



## Analysis of human information processing in performance and cognition

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Submission Date: 09-11-2013, Acceptance Date: 14-11-2013, Publication Date: 31-01-2014

### How to cite this article:

#### Vancouver/ICMJE Style

Ilamkar KR. Analysis of human information processing in performance and cognition. *Int J Res Health Sci* 2014; 2(1): 36-40.

Available from: <http://www.ijrhs.com/issues.php?val=Volume2&iss=Issue1>

#### Harvard style

Ilamkar, K.R. (2014) Analysis of human information processing in performance and cognition. *Int J Res Health Sci*. [Online] 2(1). p. 36-40. Available from: <http://www.ijrhs.com/issues.php?val=Volume2&iss=Issue1>

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### Abstract:

**Background:** Reaction time is defined as interval of time between presentation of stimulus and appearance of appropriate voluntary response in a person. Reaction time has physiological significance and is a simple and non-invasive test for peripheral as well as central neural structures. The measurement of simple reaction time has been used to evaluate the processing speed of central nervous system and the co-ordination between the sensory and motor systems in normal participants. Simple reaction time is an indirect index of processing capability of Central Nervous System. **Materials and methods:** 52 healthy males and 52 healthy females [Mean age  $27 \pm 5$  years], who individually matched for gender and age, were included in the study, by using a response analyser to evaluate the sensori-motor performance. **Results:** Simple reaction time is the simplest model of measuring the function of the central nervous system. There were significant statistical differences [ $p < 0.05$ ] between males and females performance on sensori-motor measures. Their performances were expressed in mean  $\pm$  standard deviation of the reaction time by using the student unpaired 't' test. **Conclusion:** From these study it was concluded that the males might using a more complex strategy than females and were faster than females at aiming at a target, where as the females were more accurate or there may be modulation of neurotransmitter coupled with altered rate of impulse transmission due to fluctuation in the level of sex steroids hormones affecting the sensory, motor association and the processing speed at the central nervous system due to retention of sodium and water in females.

**Key words:** Central nervous system; Cognition; Sensori-motor speed; Sex-steroids hormones; Simple reaction time

### Introduction

Reaction time is a measure of how quickly an organism can respond to a particular stimulus. Sensory neurons convert a stimulus into an electro-

chemical 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). In 'simple reaction

time' experiments, there is only one stimulus and one response [1]. Reaction time is defined as interval of time between presentation of stimulus and appearance of appropriate voluntary response in subject. Reaction time has physiological significance and is a simple and non - invasive test for peripheral as well as central neural structures [2]. Reaction time measurement is an indirect index of processing capability of central nervous system. Reaction time measurement helps in determining sensory motor association and performance of an individual [3]. It determines the alertness of a person because how quickly a person responds to a stimulus depends on his reaction time [4]. At the risk of being politically incorrect, in almost every age group, males have faster reaction times than females and females disadvantage is not reduced by practice [5-7]. In this study, a modest attempt has been made to test the various hypotheses that have been put forward by different researchers.

#### **Basis of reaction time:**

In Simple Reaction time experiments, there is only one stimulus and one response. 'X' at a known location, 'spot the dot' and 'reaction to sound' all measure simple reaction time. The simple reaction time task is an attention task that focuses primarily on speed of processing. Speed with which a person can respond, "Reaction Time" is the key to assessing ability. When a person responds to something she/he hears, sees or feels, the total reaction time can be decomposed in a sequence of components. A) **Mental processing time:** composite of Sensation, Perception/recognition, Situational awareness, Response selection and programming, is the time taken by the responder to perceive the signal that has occurred and to decide upon a response. B) **Movement time:** Once a response is selected, the responder must perform the required muscle movement that determined the time for motor preparation (e.g. tensing muscles) and motor response was same, implying that the differences in reaction time are due to processing time. Every act takes time and time can be measured. We can measure time required in doing certain amount of work as the speed of work with mastery over the task. One can rapidly perform it, whereas the more complex processes take longer time to be accomplished. For such reasons, timing of responses plays an important role in physiological experimentation. The few cells in motor cortex changed their firing well before the response. Thus there was evidence that visual and motor cortex were both involved in normal reaction time performance [8]. There were several anatomical pathways

