A study on visual, audio and tactile reaction time among medical students at Kampala International University in Uganda

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Abstract

Background: Reaction time (RT) is an indicator of neural activity, however, its variation due to visual (VRT), audio (ART) and tactile (TRT) in African medical students has not been investigated. The aim of the study was to determine relationships between VRT, ART and TRT amongst medical students in Uganda.

Materials and methods: This was a cross sectional study, the body mass index (BMI) and RT (i.e. VRT, ART and TRT) were determined using weighing scale with standiometer and the catch a ruler experiment respectively. A questionnaire was administered to collect information on participant's lifestyle patterns and analysis was done using SPSS Version 20.

Results: The mean (± SEM) VRT, ART and TRT in the study were found to be 0.148 ± 0.002s, 0.141 ± 0.002s and 0.139 ± 0.003s respectively. A strong correlation between TRT and ART was found to exist in the youthful Ugandan medical student's population. Furthermore, significant differences in ART and VRT were observed with sex, although these were absent amongst preclinical and clinical students, showing the importance of sex in RT.

Conclusion: The low VRT and ART in Ugandan medical students is indicative of a healthy somatosensory connectivity, thus of academic importance.

Keywords: Reaction time, cognitive performance, neural health, medical education.

DOI: https://dx.doi.org/10.4314/ahs.v18i3.42

Cite as: *Kasozi KI, Mbiydzneyuy NE, Namubiru S, Safiriyu AA, Sulaiman SO, Okpanachi AO, Ninsiima HI. A study on visual, audio and tactile reaction time among medical students at Kampala International University in Uganda. Afri Health Sci. 2018;18(3): 828-836. https://dx.doi.org/10.4314/ahs.v18i3.42*

Introduction

Reaction time is an important voluntary response to a stimulus since it involves the time taken for sensory perception to initiation of a motor activity[1]. This shows that time taken by the neural circuitry, integrative centre and motor pathways is an important indicators of brain activity[2]. Factors such as diet, body mass index (BMI), education level, and employment status[3] have been shown to affect neural activity. Males have been associated with lower reaction time (RT) than females[4,5]. This contrasts other observations in which no differences in RT between male and females had been reported[6]. These gender differences in RT are believed to be influenced by the nature of experiment since the female gender is better than men on choice/mental tasks[6]. In addition, exposure to drugs and

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ethanol have been known to negatively influence reaction time[7,8]. On the other hand, active participation in dynamic exercise has been associated with improved physiological outcomes[8].

In humans, the visual, auditory and tactile neural pathways have been found to be practical for routine reaction time evaluation[7,9]. In medical students, auditory reaction time (ART) has been reported to be better than visual reaction time (VRT), which would seem to imply that the temporal lobe is more developed than the occipital lobe[7]. In addition, stress in medical students has been found to be more associated with the female gender, due to the routine physiological changes that they endure every month[10]. Stress affects nervous signal processing and this interrupts cognitive function[11]. Decreased processing speeds (as measured by the RT), has also been associated with poor academic performance[12]. Bearing in mind that medical students have to endure a stressful academic life for a minimum of 3 years, their reaction time would be an important indicator of their fitness to adapt to work related stress[13]. Physiological variables such as vision and reaction time are thought to have a common variance in age related decline[14–16]. In addition to becoming slower, the variability of reaction time with age increases showing cognitive decline, thus reaction time is an indicator of ability to perform many different kinds of processing operations and it is considered to vary in males and females[17]. Controversy still persists as to whether RT can measure one's proficiency[18], however, a general consensus on the role of gender, age, exercise, academic stress level, alcohol intake and health status of an individual is not fully available and they continue to be used as variables in RT experiments[19,20]. In RT, multiple responses in the measurement of motor response in humans has been shown to be a reliable measure of neural function[21]. In this study we set out to determine the relationship between VRT, ART and TRT amongst medical students at Kampala International University in Uganda.

Materials and methods

Study design

This was a cross sectional study carried out amongst undergraduate students in the Faculty of Biomedical Sciences of Kampala International University (KIU) Western Campus of South Western Uganda. The study was carried out on a weekend, a period on which no teaching was taking place in the university, and the study participants were chosen randomly. Data was collected in line with methods as described by Balakrishman et al[1] with minor modifications.

Body Mass Index (BMI)

To determine the health status of the participants, the weight and height of the participants was taken using a weighing scale with a standiometer, both located in the department of physiology. Each participant was asked to stand upright in a standard anatomical position on a weighing scale without shoes and minimal clothing. The weight (kg) and height (m) were subsequently taken for each participant. BMI was calculated as follows; BMI = Weight/height2 ; BMI values obtained where subsequently categorized for underweight, normal weight, preobese and class one obesity using WHO classification[22] for categorization of participants health status.

