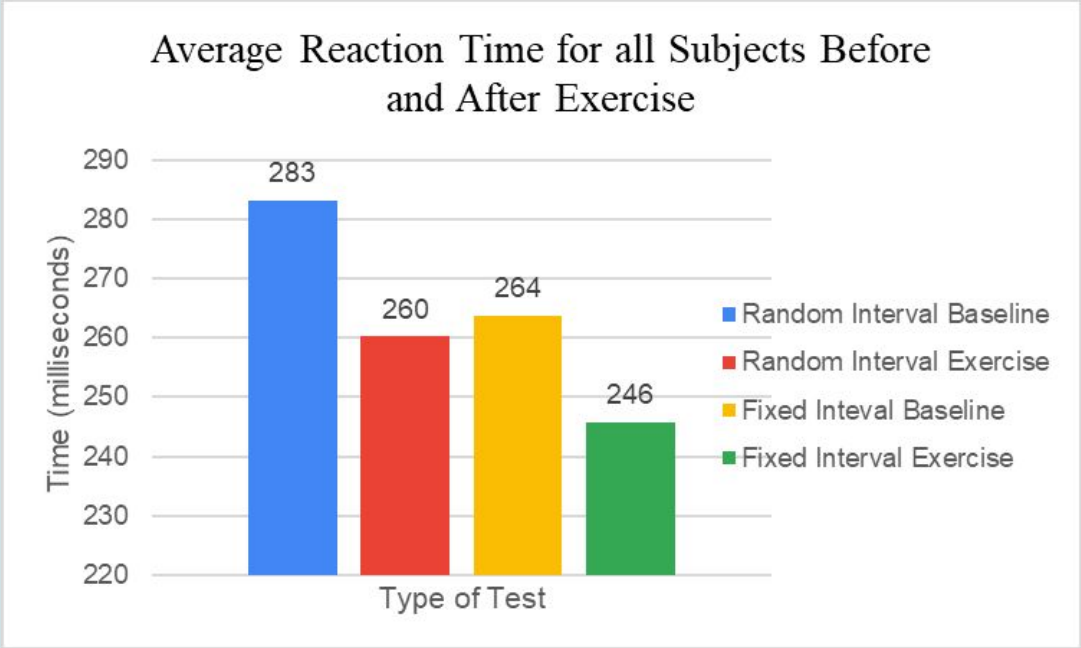

Figure 1: Bar graph displaying the average reaction time of all subjects after each test.

Results Cont.

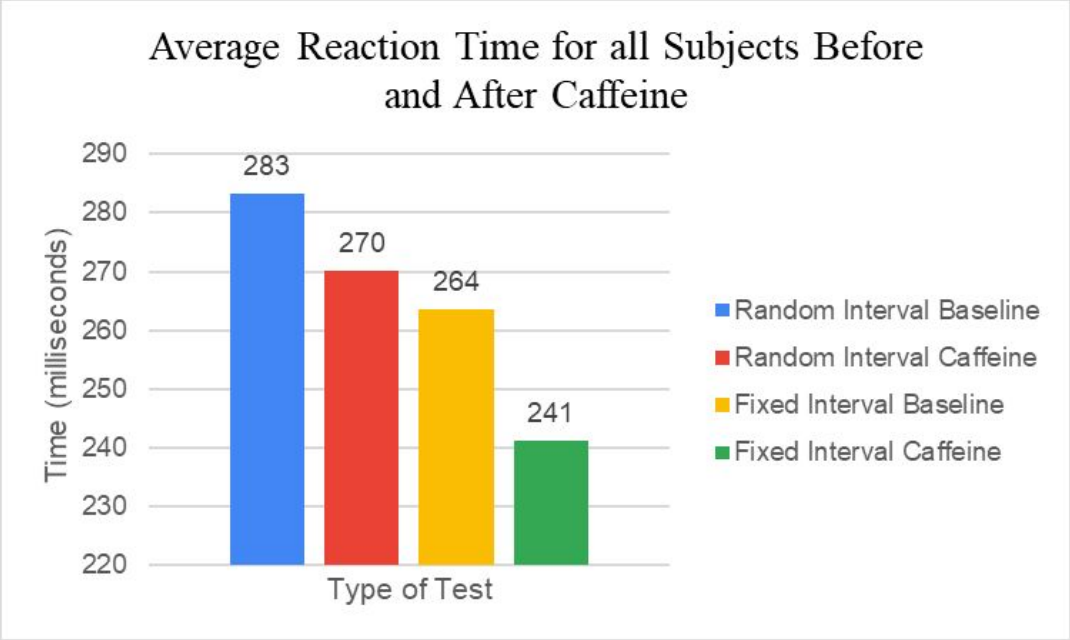

Figure 2: Bar graph displaying the average reaction time of all subjects after each test.

Data Analysis

- In this experiment, we ran two tests
  - F-test (2 sample for variances)
    - This test was done for the baseline and experimental samples for the random interval/fixed interval settings for the exercise and caffeine portions
    - From this test, we found in every category, all the variances were unequal
    - This test was a prerequisite for performing the t-test
  - T-test (2 sample assuming unequal variances)
    - This test was done for the same set of samples as for the f-test
    - We analyzed whether or not the sample means were significantly different from each other
    - After performing this test, the values we will be focusing on are the t-statistic and the t critical two tail values
    - If the t-statistic value is greater than the t-critical value, we would reject the null hypothesis, and vice-versa

F-Test Two-Sample for Variances (Random Interval)		
	Baseline	Exercise
Mean	283.2	260.2
Variance	2756.4	4173.733333
Observations	10	10
Degrees of Freedom	9	9
F-test	0.660415935	
P (F≤f) One Tailed	0.273179173	
F Critical One Tail	0.314574906	

