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IB Biology Year 2

Mrs. Evans

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Stimuli and Response

Design

Investigation Question: How do different tempos of music affect response time (tested by Response Timer app[1]) and performance quality in students during the game of Temple Run[2]?

Null Hypothesis: Music tempo has no affect on response time and performance quality in students.

Alternate Hypothesis: If the tempo of the music increases, then response time will increase (become slower) and performance quality will decrease (student will have lower score on Temple Run).

Dependent Variable: Response time, performance quality

Independent Variable: Different types of music, tempo of music

Constant: iPhone games: Temple Run and Response Timer

Control: Playing Temple Run and testing Response Timer in silence

Materials: 3 students who have previously played Temple Run, iPhone, Temple Run App, Response Timer App, calculator, computer, metronome, Piano Sonata No. 8 in C Minor (Beethoven, Movements 1, 2 and 3), Serenade for Strings in C Major (Op. 48, Tchaikovsky), Violin Concerto No. 2 in E Major (JS Bach), Symphony No. 5 (4th Movement, Dmitri Shostakovich)

[1] Response Timer is an app on iTunes that allows people to time their response/reaction times. It does so by flashing a green button, and the user must press a red button as soon as the green light is flashed. Once the red button is pressed, the app will show the user his response time.

[2] Temple Run is an iPhone game where the player runs through a maze and faces obstacles like broken roads, tree stumps, tree trunks, fire, etc, and the player must react to the games by jumping, ducking, sliding, etc. on the spot. The players also collect coins and power ups to maximize score.

Procedure:

1. Use a metronome to measure the amount of beats per minute of each piece of music and record the number

2. Test student's response time using Response Timer and performance quality in Temple Run in silence. This will be the control.

3. Let each student to listen to the different types of music for 1 minute to allow the brain to get used to the music.

4. After 1 minute, I will continue to play the music, but I will test their response time in the app, Response Timer and record the data.

5. After recording the student's response time, the student will then proceed to play Temple Run, and I will record the score, distance and amount of coins collected for that play. This will be the data for the performance quality.

6. Repeat the steps for each song

7. Repeat the procedure for each student.

Data Collection and Processing:

Raw Data

Tempo of each Song

Song	Tempo (Beats per Minute)
No Music	0
Serenade for Strings in C Major	66 ± 1
Piano Sonata No. 8 in C Minor (Movement 2)	76 ± 1
Violin Concerto No. 2 in E Major	108 ± 1
Piano Sonata No. 8 in C Minor (Movement 3)	144 ± 1
Symphony No. 5 (Movement 4)	192 ± 1
Piano Sonata No. 8 in C Minor (Allegro of Movement 1)	200 ± 1

**Songs listed in order of increasing tempo.

Response Time ± .001 (seconds)

Song	Trial 1	Trial 2	Trial 3
No Music	.326	.310	.355
Serenade for Strings in C Major	.350	.311	.374
Piano Sonata No. 8 in C Minor (Movement 2)	.283	.312	.347
Violin Concerto No. 2 in E Major	.359	.654	.369
Piano Sonata No. 8 in C Minor (Movement 3)	.342	.607	.402

Symphony No. 5 (Movement 4)	.402	.630	.404
Piano Sonata No. 8 in C Minor (Allegro of Movement 1)	.597	.662	.736