Reaction Time Stimuli

Visual, auditory and tactile reaction time were determined by the catch a ruler experiment[23] with minor modifications. In brief, a participant was requested to extend their index finger and thumb, to form a 'C' and the ruler (Aim ruler, 30 cm, KEBS, SM#3874, Made in Kenya) was held so that the zero mark was close to the edge of the participant's extended fingers without touching them. During VRT, the ruler was released randomly within a space of 20 seconds without making any visual gestures. In ART, the ruler was released after the participant hearing the word 'hold' being said by the investigator and their eyes being blind folded and no auditory cue was given. Finally, TRT was assessed after tapping the shoulder on the non-dominant arm as the ruler was being released. Subsequently, the distance (d) of the ruler was recorded in centimeters (cm) and using Newton's 2nd law of motion, RT was calculated using the following formula,

$t = \sqrt{(2*d/981)}$

Therefore, RT = $\sqrt{2d/981}$ in seconds.

Participant variables

A structured questionnaire was used to acquire information on participant's variables. In brief, questions on participant's age, education level, marital status, exercise, drug use, alcohol intake, sports, academic challenges, auditory problems, and study level were assessed.

Statistical analysis

The distance (d) was taken four times from each participant and the mean distance (d) was used to compute the VRT, ART and TRT for each participant. Data on RT as well as participant variables from the questionnaire were entered into Microsoft word Excel version 2010. These were then exported into SPSS Version 20 for analysis and descriptively presented as mean ± SEM in tabular form, while significance was reported when $P < 0.050$.

Results

Study population description.

The mean age of the study participants was 22.390±0.426 yrs while the tactile reaction time was the shortest. In addition the mean BMI was established to be 19.441±0.425 as shown in the Table 1.

Table 1: Mean reaction time, age and BMI in study population.

Variable	N	Mean ± SEM	95% Confidence interval	
			LL	UL
Age (yrs.)	57	22.390±0.426	21.53	23.24
VRT (s)	57	0.148±0.002	0.145	0.152
ART (s)	57	0.141±0.002	0.137	0.145
T RT (s)	57	0.139±0.003	0.134	0.144
BMI (kg/m^2)	57	19.441±0.425	18.59	20.291

KEY: N = Number of participants, RT = Reaction time in seconds (s), BMI = Body mass index, LL = lower limit and UL = upper limit of the confidence intervals

Further analysis showed that there exists a strong relationship between tactile and auditory reaction time ($P < 0.05$) as shown in Table 2.

Table 2: Correlation of reaction time, age and BMI in study population.

Variables	Visual	Auditory	Tactile	Age	BMI
	Pearson correlation coefficient (P value)				
Visual	1	0.259(0.051)	0.188(0.161)	0.075(0.580)	0.102(0.449)
Auditory		1	0.408(0.002)*	0.065(0.631)	- 0.134(0.320)
Tactile			1	0.99(0.465)	0.220(0.100)
Age				1	0.194(0.149)
BMI					1

Reaction time variation with population demographics

Reaction time was lower in the normal weight population, mature entrant students, students who didn't have retakes, dependants, those with good hearing abilities, preclinical students, single students, and those who exercise regularly as well as among males than females. Mean VRT and ART were not significantly different ($P > 0.05$) among preclinical and clinical students while preclinical students had a better tactile performance as shown in Table 3.

Table 3: Reaction time changes with study population demographics.

Parameter	Variable	N	Visual	Auditory	Tactile
			Mean ± SEM Reaction time in seconds		
BMI	Underweight	20	0.149±0.003	0.144±0.004	0.136±0.004
	Normal	36	0.148±0.002	0.139±0.003	0.140±0.003
	Pre-obese	1	0.156±0.000	0.134±0.000	0.156±0.000
Education entry level	Direct	55	0.148±0.002	0.142±0.002	0.139±0.003
	Mature	2	0.150±0.021	0.121±0.148	0.138±0.021
Occupation status	Self employed	6	0.152±0.003	0.144±0.005	0.148±0.003
	Dependant	38	0.147±0.002	0.139±0.003	0.136±0.003
	Sponsored	13	0.151±0.003	0.146±0.005	0.144±0.004
No. of retakes	None	46	0.148±0.002	0.140±0.002	0.139±0.003
	One	9	0.154±0.002	0.144±0.007	0.140±0.007
	≥ Two	2	0.128±0.009	0.139±0.020	0.145±0.003
Hearing challenges	Yes	10	0.158±0.003	0.144±0.006	0.133±0.005
	No	47	0.146±0.002	0.140±0.002	0.141±0.003
Study level	Preclinical	47	0.148±0.002	0.140±0.002	0.138±0.003
	Clinical	10	0.148±0.005	0.144±0.005	0.145±0.004
Marital Status	Married	7	0.160±0.003	0.145±0.004	0.139±0.004
	Single	45	0.146±0.002	0.140±0.003	0.138±0.003
	Dating	5	0.157±0.004	0.147±0.005	0.151±0.006
Exercise	Regularly	12	0.143±0.005	0.140±0.005	0.138±0.005
	Irregular	26	0.150±0.003	0.142±0.003	0.139±0.003
	Sedentary	19	0.149±0.003	0.140±0.004	0.140±0.006
Sex	Female	17	0.153±0.003	0.147±0.003	0.144±0.004
	Male	40	0.146±0.002	0.138±0.003	0.137±0.003