whereby information may pass from sensory to motor cortex. They reported the possibility of three major routes whereby visual cortex was connected to motor cortex. They are Pathway involving series of cortico-cortical synapses, Connections from cortex through basal ganglia thence to ventral thalamus and back to motor cortex, Pathway from cortex to cerebellum via pons and then back to motor cortex via ventral thalamus. The commands for voluntary movements originate in cortical association areas. The movements are planned in cortex as well as in basal ganglia and the lateral portions of cerebellar hemispheres. Basal ganglia and cerebellum both funnel information to pre-motor and motor cortex, by the way of the thalamus. Motor commands from motor cortex are relayed in large part via the corticospinal tracts the corresponding corticobulbar tracts to motor neurons in brain stem. However, collaterals from these pathways and a few direct connections from motor cortex end on brain stem nuclei which also project to motor neurons in the brain stem and spinal cord and these pathways can also mediate voluntary movements [9].

#### **Materials and Methods**

The simple reaction time was measured in normal participants after taking the informed consents of all healthy males [n=52] and healthy females [n=52] with the [mean age  $27 \pm 5$  years], Who individually matched for gender and age, from the random population were included in this study, by using a response analyser to evaluate the reaction time and compared their reaction times within [Mean $\pm$ SD] to reach any statistical difference. These study was carried out in the department of physiology with the co-operation of medicine and psychiatry department, Government medical college and hospital, Nagpur with due permission of the ethical committee.

Neuropsychological data were determined with the Folstein Mini-Mental State Examination (MMSE) and Hamilton Rating Scale for Depression (Ham-D). MMSE scores for these normal participants ranged from 26 to 30 ( $29.0 \pm 1.2$ ) indicating no significant cognitive impairment. Ham-D scores ranged from 0 to 8 ( $3.1 \pm 2.2$ ), indicating no significant depressive symptoms [10,11].

#### **Procedure for measurement of simple reaction time:**

The auditory and the visual reaction times of all the normal participants in the present study were measured by using a reaction time instrument [a

response analyzer] by the Yantrashilpa System, Pune, in a quiet room with good visibility conditions. The subjects were asked to sit comfortably on chairs in front of the table on which the response analyzer was placed. They were then explained about the details and the procedure of the test. All the normal participants in the study were right handed and they responded with their right hands. For recording the auditory reaction time, an audio mode was switched on, the required time interval for applying the stimulus was adjusted and then, the sound was set at a low frequency or a high frequency as required. The display was reset to zero by using a reset switch. The normal participants were instructed to respond as soon as he/she heard the sound, by pressing the response key with the index finger already on it. The sound stimulus was applied from the side and the subjects responded by pressing the response key.

An auto display on the analyzer indicated the reaction time of the individual to the auditory stimulus. Sufficient trials were given for a proper understanding and to alleviate any fear or apprehensions, pre-performance the education, trials and training. Three readings for a low frequency sound were recorded and then, the average of the three readings was considered as the auditory reaction time for a low frequency sound. The same procedure was then applied for a high frequency sound. Thus, the auditory reaction time was recorded for a low frequency sound and a high frequency sound separately. For recording the visual reaction time, the visual mode was switched on. Then, the required colour light (i.e. red or green) was set on the visual stimulus box. The display was set to zero by using a reset switch. The normal participants were instructed to respond as soon as he/she saw the glow, by pressing the response key with the index finger already on it. The visual stimulus was applied from the front side and then the subjects responded by pressing the response key. The auto-display on the analyzer indicated the reaction time of the individual to the visual stimulus e.g. the red coloured light. Three readings were taken and their average was considered as the visual reaction time for the red coloured light. The same procedure was applied for the green light. Thus, the visual reaction times were recorded for the red and green lights separately [12,13].