F-Test Two-Sample for Variances (Fixed Interval)		
	Baseline	Exercise
Mean	263.7	245.8
Variance	1617.344444	3307.511111
Observations	10	10
Degrees of Freedom	9	9
F-test	0.488991387	
P (F≤f) One Tailed	0.150738702	
F Critical One Tail	0.314574906	

F-Test Two-Sample for Variances (Random Interval)		
	Baseline	Caffeine
Mean	283.2	270.2
Variance	2756.4	6095.955556
Observations	10	10
Degrees of Freedom	9	9
F-test	0.452168651	
P (F≤f) One Tailed	0.126364846	
F Critical One Tail	0.314574906	

F-Test Two-Sample for Variances (Fixed Interval)		
	Baseline	Caffeine
Mean	263.7	241.3
Variance	1617.344444	3017.788889
Observations	10	10
Degrees of Freedom	9	9
F-test	0.535936907	
P (F≤f) One Tailed	0.183257822	
F Critical One Tail	0.314574906	

T-Test Two-Sample for Variances for Random Interval		
	Baseline	Exercise
Mean	283.2	260.2
Variance	2756.4	4173.733333
Observations	10	10
Hypothesized Mean	0	
Degrees of Freedom	17	
T Stat	0.873689348	
P (T≤t) One-tail	0.1972311	
t Critical One-tail	1.739606726	
P (T≤t) Two-tail	0.394462199	
t Critical Two-tail	2.109815578	

T-Test Two-Sample for Variances for Fixed Interval		
	Baseline	Exercise
Mean	263.7	245.8
Variance	1617.344444	3307.511111
Observations	10	10
Hypothesized Mean	0	
Degrees of Freedom	16	
T Stat	0.806596406	
P (T≤t) One-tail	0.215862883	
t Critical One-tail	1.745883676	
P (T≤t) Two-tail	0.431725766	
t Critical Two-tail	2.119905299	

T-Test Two-Sample for Variances for Random Interval		
	Baseline	Caffeine
Mean	283.2	270.2
Variance	2756.4	6095.955556
Observations	10	10
Hypothesized Mean	0	
Degrees of Freedom	16	
T Stat	0.436932076	
P (T≤t) One-tail	0.334000068	
t Critical One-tail	1.745883676	
P (T≤t) Two-tail	0.668000136	
t Critical Two-tail	2.119905299	

T-Test Two-Sample for Variances for Fixed Interval		
	Baseline	Caffeine
Mean	263.7	241.3
Variance	1617.344444	3017.788889
Observations	10	10
Hypothesized Mean	0	
Degrees of Freedom	16	
T Stat	1.04043967	
P (T≤t) One-tail	0.15680172	
t Critical One-tail	1.745883676	
P (T≤t) Two-tail	0.31360344	
t Critical Two-tail	2.119905299	

Potential Errors

- Potential errors that could have occurred while recording data for this experiment are:
  - Failing to start the reaction tests immediately after the subject completed their one minute of exercise.
    - Having a long pause between exercising and the start of the recording could change the effect of adrenaline to the subjects reaction time.
  - Having no set amount of coffee each subject were to drink.
    - This could cause some subjects to receive more caffeine than others causing an imbalance between the tests.
  - The subject not exercising long enough or not at an intense pace.
    - Exercising for one minute might not be long enough to receive a substantial amount of adrenaline ones body typically would during normal exercise.
    - Subjects could have exercised at different levels of intensity causing an imbalance in data collection for the tests.
  - Poor Calibration

Discussion/Conclusion

- After performing a t-test on the average values of reaction time baseline, after exercise, and after having caffeine the p-value was found to be less than the critical value.
    - Therefore we fail to reject our null hypothesis
- Based on previous research we expected that both exercise and caffeine would result in a significant decrease in reaction time.
    - In the case of exercise we expected that adrenaline would get the blood pumping enough to improve cognitive function.
    - Caffeine has been shown to improve visual and cognitive function.
- However due to the small scale of our experiment along with the limited resources it is difficult to fully trust these results.
    - Some improvements that could be made in future experiments include:
        - Having a larger sample size
        - Separating subjects into non-caffeine drinkers, regular coffee drinkers, sedentary people, and people who regularly exercise.

References

Saville, C. W. N., de Morree, H. M., Dundon, N. M., Marcora, S. M., & Klein, C. (2018). Effects of caffeine on reaction time are mediated by attentional rather than motor processes. *Psychopharmacology*, *235*(3), 749–759. https://doi.org/10.1007/s00213-017-4790-7

Santos, V.G.F.; Santos, V.R.F.; Felippe, L.J.C.; Almeida Jr., J.W.; Bertuzzi, R.; Kiss, M.A.P.D.M.; Lima-Silva, A.E. Caffeine Reduces Reaction Time and Improves Performance in Simulated-Contest of Taekwondo. Nutrients 2014, 6, 637-649. https://doi.org/10.3390/nu6020637

Brisswalter, J., Arcelin, R., Audiffren, M., & Delignières, D. (1997). Influence of physical exercise on simple reaction time: effect of physical fitness. *Perceptual and motor skills*, *85*(3 Pt 1), 1019–1027. https://doi.org/10.2466/pms.1997.85.3.1019

Bender, V.L., McGlynn, G.H. The effect of various levels of strenuous to exhaustive exercise on reaction time. Europ. J. Appl. Physiol. 35, 95–101 (1976). https://doi.org/10.1007/BF02333799

Mark Miller. Boost your reaction time with caffeine. https://www.goviter.com/blogs/viter-energy-blog/boost-your-reaction-time-with-caffeine