Further analysis showed significant differences exist in the visual reaction time (ANOVA, $P < 0.05$) on hearing challenges, retakes, and marital status as shown in Table 4.

In addition, reaction time variations in the male and female population were strongest in the auditory and visual observations than in the tactile observations as shown in Table 5.

Table 4: ANOVA on reaction time and population parameters

Parameter	Visual	Auditory	Tactile
	R^2, ANOVA summary showing F (P) values		
BMI	0.001, 0.260 (0.772)	0.022, 0.619(0.542)	0.018, 0.668(0.517)
Education entry	0.016(0.899)	3.272(0.76)	0.009(0.925)
Occupation	0.002, 0.710(0.496)	0.006, 0.908(0.409)	0.000, 1.460(0.241)
Retakes	0.005, 3.464(0.038)*	0.002, 0.240(0.787)	0.004, 0.109(0.897)
Hearing challenges	7.301(0.009)*	0.432(0.514)	1.269(0.285)
Study Level	0.000(0.987)	0.489(0.496)	0.947(0.335)
Marital Status	0.013, 5.160(0.009)*	0.000, 0.639(0.532)	0.015, 1.031(0.364)
Exercise	1.403(0.255)	0.078(0.925)	0.049(0.952)
Sex	3.663(0.061)	3.473(0.068)	1.752(0.191)

KEY: R^2 = Measure of association.

Table 5: Independent T-test in female and male population.

Reaction Time (s)	P- value	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
				Lower	Upper
Auditory	0.05*	0.008716	0.004308	-1.55E-05	0.017447
Visual	0.045*	0.007237	0.003489	0.0001641	0.014309
Tactile	0.164	0.007305	0.005143	-0.003129	0.017739

Population variables amongst female and male medical students.

A majority (63.2%) of the population was of normal weight, were direct entrant students (96.5%), single (78.9%), exercise irregularly (45.6%), not taking any drugs (91.2%), not taking alcohol (70.2%), and not very much interested in sports (45.6%). In addition 82.5% of the participants had clear hearing and significant differences existed between the female and male participants as shown in Table 6.

Table 6: Variations in student parameters amongst female and male students.

Parameter	Variable	Frequency (%) of participants sex			P -value
		Female	Male	Total	
BMI	Underweight	4(7.0)	16(28.1)	20(35.1)	0.175[b]
	Normal	12(21.1)	24(42.1)	36(63.2)	
	Pre-obese	1(1.8)	0(0)	1(1.8)	
Education Level	Direct	16(28.1)	39(68.4)	55(96.5)	0.511[a]
	Mature	1(1.8)	1(1.8)	2(3.5)	
Marital status	Married	1(1.8)	6(10.5)	7(12.3)	0.521[b]
	Single	15(26.3)	30(52.6)	45(78.9)	
	Dating	1(1.8)	4(7.0)	5(8.8)	
exercise	Regular	3(5.3)	9(15.8)	12(21.1)	0.917[b]
	Irregular	8(14.0)	18(31.6)	26(45.6)	
	No need	6(10.5)	13(22.8)	19(33.3)	
Drugs	Amphetamine opioids Benzo-diazepam	1(1.8)	0(0.0)	1(1.8)	0.177[b]
	Antibiotics	0(0.0)	1(1.8)	1(1.8)	
	Herbal	2(3.5)	1(1.8)	3(5.3)	
	None	14(24.6)	38(66.7)	52(91.2)	
Alcohol	Regular (1glass/day)	1(1.8)	11(19.3)	12(21.1)	0.135[b]
	Irregular (3glasses/week)	1(1.8)	4(7.0)	5(8.8)	
	Never	15(26.3)	25(43.9)	40(70.2)	
sports	Actively involved	2(3.5)	13(22.8)	15(26.3)	0.154[b]
	Irregular	1(1.8)	7(12.3)	8(14.0)	
	Spectator	3(5.3)	5(8.8)	8(14.0)	
	Never	11(19.3)	15(26,3)	26(45.6)	
Type of sport	Soccer	0(0.0)	11(19.3)	11(19.3)	0.044*[b]
	Football	0(0.0)	6(10.5)	6(10.5)	
	Baseball	0(0.0)	1(1.8)	1(1.8)	
	Basketball	2(3.5)	2(3.5)	4(7.0)	
	Athletics	3(5.3)	5(8.8)	8(14.0)	
	None	12(21.1)	15(26.3)	27(47.4)	
Retakes	None	12(21.1)	34(59.6)	46(80.7)	0.446[b]
	One	4(7.0)	5(8.8)	9(15.8)	
	≥ Two	1(1.8)	1(1.8)	2(3.5)	
Hearing problems	Yes	6(10.5)	4(7.0)	10(17.5)	0.031*[a]
	No	11(19.3)	36(63.2)	47(82.5)	
Study level	Preclinical	13(22.8)	34(59.6)	47(82.5)	0.337[a]
	Clinical	4(7.0)	6(10.5)	10(17.5)	

