Reaction time of a group of physics students

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Abstract
The reaction time of a group of students majoring in physics is reported here. Strong correlation between fatigue, reaction time and performance has been observed and may be useful for academicians and administrators responsible for working out timetables, course structures, student counsellings, etc.

Introduction
Animals respond to the environment using their sensory organs for collecting information that is passed on to the brain and analysed for action. However, this takes a perceivable time: this time is called the reaction time. The definition of reaction time or latency as given in the dictionary is ‘the interval of time between application of stimulus and detection of a response’ [1]. Human reaction time is ultimately limited by how fast nerve cells conduct nerve impulses. Although this speed is almost 250 miles h\(^{-1}\), messages still take a significant amount of time to travel from sensory organs to the brain and back to the appropriate muscle groups.

A common ‘experiment’ done as a game by children is for one person to hold a measuring ruler about chest high and have someone place their thumb and index finger about an inch apart somewhere along the (bottom) length of the ruler. The ruler has to be caught as it falls. The ruler would not be caught immediately and a length of the scale would pass through the finger and thumb before it is caught (figure 1). From simple laws of mechanics, using the equation

\[ t = \sqrt{\frac{2s}{g}} \]

where response time \( t \) in this experiment is related to \( s \) the length of scale that has dropped and \( g \) is the acceleration due to gravity (9.8 m/s\(^2\)), then the reaction time of the child can be calculated. Interest in the measurement of human reaction time apparently began as a result of the work of a Dutch physiologist named F C Donders. Beginning in 1865, Donders [2] became interested in the question of whether the time taken to perform basic mental processes could be measured. Until that time, mental processes had been thought to be too fast to be measurable. In his early experiments, Donders applied electric shocks to the right and left feet of his subjects. The subject’s task was to respond by pressing a telegraph key with his right or left hand to indicate whether his right or left foot had received the shock. Interest in measuring and minimizing the reaction time is of crucial interest today in medicine, military strategy, traffic control and sports. Things can be put into a better perspective by using an example. In the game of cricket, the average distance between the bowler and batsman is 20 m. With a spin bowler delivering the ball at around 80 km h\(^{-1}\), the batsman has 0.9 s (900 ms) to ‘see’ the ball, decide the shot and implement it! An analysis of high-speed film of international cricketers batting on a specially prepared pitch which produced unpredictable movement of the ball is reported, and it is shown that, when batting, highly skilled professional cricketers show reaction times of around 200 ms [3].
Figure 1. The reflexes of a person can be estimated from what length of the ruler drops before he or she can catch it.

Methodology adopted
Various methods have been used to measure the reaction time. Essentially, these involve measuring a simple reaction time, like in Donders’ experiment, or recognition reaction time or choice reaction time. In choice reaction time experiments the subject must give a response that corresponds to the stimulus, such as pressing a key corresponding to a letter as soon as the letter appears on a display amidst a random display of characters. In this article we are reporting the results of our experiment done using this method. The reaction time is known to be affected by factors such as age, gender, fatigue/exercise, distractions and intelligence. Our sample group was students of physics/electronics in the age group of 18–21, where studies have shown the reaction time to be the minimum in a human life span [4–8]. These works report the reaction time of people in the age group of our study to be ~200 ms.

We have sampled and recorded the reaction time of 137 students from the sciences, commerce and arts streams; however, here we discuss data for 44 students who were majoring in physics/electronics. Usually such experiments sample 20 or more people and make them repeat the experiment over a long period of time [9]. Another approach is where a single reading is taken after allowing the test person a period of practice [10]. We first tested the effect of practice on a group of students. Figure 2 shows the variation of reaction time of students with increasing practice. Raw reaction times, i.e. the first attempt, of the students were poor. As they practised, a recording was taken at every 15 min. Practice, however, did not keep on improving the reaction time. Only four out of ten students had a better reaction time on their fourth recording (i.e. after 45 min of practice) as compared to their third try (30 min into practice). While one might be tempted to conclude this as improvement with practice, it should be noted that three of these four students in their fourth attempt performed worse than at their second attempt. The spectrum of reaction time is within ±0.422 s of the average values. This deviation is just ±0.075 s when the first attempt is neglected. Hence, in our experiment, our approach has been to allow subjects to familiarize themselves with the machine for 20–25 min before taking their reaction time.
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**Figure 2.** The dark thick line shows the variation of the average time recorded by the students of the given roll number. The repeated attempts of the students resulted in an average ±0.422s deviation from their average.

|          |          |          |          |
|----------|----------|----------|----------|
| Class    | Girls    | Boys     | Marks    |
| 1st year | 6        | 8        | 0.13     | 69       |
| 2nd year | 4        | 14       | 0.12     | 74       |
| 3rd year | 9        | 5        | 0.10     | 87       |

