Cognitive Performance of Skilled Operators in Control Panel Operation

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Abstract : The visual system of human being faces an enormous range of data and information. Visual system identifies information, determines the shape & finally send information to brain to guide the action. Effectiveness of this information processing and counter action is measured by response time which consists mainly of Reaction Time (RT) and Movement Time (MT). RT is a measure of how quickly one can respond to visual or auditory stimulus. MT is time of muscle movement to perform necessary action. RT is greatly affected by many factors. The study of RT and factors on which it depends is very important because slower than normal response time may have very dangerous or fatal result. For example in high pressure line activities in power plant requires RT & MT in milliseconds and any lag in response may have fatal results. Some of the factors on which response time depends are: number stimuli, type of stimulus, stimulus intensity, stimulus location, age, gender, arousal, personality, experience etc. An experiment is carried out to find out effects of personality type, experience, stimulus location, stimulus intensity, subject's posture on reaction time and movement time.

1 Introduction

Reaction is a purposeful voluntary response to a stimulus. There is a cer-tain time period between application of stimulus and appropriate motor re-sponse. The responsibility of visual system is to identify items, determine their layout and finally guide action to them [1].

The model for information flow within an organism can be represented in this way:
Stimulus → Sensory Neuron → Spinal Cord or Brain → Motor Neuron → Response

Effectiveness of this information processing and counter action is measured by response time which consists mainly of Reaction Time (RT) and Movement Time (MT). RT is a measure of how quickly one can respond to visual or auditory stimulus. MT is time of muscle movement to perform necessary action. Response time depends on several factors so there can be no universal response time for a particular stimulus. Expectation, urgency, cognitive load, stimulus response compatibility, psychological refractory period, response complexity affects response time. Apart from these number of stimulus, type of stimulus, stimulus intensity, stimulus location, age, gender, fatigue, practice, distraction and personality are the other factors which affect response time.

The time it takes to make decision increases as number of alternatives increases. This is governed by Hicks Law which states that the time required to make a decision is a function of the number of available options [2]. The auditory reaction time is faster than visual reaction time [3]. Simple auditory reaction time has the fastest reaction time for any given stimulus [4]. In one experiment it was fund that mean reaction time to detect visual stimuli is approximately 180 to 200 milliseconds, whereas for sound it is around 140-160 milliseconds [5]. Conversely there are also researches which shows that reaction time to visual stimuli is faster than to auditory stimuli [6]. In another experiment again it was found that visual reaction time is faster than auditory reaction time during or after exercise [7]. In an experiment it was found that mean visual reaction time is around 331 milliseconds as compared to the mean auditory reaction time of around 284 milliseconds. This shows that auditory reaction time is faster than visual reaction time [3]. Auditory stimulus takes only 8-10 milliseconds to reach the brain, but on the other hand, a visual stimulus takes 20-40 milliseconds [8]. This implies that the faster the stimulus reaches the motor cortex, faster will be the reaction time to the stimulus. Therefore since the auditory stimulus reaches the cortex faster than the visual stimulus, the auditory reaction time is faster than the visual reaction time [3].

Reaction time (RT) is known to decrease as a function of stimulus intensity, approaching an asymptote for the most intense stimuli. This finding is true for simple reaction time tasks and in some cases for complex tasks [9]. It was found that visual stimuli that are longer in duration elicit faster reaction times [10], similar results were found for auditory stimuli in other experiment [11] [12]. It was reported in studies that the weaker the stimulus is, the longer the reaction time is. However, after the stimulus gets to certain strength, reaction time becomes constant [13].

Location of stimulus affects movement time but its effect on reaction time has not been significant in previous studies [14]. This is governed by Fitts Law.

Simple reaction time shortens from infancy into the late 20s, then in-creases slowly until the 50s and 60s, and then lengthens faster as the person gets into his 70s and beyond [15] [16] [17]. Adolescents will probably have slower reaction times than adults [18]. This age effect was more marked for complex reaction time tasks [16] [17]. Male have lesser visual reaction time than female [19]. In a study of 250 healthy medical students comprising of equal number of male and female candidate, it resulted that human reaction time of female is higher than that of male [20].

2 Experiment

A Simple Reaction Time Test is performed on control panel to find out effect of personality type, intensity of stimulus, operator distance, experience and operator posture on reaction time and movement time.

