THE STUDY OF FACTORS AFFECTING REACTION TIME IN HUMANS

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ABSTRACT

The purpose of the experiments was to study the effect of factors including age, vision, hearing and the use of dominant and non-dominant hand on a person’s reaction time. Reaction time is the elapsed time between the presentation of a sensory stimulus and the subsequent behavioral response. Subjects from three different age groups were asked to catch a meter stick and based on the distance of the drop, their reaction times were calculated. It was found that middle school students had the fastest reaction time, followed by upper school students and then adults. While a slowdown in the development of interconnections between neurons in the brain, from childhood through adulthood, might have caused the overall increase in reaction times with age, the superior reaction times among middle school subjects may also have been due to them being frequently engaged in activities requiring faster reaction times like sports and video games (which may have resulted in greater levels of interconnections developing in specific areas of the brain).

INTRODUCTION

Reaction time (RT) is the elapsed time between the presentation of a sensory stimulus, auditory, olfactory or tactile. There are three main types of reaction time. The first type is called a “simple reaction time” where there is only one stimulus and one response. An example of this type of reaction time would be time taken to hit a button when a light changes. The second type of reaction time is the “recognition reaction time”. In this case, there is still only one stimulus and one response, but there are symbols to respond to and symbols to ignore. An example of this type of reaction time would be how quickly one would catch a dropped stick on a specific word cue, while ignoring other words said. A third type of reaction time is called “choice reaction time” where there are multiple stimuli and multiple responses. For example, flashing even or odd numbers on a screen and asking the subject to press one button when presented with an even
number and another button when presented with an odd number. The time it takes to decide what button to press and then do the same is called a choice reaction time.

When measuring all the different kinds of reaction times, what is being measured is how long it takes for the organism to respond to the stimulus. The process that takes place in the human body from the time a stimulus is presented to the time of response is represented in the figure below -

**Stimulus → sensory neurons → brain → motor neuron → response**

*Figure 1: Flow of information in the brain*

Reaction times are based on how fast the nervous system responds to the action or stimulus. The stimulus gets transferred to the sensory neurons, which then take it to the brain. The brain, in turn, sends a message back to the muscles through the motor neurons. The muscles help the corresponding body part to respond to the stimulus.

Many factors affect a person’s reaction time. These include age, gender, physical fitness, distraction levels, alcohol, fatigue, or even personality type. To understand why age affects reaction time, one has to study the effect of age in the brain and nervous system. The brain and nervous system go through development from infancy to adulthood. In a newborn, there is a rapid period of brain growth with neurons in all parts of the brain making trillions of connections. Connections in the parts of the brain that control basic survival and reflexes are already well-developed. During early and middle childhood, the brain forms and refines this complex network of connections in the brain through synaptogenesis (the process of creating synapses, or connections, between neurons), pruning (the selective elimination or "weeding out" of non-essential synapses based on a child’s specific experience) and myelination (the process of forming a coating or sheath of fatty substances known as myelin on the axon of a neuron). Motor, social and cognitive development happens during this time. During adolescence, the brain continues to mature and grow, with further synapse connection, pruning and myelination happening. During adolescence, development happens in the areas of insight, judgment, inhibition, reasoning, and social conscience. During adulthood, the brain continues to develop connections, however, the rate of making connections is much slower than childhood and synapses get formed only based on specific experiences. As the person ages further into adulthood, the brain and spinal cord will slowly begin to lose nerve cells and
become smaller. As a result, the nervous system might respond or react slower than it used to. This can lead to memory problems, slowing down thought process, and deteriorating reflexes. Brain studies have shown that repeated experiences in certain areas can create complex networks of synaptic connections in that area and make it stronger.

Numerous experiments have been done in the past, relating to reaction time. An example of one such experiment was the one done by Harrison Zhang to determine whether temperature affects memory or reflexes. In this experiment the test subjects were subjected to two rounds of testing. In the first round, the test subjects were asked to go outside and stand in the cold for two minutes and after the two minutes the subjects would come back inside to take a reflex test. The reflex test involved the subject catching balls of different sizes thrown to them by a ball handler standing five feet away. After this test, the subjects had to go back outside for another two minutes. When the subjects came back inside they had to take the memory test. For the memory test subjects had to memorize words and pictures that were shown. Both these tests were repeated when the test subjects were warm. The results of the reflex test showed that the test subjects performed better when warm and the results of the memory test showed that test subjects did better in the cold.

**METHODS AND MATERIALS**

The materials that were used for the experiments described below included a timer, a meter stick, headphones and a tablet computer.