**Table 1.** The table compares the male–female distribution of the three classes and their performances.

**Results**

We shall now discuss our observations of physics/electronics students in detail. Figure 3 shows the performance of the students from the first, second and third years majoring in physics/electronics. Along with each histogram, a Gaussian

\[
f(x) = ae^{\frac{-x^2}{2c^2}}
\]

(1)

was fitted to estimate the mean reaction time \(b\) of the class and the deviation from the mean (using \(c\)). Table 1 details the results for all three classes. The lower mean reaction time and narrower deviation from the mean of the third year students show a collective better performance. The larger value of \(c\) as seen in the case of first and second year students suggests a spectrum of performance in the reflex test with a large variation from the mean value. A broader sampling of reaction time with larger age variation was collected based on gender (results not shown here). We found no variation...
in performance based on gender, with the ratio of female to male reaction time being equal to unity, i.e. \( R_{FM} = 1 \). Bellis [11] and Engel [12] reported \( R_{FM} = 1.1 \), with males having a faster reaction time. However, recent studies by Silverman [13] report that the difference in male–female reaction time was narrowing. Table 1 gives the number of boys and girls in each class. Even though the ratios of boys and girls are not same in these classes, no correction is called for in figure 4 since \( R_{FM} = 1 \).

As stated earlier, the third year students appear to be a more responsive group, and it was thought worthwhile to test if the reaction time had any correlation with learning ability. A comprehensive test was designed to test all the students under study for their ability to comprehend, learn on their own, analyse and solve a given problem. The test was different from the ordinary annual examination these students face, and also care was taken that the evaluators were not prejudiced or influenced by the results of figure 3. Figure 4 shows how reaction time seems to correlate strongly with the student’s ability to learn. This result is consistent with the findings of Deary et al [14]. All these students were admitted to the college based on their performance in the higher secondary (HS) examination conducted by the Central Board of Secondary Education (CBSE, India). All the students had marks between 78 and 84% in their HS examination. The resolving of their performance with respect to their reaction time hence was made possible because of the complex method adopted for evaluation. In his paper, Schweitzer [15] reports that the speed advantage of more intelligent people is greatest in tests requiring complex responses. In contrast, figure 4 suggests faster students are stimulated and respond keenly to tests having a degree of complexity.

Another interesting result we have found is how the students’ reaction times vary after they attend an hour-long lecture. We took recordings from the first year students before they entered the lecture hall and again an hour later as they emerged from their mathematical physics class. This particular class subject was selected after studying the students’ responses to a questionnaire, in which the majority reported it as the most difficult subject. The subject was also low in popularity, with students complaining that the 60 min lecture was hard to follow and sustain concentration in. Also, their performances in class tests were consistently poor. Figure 5 shows the variation of performance. Barring four students, all the students showed a deterioration in reaction time. ‘Stress’, hence, makes the reaction time poor. Slower response due to fatigue doing a complicated task was reported as back as in 1953 [16].

**Conclusion**

In conclusion, the fatigue level seen in students after attending an hour of intense training in mathematical physics, that requires a very high level of concentration, does advocate reducing the duration of a lecture from 60 to 40–45 min for students below 21 years. A reduction in response
time is also a reduction in concentration level and hence suggests that much of the information imparted by the instructor (figure 5) would not have been absorbed anyway. The methodology adopted in teaching difficult subjects also should be reviewed1. At present a teacher is expected to introduce and complete the whole textbook on vectors, tensor analysis and vector calculus along with adequate practice in about 70 lectures. Under such constraints it is nearly impossible to make the lectures ‘lively’ as well as going slowly. It would be prudent to reduce the course content to a realistic amount, giving more importance to problem solving in which the problems also deal with day to day experiences. Questions based on derivations and direct application also do not seem to stimulate students and fail to resolve students based on their ability. A rethink in course structure, lecture length and style of questioning would revitalize science education with keen minds willing to take up the challenge.

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1 This statement is reserved for the methodology followed in Delhi University, since the authors are in no position to comment on scenarios elsewhere.

Charu Saxena graduated from S.G.T.B. Khalsa College (University of Delhi) and this work was done as a part of her final year project. After graduation, she joined Wipro where she is involved with computers, embedded systems and their programming. Currently she is also pursuing her Masters from BITS Pilani.

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Dr Arun completed his education from Delhi University and after finishing his doctorate started teaching physics and electronics under-graduates. He has been teaching in Khalsa College for the last ten years. While he continues with his research in Material Science, over the last four to five years he has been involved in doing projects like the one in this article with his final year students. He takes pleasure in doing science at this level with students so that they appreciate the essence of scientific curiosity and research.