Temple Run

Student 1

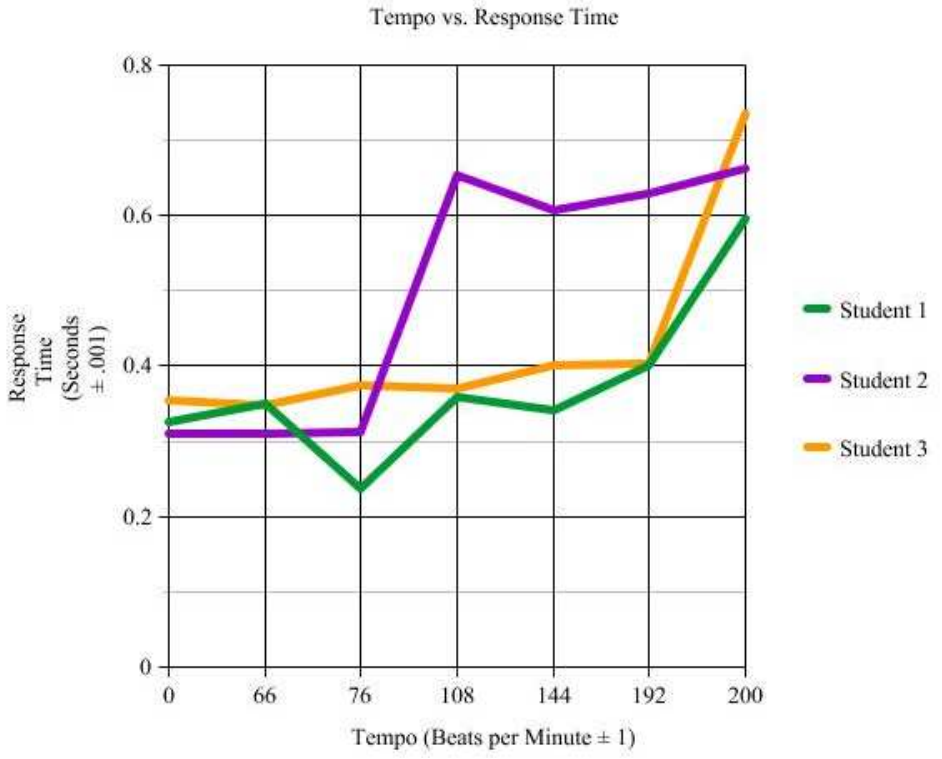
Song	Score
No Music	2,009,736
Serenade for Strings in C Major	982,845
Piano Sonata No. 8 in C Minor (Movement 2)	613,475
Violin Concerto No. 2 in E Major	599,545
Piano Sonata No. 8 in C Minor (Movement 3)	626,715
Symphony No. 5 (Movement 4)	105,030
Piano Sonata No. 8 in C Minor (Allegro of Movement 1)	45,360