KEY: *Significant differences observed when $P < 0.05$; a = Fisher's Exact test, b = Chi-square test.

Discussion

Medical students were relatively youthful and had relatively low reaction times in this study population (Table 1). These observations are in agreement with common observations that youthful individuals are more reactive than elderly counterparts[15,16]. In addition, a strong relationship between the auditory and tactile RT in this population (Table 2) would be indicative of a highly somatosensory cortex, thus showing a close relationship between touch and sensory areas in the cerebral cortex[9,21] and this would indicate that the Institution investigated is a private University and stress in medical students is common[24]. Underlying factors to this would be related to several examinations (Table 6) and this would be related to oxidative stress mechanisms[25]. Also, the high financial stress due to the fee structure in comparison to public universities would also affect the mental health of the students[26,27]. This is important since voluntary response due to a sensory modality is closely controlled by the integrative centre of the brain[1,2], which is responsible for handling stress. The role of age in influencing RT[17] was not significant (P > 0.05) probably due to the small age range of the current study (Table 2).

Reaction time was generally better in participants with healthier lifestyles and those who were in their prime during medical school (Table 3). Bearing in mind that BMI, education and stress levels have been shown to affect RT[3], observations made from this study show that the medical students in this community are able to adapt adequately. On the other hand, no significant differences (P > 0.05) in VRT, ART and TRT between male and female where found in this study. Our findings suggest that in medical students who share a common background, variations in RT are not gender specific and this is contrary to previous findings[4,5], probably due to differences in geographical settings, social-cultural and education systems. Furthermore, significant differences in VRT amongst students with hearing, academic and marital obligations were demonstrated by the study (Table 4 and 5), thus observations in the study show that the visual pathway plays a crucial role in somatosensation. This means that students who have challenging backgrounds should be given more time to adapt through improved counselling services[10,12]. Regular exercise, remaining single, having a normal body weight and not being involved in drugs is important for medical students (Table 6). Special emphasis should be placed on girls who endure periodic changes through their body than boys[10,12,18] to ensure that the status quo (sex vs RT, P > 0.05), in this community on RT is maintained for the promotion of fair competition. The study was able to establish a direct relationship between VRT and ART in both males and female medical students (Table 5). This is important for improved medical education, however, the VRT still continues to be better developed which is in agreement with recent observations[7].

Bearing in mind that teaching methods between preclinical and clinical students vary, the study showed that TRT was better amongst preclinical than clinical students (Table 5). Observations in the study show that no significant variations may be present in the study population, although RT has been found to vary amongst individuals[12]. These findings are important since during clinical education, the ability of an individual to learn and respond to a particular stimuli may affect patient outcomes[16,21], especially in stressful working environment-the hospital[28,29]. In our study, 17.5% of our study participants were clinical students and this might be a limitation of the study, however, we have been able to demonstrate that Ugandan undergraduate medical students have good RT scores.

Conclusion

Visual, auditory and tactile reaction time in Ugandan medical students was low due to their youthful vigour and healthy lifestyle patterns. In addition, a close relationship between visual and tactile reaction time was established in this population, showing a need for further research in this area, especially amongst clinical students. This is relevant for exploring better teaching methods, understanding student adaptability to learning amidst the several stressors in a medical education milieu. RT studies maybe used to predict choice of medical specialization among students.

Declarations

Ethical considerations

Institutional ethical approval was acquired from Kampala International University Western Campus.

Conflict of interest

Authors declare no conflict of interest.

Funding

There was no research grant for this research activity.

Authorship contributions

All authors contributed equally to the development of the manuscript. K.I.K, N.E.M, S.N, H.I.N, and A.O designed the study, K.I.K, S.N, A.S, S.O.S conducted data collection and analysis, K.I.K, N.E.M, S.N, A.O, A.O, S.0.S and H.I.N prepared initial draft, reviewed and approved it for submission.

Acknowledgment
Authors wish to thank the support offered by TReNDS in Africa, for their technical support and comments during conceptual development of the research work.

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