The first experiment was conducted to determine if age affected reaction time to a visual stimulus. This experiment was conducted by first having the test subject seated near the edge of a table, with his/her elbow on the table and wrist extended over the side. The assessor held the ruler vertically in the air between the subject's thumb and index finger, but not touching either. The zero mark on the ruler was aligned with the subject’s fingers. The subject indicated when he/she was ready. Without warning, the ruler was released and the subject had to catch it as quickly as possible as soon as they saw it fall. The distance the ruler fell was recorded in cm. The test was repeated three times for each subject in each age group. There were three age groups, namely middle school students, upper school students and adults and three subjects in each age group. Once this experiment was conducted, the average distance of the drop for each subject
and that for each age group was calculated. Following this, the reaction time based on the average distance of the drop was calculated for each age group. The formula used for calculating reaction time was \( d = vt + \frac{1}{2}at^2 \) (\( d= \) distance, \( v= \) velocity, \( t= \) time, \( a= \) acceleration).

The second experiment was conducted to determine if age affected reaction time to an auditory stimulus. This experiment was conducted by having the test subjects listen to a beep that came every 10sec for 30sec. This beep was generated from a website online. The test subject was asked to signal when he/she heard the beep by saying the word “now” aloud. The assessor started the timer as soon as the beep was generated and stopped the timer when the test subject signaled the beep. The reaction time was measured by calculating the number of seconds it took for the test subject to signal that he/she heard the beep. The test was repeated three times for each person in each age group. There were three age groups, namely middle school students, upper school students and adults and three subjects in each age group. Once this experiment was conducted, the average reaction time for each subject and that for each age group were calculated.

The third experiment was conducted to determine if the reaction time was affected when test subjects used their dominant versus their non-dominant hand to perform the tasks. This experiment was conducted by first having the test subject seated near the edge of a table, with their elbow of the dominant hand on the table and their dominant wrist extended over the side. The assessor held the ruler vertically in the air between the subject's thumb and index finger, but not touching either. The zero mark on the ruler was aligned with the subject’s fingers. The subject indicated when he/she was ready. Without warning, the ruler was released and the subject had to catch it as quickly as possible, as soon as they saw it fall. The distance the ruler fell was recorded in cm. The above test was repeated with the subject’s non-dominant hand. There were three test subjects and the experiment was repeated three times for each test subject using both dominant and non-dominant hand. The average distance was then calculated for each test subject when the subjects used their dominant hand and when they used their non-dominant hand. Following this, the reaction time, based on the average distance dropped, was calculated for each age group, for each hand. The formula used for calculating reaction time was \( d = vt + \frac{1}{2}at^2 \) (\( d= \) distance, \( v= \) velocity, \( t= \) time, \( a= \) acceleration).
The fourth experiment, which was a follow up to the first experiment, was conducted to determine whether the reaction time was affected when test subjects used only one eye, versus both eyes to perform the tasks. This experiment was conducted by first having the test subject seated near the edge of a table, with his/her elbow on the table and wrist extended over the side. Each subject had his/her right eye closed with the other hand. The assessor held the ruler vertically in the air between the subject’s thumb and index finger, but not touching either. The zero mark on the ruler was aligned with the subject’s fingers. The subject indicated when he/she was ready. Without warning, the ruler was released and the subject had to catch it as quickly as possible as soon as he/she saw it fall. The distance the ruler fell was recorded in cm. The above test was repeated with the subject’s left eye closed and then again with both eyes open. There were three test subjects and the experiment was repeated three times for each test subject using left eye open, right eye open and both eyes open. The average distance was then calculated for each test subject when they used one eye (right and left) and both eyes. Following this, the reaction time, based on the average distance dropped, was calculated for each age group, for each hand. The formula used for calculating reaction time was \( d = vt + \frac{1}{2}at^2 \) (\( d \) = distance, \( v \) = velocity, \( t \) = time, \( a \) = acceleration).

The fifth experiment, which was a follow up experiment to the second, was conducted to determine whether reaction time to an auditory stimulus was affected when only one ear was used versus both, when performing the tasks. This experiment was conducted by having the test subjects listen to a beep that came every 10sec for 30sec. The beep was generated from a website online. The subject had to listen to the beep through a pair of headphones. In the first version of the experiment, an earpiece was placed in only one ear, while in the second version both ears had earpieces. The test subject was asked to signal when he or she heard the beep by saying the word “now” aloud. The assessor started the timer as soon as the beep was generated and stopped the timer when the test subject signaled the beep. The reaction time was measured by calculating the number of seconds it took for the test subject to signal that he or she heard the beep. The results were recorded for each version, first with the beep fed into one ear and then with the beep fed into both. The test was repeated three times for each subject, for both versions of this experiment and separate averages were calculated based on the results of each. The time from when the beep was sounded to when the test subject responded to it was the reaction time.
RESULTS AND DISCUSSION

Figure 2. Which age group has the best reaction time when given a visual stimulus.