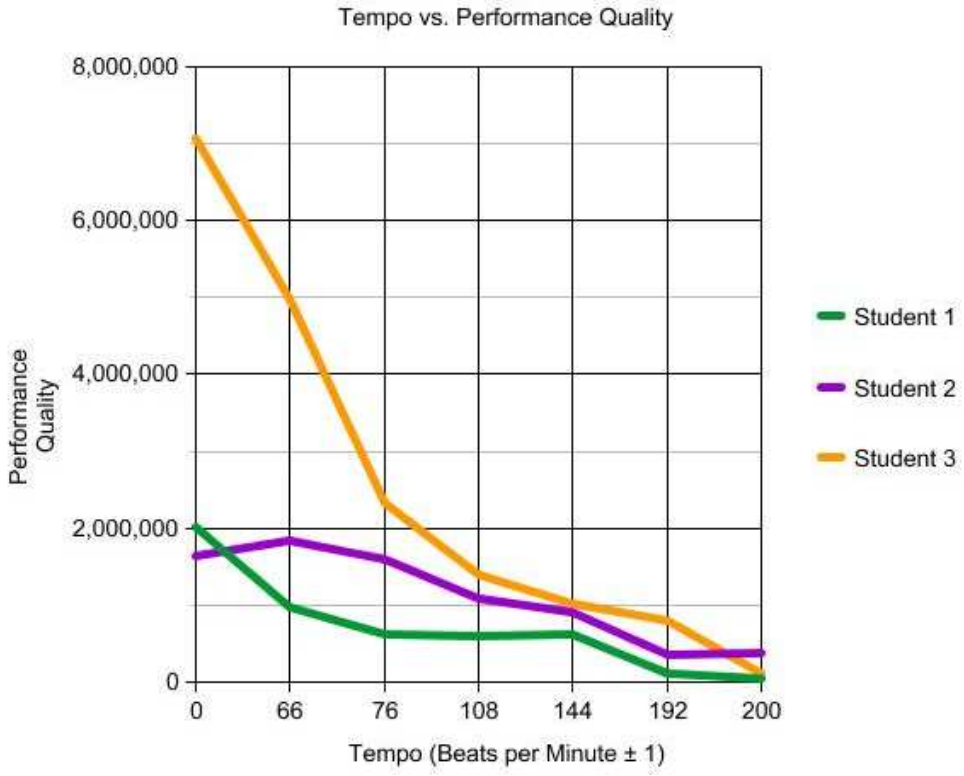
Student 2

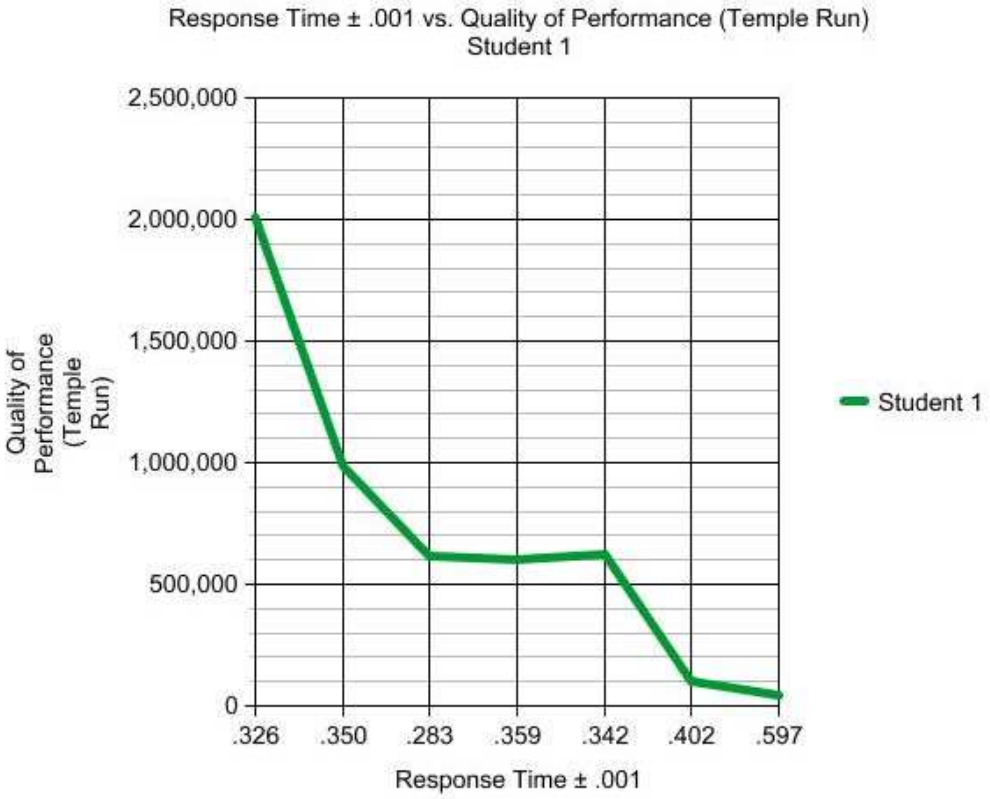
Song	Score
No Music	1,632,515
Serenade for Strings in C Major	1,829,925
Piano Sonata No. 8 in C Minor (Movement 2)	1,602,765
Violin Concerto No. 2 in E Major	1,085,940
Piano Sonata No. 8 in C Minor (Movement 3)	916,430
Symphony No. 5 (Movement 4)	359,685
Piano Sonata No. 8 in C Minor (Allegro of Movement 1)	381,600