2.1 Equipment

Apparatus on which this experiment is performed is Analog type Control Panel Board. This panel is divided into two parts. Upper part is known as annunciation panel and signals are displayed on this part. Second part is known as control panel which consists of buttons,

knobs and switches for performing corrective action.
2.2 Participants
Individuals of the same age group are selected for this experiment to reduce the effect of age. 9 healthy male operators with age between 27 to 32 years and height 171 to 183 cm were selected to perform this experiment. These all operators are having experience of 1 to 6 years. These operators are classified into three categories: Extravert, Introvert and Ambivert. Of these nine operators, 3 are Extraverts, 2 Introverts and 4 Ambiverts as per Eysenck Personality Theory.

2.3 Design of Experiment

The type of variables are assigned as below in SPSS analysis
Dependent variables: Reaction time and Movement time
Fixed variables: Personality, Posture, Intensity of hooter & distance from control panel
Covariate: Experience

2.4 Method

The test conducted is simple response test. In this experiment reaction time is defined as the time required by the operator to identify the signal on the control panel annunciation area. Hence reaction time is time between occurrence of hooter along with signal and initiation of movement of operator. Movement time is defined as the time required by the operator to perform the necessary push to the control button/knobs in the control system area of the control panel after reaction time is over.
There are two cases. In Case 1 operators are seated and in Case 2 operators stand. Both cases are further subdivided into 2 categories. In each category readings at operator's distance of 0.5 m and 1 m from control panel board are recorded. In every cases and subcases reading at two sound intensities (80 dB and 85 dB) of hooter are recorded. Hence overall we have 8 cases for which readings are to be recorded for each personality type.

3 Result

Univariate ANOVA is performed on IBM SPSS software. Personality affects both reaction time and movement time. Movement time is more dependent on personality. Significance value of dependence of movement time on personality ($p<0.000$) is lesser than significance value of dependence of reaction time on personality ($p<.019$). Position also affects both reaction time and movement time. Here also dependency of movement time is greater than reaction time on position. Significance value of dependence of movement time on position ($p<0.001$) is lesser than significance value of dependence of reaction time on position ($p<0.02$). Distance from the control panel affects both reaction time and movement time significantly. Both the significance value are $p<0.001$. Reaction time is more dependent than movement time on intensity of hooter. Significance value of dependence of reaction time on intensity of hooter ($p<0.001$) is lesser than significance value of dependence of movement time on intensity of hooter ($p=.021$). Personality together with distance affects movement time ($p<0.001$) significantly which is not the case with reaction time ($p<0.097$).

Distance together with intensity of hooter affects reaction time significantly ($p<0.001$) whereas movement time is significantly independent ($p < 0.816$).

4 Discussion

Practice-related improvement in motor performance can be attributed to changes in central processing time, as measured by RT, or by changes in the peripheral components, as measured by MT. Although a new /inexperienced subject needs time to be familiar with the operations to perform as a counter of visual/auditory (in our case both are occurring) stimulus that occurs which results in large movement time. Here in our case since all the subjects are normally of the same age group and intelligence and are expert in their field there is very little in fact no general trend or relationship between reaction time and experience. Similarly movement time is also not showing any relationship with experience as all the subjects are of same capability and intelligence. The effect of practice is over in all the cases.

Target distance affects movement duration in aiming tasks but its effect on reaction time has not been significant in various previous studies. In general as the distance between operator and location of stimulus is more, the subject has to travel more distance from his position to operate the control panel, resulting in larger time requirement for operation. Thus movement time increases.

In this experiment reaction time decreases as the distance between subject and location of stimulus increases while in previous researches it has been shown that if advanced preparation is allowed the reaction time is independent of distance. All the subjects in our case are experienced and have well practice of the control panel, location of all the stimuli, its probability to happen etc. while in the earlier cases experiments have been done by selecting few subjects and new model has been framed for the experiments. In some cases subjects have been given chances for practice too but all these do not result in expertise as in our case. Hence as the distance between subject and control panel increases vision angle of operator increases i.e. visual stimulus is now present in the centre of peripheral system. Now logically as the distance increases, operator has to give some extra effort in reading out the stimulus which occurs as now the stimulus size decreases resulting in larger reaction time. But in our case subject is not at all reading the stimulus as he is expert enough to find out the exact stimulus by seeing its location which is now more visible as the distance increases.

Reaction time decreases as distance between subject and stimulus in-creases. But it results in higher movement time. For optimization of response time make annunciation panel and control panel in two separate parts. Place annunciation panel at a distance from subject so that visual stimulus may come in central vision for reduction in reaction time. Place the control board near the place of operator to eliminate time of movement resulting in lesser movement time. Thus response time will decrease considerably.

References

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