In the experiment measuring reaction times to a visual stimulus across three age groups, the overall average reaction time was 0.23sec for middle school students, 0.29sec for upper School students and 0.30sec for adults. Hence it was concluded that middle school students have the fastest reaction time to a visual stimulus and adults have the slowest reaction time to a visual stimulus. This could have been because middle school students might have been engaged more frequently in activities that required quick reaction times and studies have found that high levels of activity in specific parts of the brain lead to complex and stronger set of synapses and interconnections between neurons developing in areas related to those activities. Also brain studies have found that Synaptogenesis (the process of interconnections developing between neurons) is at its highest during the childhood and adolescent stages of life, and it slows down as humans enter adulthood. This might have been a factor that caused reaction times in the adults to be slowest of the three age groups.
In the experiment measuring reaction times to an auditory stimulus across three age groups, the overall reaction time for middle school students was 1.12 sec, 1.20 sec for upper school students and 1.21 sec for adults. It was concluded that middle school students showed the fastest reaction time to an auditory stimulus and adults showed the slowest reaction time to an auditory stimulus. This could have been because middle school students might have been engaged more frequently in activities that required quick reaction times. Studies have found that high levels of activity in specific parts of the brain lead to a complex and stronger set of synapses and interconnections between neurons developing in areas related to those activities. Also, brain studies have found that Synaptogenesis (the process of interconnects developing between neurons) is at its highest during the childhood and adolescent stages of life, and it slows down as humans enter adulthood. This might have been a factor that caused reaction times in the adults to be slowest of the three age groups.

**Figure 3.** Which age group has the best reaction time when given an auditory stimulus.
In the experiment measuring reactions times when using dominant hand versus non-dominant hands, subjects had an average reaction time of 0.25sec when using their dominant hand and 0.26sec when using their non-dominant hand. It was concluded that subjects had faster reaction times while using their dominant hand as compared to when using their non-dominant hand. The reason for this could be because people use their dominant hand more often in all daily activities (eating, writing). The parts of the brain that are connected to the use of the dominant hand might show a greater level of interconnects between neurons, thus developing a more effective use of this hand.
Figure 5. How the number of eyes someone uses affects reaction time when given a visual stimulus.

In the experiment measuring reactions times using one eye (left and right) versus two eyes, subjects had an average reaction time of 0.25sec while using both eyes, 0.27sec while using only the left eye and 0.267sec while using only the right eye. Hence it was concluded that when given a visual stimulus, subjects had faster reaction times when they had both eyes open versus when having only one of the eyes open. It was also found that there was not a significant difference in the reaction time when either left or the right eye was closed. The reason for this might have been that vision is clearer, when using both eyes. Also, humans are used to experiencing daily life using two eyes. So when having to experience a situation that asks for the use of only one eye, it takes some adjustment, which might have resulted in a slower reaction.
Figure 6. How does the number of ears used affect the reaction time when using an auditory stimulus.

In the experiment measuring reactions times using one ear (left and right) versus both ears, subjects had an average reaction time of 0.9 sec while using both ears and 1.3 sec when using one ear. Hence it was concluded that, when given an auditory stimulus, people had faster reaction times when using both ears to hear the buzzer versus when using only one ear. The reason for this might be that hearing is more powerful and has more volume when using both ears. Also, humans are used to experiencing daily life using both ears. So, when having to experience a situation that asks for the use of only one ear, it takes some adjustment, which might have resulted in a slower reaction.

CONCLUSION

Based on the experiment conducted to measure reaction time across three different age groups (middle school, upper school and adults), it was concluded that the middle school age group had the fastest reaction time. The hypothesis was incorrect, as it was expected that among the three chosen age groups, the upper school age group would have had the fastest reaction time, as it was thought that brain development would be at its peak at this age (among the three tested age groups). Understanding the factors that affected reaction time was important, as reaction time
played a critical part in various activities that humans engaged in, such as driving and playing a sport. Some additional experiments related to conditions under which reaction times get affected would have been to measure reaction times when the test subject performed the tasks while using a cell phone, or when the test subject performed tasks after skipping a meal.

**CITATIONS**