Student 3

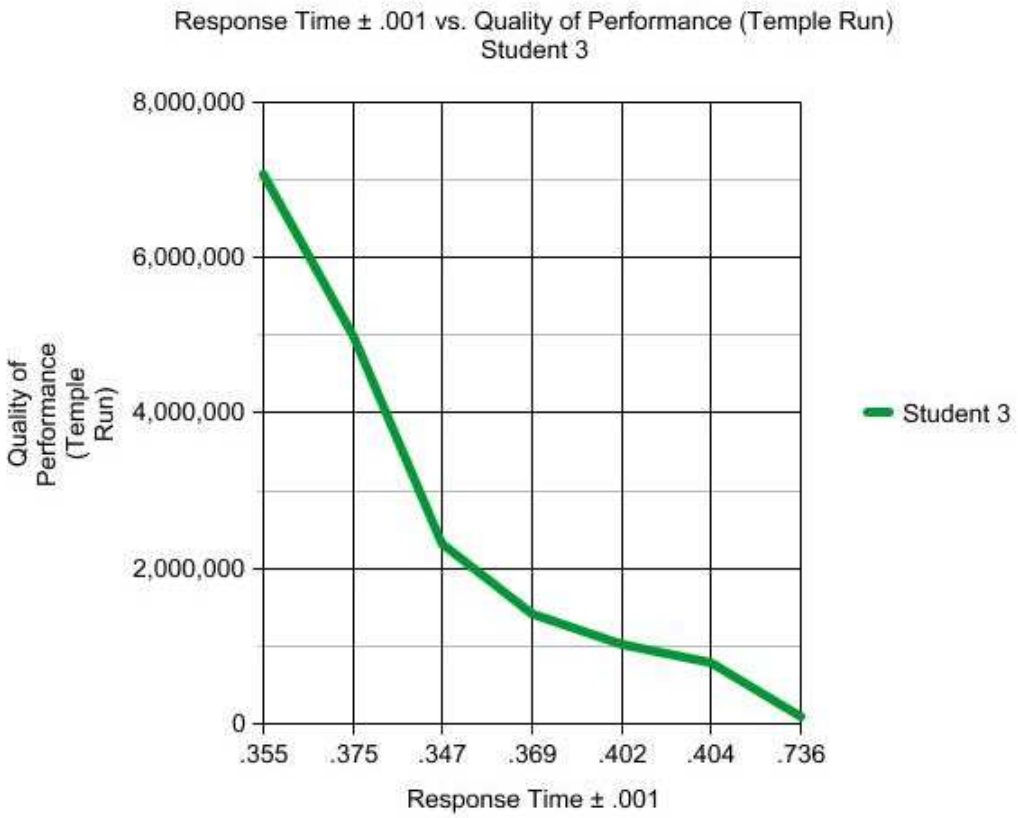
Song	Score
No Music	7,069,155
Serenade for Strings in C Major	4,986,270
Piano Sonata No. 8 in C Minor (Movement 2)	2,323,421
Violin Concerto No. 2 in E Major	1,403,755
Piano Sonata No. 8 in C Minor (Movement 3)	1,014,930
Symphony No. 5 (Movement 4)	793,080
Piano Sonata No. 8 in C Minor (Allegro of Movement 1)	101,342


Tempo vs. Response Time
Response Time (Seconds ± .001)
0.8
0.6
0.4
0.2
0
0
66
76
108
144
192
200
Tempo (Beats per Minute ± 1)
Student 1
Student 2
Student 3


Tempo vs. Performance Quality
Performance Quality
8,000,000
6,000,000
4,000,000
2,000,000
0
0
66
76
108
144
192
200
Tempo (Beats per Minute ± 1)
Student 1
Student 2
Student 3


Response Time ± .001 vs. Quality of Performance (Temple Run)
Student 1
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
Quality of Performance (Temple Run)
.326
.350
.283
.359
.342
.402
.597
Response Time ± .001
Student 1


Response Time ± .001 vs. Quality of Performance (Temple Run)
Student 2
2,000,000
1,500,000
1,000,000
500,000
0
Quality of Performance (Temple Run)
.310
.311
.312
.654
.607
.630
.662
Response Time ± .001
Student 2



Processed Data

Pearson's Correlation Test:

Tempo and Response Time:

Student 1: .693617
Student 2: .844965
Student 3: .639486

Tempo and Performance Quality

Student 1: -.926984
Student 2: -.922726
Student 3: -.91517

Response Time and Performance Quality

Student 1: -.547585
Student 2: -.896101
Student 3: -.495064

Qualitative Analysis

Student 1

Song	
No Music	Focused, no disruption
Serenade for Strings in C Major	Calming, soothing, strings were ethereal, delicate
Piano Sonata No. 8 in C Minor (Movement 2)	Happy, relaxing
Violin Concerto No. 2 in E Major	Upbeat, regal, playful
Piano Sonata No. 8 in C Minor (Movement 3)	Quite upbeat, minor, fast
Symphony No. 5 (Movement 4)	Fast, loud, grand, over the top with drums, sounds like Soviet Russia
Piano Sonata No. 8 in C Minor (Allegro of Movement 1)	Suspenseful, intense, fast, loud