**Inclusion and Exclusion criteria:**

Minimum educational qualifications as higher secondary school passed were included in this study. Normal participants were also excluded for visual or auditory impairment sufficient to

compromise evaluation and testing. No normal participants were taking psychotropic medications or drugs known to affect the brain dopamine system. All normal participants underwent a clinical examination by a physician, psychiatrist, and neurologist to exclude any neurological or psychiatric disease, alcohol or substance abuse. Screening procedures included a medical history, physical and neurological examination, ECG, thyroid function studies, were also done to exclude cardiovascular diseases, hyperthyroidism, hypothyroidism, Diabetes. The data thus obtained was statistically analyzed using student unpaired ‘t’ test. Where  $p < 0.05$  consider as statistically significant.

**Results**

The simple reaction time was measured by using the following parameters: Auditory reaction time [ART] and Visual reaction time [VRT] in seconds.

**Table 1: Showing that mean values with standard deviation of males and females.**

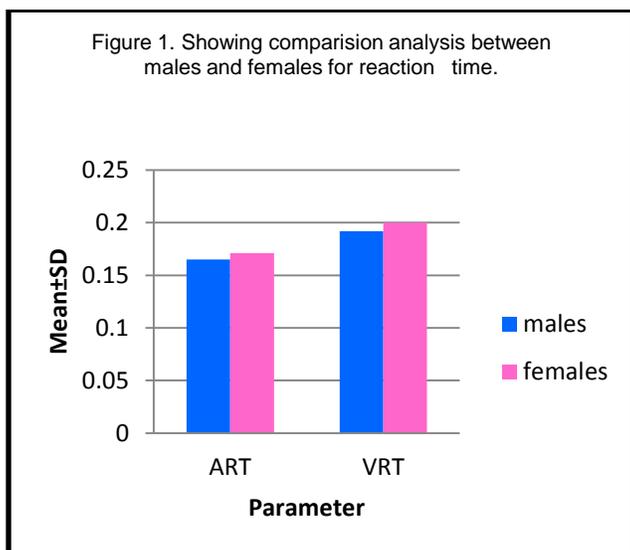
Parameters	Males [Mean ± SD]	Females [ Mean ± SD]	P value
Auditory reaction time (secs)	0.165 ± 0.010	0.171 ± 0.007	0.0499
Visual reaction time (secs)	0.192 ± 0.010	0.200 ± 0.008	0.0194

$P < 0.05$  consider as statistically significant. Showing that mean values with standard deviation of females are increased than those of males and was statistically significant.

**Discussion**

Males are able to respond faster to both visual and auditory stimuli, there might be intrinsic neurological advantage [12-16]. Their almost all of the males-females difference is accounted for by the lag between the presentation of the stimulus and the beginning of muscle contraction [17].

**Figure 1: Showing comparison analysis between males and females for reaction time**



Males might be using a more complex strategy than females and females might be aiming at a target, for accurateness [18]. In females the neural transmission i.e. hearing sensation may be affected by estrogen secretion and its influence on acetylcholine synthesis [19], thus correlating effect of sex steroid hormones with auditory thresholds and concluding that the circulating levels of sex steroid hormones, particularly female sex hormones affect the functioning of sensory nervous system [20]. On the basis of varying level of sex steroids during different phases of menstrual cycle which have sodium and water retaining effect. This retention of salt and water could modify the axonal conduction. It is also suggested to alter the availability of the neurotransmitter at the synaptic level. This modulation of neurotransmitter coupled with altered rate of impulse transmission due to fluctuation in the levels of hormones affect the sensory motor association with the processing speed at the Central Nervous System [21,22], which reduces the velocity of nerve impulse and increases the synaptic delay [23]. Males are better than females in discrimination of duration as well as in required session time, in terms of the assumption of a neurotransmitter related internal clock and with respect to gender differences in reaction time [24]. Anatomical and brain mapping studies showing a higher bilateral symmetry of female brains and a higher asymmetry of male brains, a significant correlation between the inter-hemispheric reaction times as a transition between a holistic-information-processing strategy and an

analytic strategy, males showed an analytic strategy [25]. Brain-Nerve Conduction Velocity in the visual nerve pathway may be faster in males than in females [26].

### Acknowledgements

Author wish to thank to the departments of medicine and psychiatry, Government Medical College & hospital, Nagpur and all the participants for their participation and co-operation to make these studies successful.

**Source of Funding:** Nil

**Source of Conflict:** Nil

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