Student 2

Song	
No Music	Quiet
Serenade for Strings in C Major	Light as a feather
Piano Sonata No. 8 in C Minor (Movement 2)	Slow, moderately content
Violin Concerto No. 2 in E Major	Happy
Piano Sonata No. 8 in C Minor (Movement 3)	Sad, minor, unexpected
Symphony No. 5 (Movement 4)	Nervous, jittery, accident prone
Piano Sonata No. 8 in C Minor (Allegro of Movement 1)	Scary almost, unexpected

Student 3

Song	
No Music	Focused
Serenade for Strings in C Major	Still focused, quiet, stimulated brain
Piano Sonata No. 8 in C Minor (Movement 2)	More brain stimulation
Violin Concerto No. 2 in E Major	Not as light, but very active
Piano Sonata No. 8 in C Minor (Movement 3)	Active, but started to lose focus on Temple Run
Symphony No. 5 (Movement 4)	Made very stupid mistakes, shocked, a few scares, almost no focus, lost a lot of opportunities
Piano Sonata No. 8 in C Minor (Allegro of Movement 1)	Beginning was mellow, but later on the upbeat tempo made me lose focus and I was very accident prone

Conclusion/Evaluation/Improvements:

In this experiment, I wanted to test the tempo of music and how it affects the focus of students in both response time and performance quality. I picked out different pieces of classical music and measured their tempos with a metronome and collected the data in beats per minute. Next, I picked 3 test subjects who have all played Temple Run before—so they were decently experienced—and took them into a quiet room and tested their response time in a quiet room without music. Next, I let them listen to each song for about a minute to let the songs sink into their heads, and after a minute, I took their response times on the Response Timer app. After taking their response times, I had them play Temple Run and recorded their scores. This procedure was done after every piece. From my notes and research, I hypothesized that as the tempo of a music piece increased, the response time would increase, because a faster tempo will stimulate the Central Nervous System and bring the sympathetic nervous system create a "fight or flight" mentality. This will arouse the nervous system and make the body more aware and stressed, and the stress response could halt productivity and bring anxiety which could slow response time and decrease productivity. The slower-beat music brought a "relaxing and renewing" feeling to my test subjects, and it brought the parasympathetic nervous system, which brought the body to rest, reducing stress, tenseness and anxiety. They were able to be more focused on their response times, so they had quicker response times during the slower pieces, and their scores in Temple Run were higher because they were relaxed and stress free; this made it easier for them to focus on the game.

My data fit very well with my hypothesis. The songs were listed in order of increasing tempo, and for the correlation between tempo and response time, there were some inconsistencies in the middle, but it was a general upward trend, showing that as the tempo

increased, the response time was longer, and there was a direct correlation between those two variables. The graph Tempo vs. Response Time shows some inconsistencies to my hypothesis in the middle, but it is a general upward trend. These inconsistencies made me wonder if the medium tempo-ed songs were a nice medium between the two. They were just fast enough to stimulate the system, but not enough to bring out the anxious sympathetic nervous system. I did a Pearson's Correlation Test between Tempo and Response time, and for each of the three trials, I got a positive number greater than .5. For a Pearson's Correlation Test, if the result is positive, then it means that there may be direct correlation. If the result is 1, then there is absolute correlation between the two variables, but if the result is 0, then it means that there is no correlation. For tempo and response time, my numbers were .693617, .844965 and .639486. All of these numbers are positive and closer to 1, so there is a pretty heavy degree of correlation between the tempo of a piece of music and the response time one has as a reaction to the tempo. This supports my hypothesis because as the tempo increased, the time it took for my subject to respond also increased, so according to this experiment, as tempo increases, response time also increases.

For Tempo vs. Performance Quality, I hypothesized that as tempo increased, performance quality would decrease because of the anxiety and the stress. As shown in my data and my graphs, there was a general downward trend that showed the scores in Temple Run dropping as the music tempo was increasing. This was supported by the Pearson's Correlation Test because my calculated numbers for that test was -.926984, -.922726, and -.91517. A negative number in the Pearson's Correlation Test means that there is an inverse relationship, and just like the direct relationship, 0 means there is no correlation and -1 means that there is an absolute inverse correlation. My numbers are very close to -1, so we can see that there is definitely an inverse

relationship between the tempo of a song and the performance quality of the person listening to the song. As the tempo increases, stress and anxiety would increase, and performance quality would go down. Lastly, I wanted to see the response time compared to the performance quality, because I hypothesized that it was an inverse relationship. As response time increased, the score on Temple Run had to have decreased because it is a game based on how fast the player can react to given obstacles. The graphs show the downward trend that as response time became longer, the score decreased, and the Pearson's Correlation Tests also showed numbers of -.547585, -.896101, and -.495064. These numbers show that there is an inverse correlation between the two variables, and that slower response time will lead to lower productivity. My test subjects noticed that when the tempo became faster, their heart rates increased, their hair stood up, their adrenaline rushed and they became tenser and anxious, even jittery at times, causing them to make "stupid mistakes" because of an "out of the blue spazz" which caused them to die during Temple Run.

From both my quantitative and qualitative analysis, I can conclude that the quicker the tempo of a song, the more stimulated the Central Nervous System becomes (sympathetic nervous system), and this increases anxiety and stress causing slower/longer reaction times thus decreasing productivity. The slower tempo songs were much more soothing, relaxing and renewing to the Central Nervous System (parasympathetic nervous system), and this minimal level of stress allowed my test subjects to be more focused, thus having a quicker response time a higher score on Temple Run (higher productivity). The null hypothesis must be rejected because from both the raw data and the Pearson's Correlation Tests, there is in fact correlation among music tempo, response time and performance quality. Students 1 and 3 had their best scores during the silent trial, while student two had his best score during the slowest piece, but did very

well during the silent trial. The silent trial, also known as the control actually gave the quickest response times and optimal or near optimal scores.

Improvements:

While doing my experiment, I noticed subtle reactions to the volume of the song. I realized that it was not only tempo that affected the stimulation of the nervous system. The loud music definitely made my test subjects more shocked and stimulated, causing them to be more accident prone, which could definitely have affected their death on Temple Run. Because I did not consider volume or the emphatic levels that the artists played the piece, there was no pattern of volume, but the volumes were different and scattered all over the place, and that could have been a factor that affected the experiment negatively. It could have increased the stimulus or decreased the stimulus without any sort of pattern. Next time, I will definitely consider volume as a factor into this and organize my experiment accordingly. One time during the experiment, I received a text message and this disrupted my test subject's focus while she was playing Temple Run. I will know to turn off notifications the next time I do this experiment.

Along with volume, my test subjects cited the composition, or the key of the piece as a factor that stimulated or relaxed the brain. The major keys usually stimulated the brain while the minor keys depressed it. The abrupt sharps and flats and clash of instruments were quick, unexpected distractions that stimulated the nervous system. The next time I do this experiment, I will consider decreasing/making this detail uniform alongside volume, so the unwanted factors are not included in this experiment.

Just like any experiment, there are the uncontrollable factors at the time. The game Temple Run itself is different each round of play. Some rounds offer more opportunities than others by giving more or better power ups. This could have inflated or deflated the score, thus

making the data less accurate. If I were testing performance quality next time, I would get a more uniform game that gives a fair opportunity to my test subjects instead of give them different unexpected scenarios and opportunities in an arcade-style game. Temple Run is also a game that requires high focus, and it is not a universal representation of test for performance quality. Some of my test subjects drank caffeine beforehand, so the next time, I will properly inform my test subjects to not take caffeinated items and eliminate intakes that are major influences/stimuli/depressants to the nervous system. My test subjects also had some inherent stress and weariness from homework (final extended essays due at midnight), sports etc, and the inherent stress or weariness is almost impossible to eliminate as a factor influencing the outcome of the data, but the next time, I would record their stress and do the experiment when they have lower levels of stress, so the music could influence their central nervous system more.