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Critical Fusion Frequency and Audio-Visual Reaction Time as a Function of Age

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Abstract

Background & objective: Aging is associated with physiological changes in functioning of different parts of the body. One of the changes commonly seen in elderly persons is slowness of the movements. Many studies concluded that audio-visual reaction time (RT) increases with age. Critical fusion frequency (CFF) is the frequency at which an intermittent light stimulus appears to be completely steady to the observer. It is been observed that CFF decreases with age. But whether this decrease is a progressive phenomenon is not clear. Hence, the present study was designed to investigate CFF in various age groups.

Materials & method: The study involved hundred subjects within the age group of 20-70 years. Subjects were divided into five age groups. Audio-visual reaction time and critical fusion frequency were measured. Data was statistically analyzed by using one way ANOVA for group wise changes in RT and CFF. Relationship between visual RT and CFF was found out by Pearson's coefficient of correlation.

Results: Visual RT and Audio RT were positively and significantly correlated with age whereas CFF was significantly and negatively correlated with age in male and females separately as well as when combined together. ($p<0.001$)

Conclusion: From our study we conclude that the RT increases and CFF decreases with age. These changes are similar in both male and female subjects.

Keywords: *Audio-visual reaction time, Critical Fusion Frequency, Age.*

Introduction

Aging in humans is a multidimensional process of physical, psychological, and social change. It is associated with physiological changes in functioning of different parts of the body. One of the changes commonly seen in elderly persons is slowness of the movements.[1] Adequate and timely response to the auditory and visual stimuli are necessary in day to day activities & these activities are executed by reflex mechanisms involving cerebral cortex. Many studies concluded that reaction time (RT) increases with age.[2] But relationship between the age and changes in RT is not clear.

Critical fusion frequency is the frequency at which an intermittent light stimulus appears to be completely steady to the observer. Stimuli presented at a higher rate than the CFF are perceived as continuous stimuli. Measurement of CFF is used as a test for fatigue of the central nervous system, cortical processing capacity and level of cortical activity or arousal in a person.[3] It has also been observed that CFF decreases with age.[4,5] But whether this decrease is a progressive phenomenon is not clear.[6-8]

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Hence, the present study was designed to investigate changes in audio-visual RT and CFF in various age groups. To find out age wise changes in auditory and visual reaction time in healthy subjects. To study changes in critical fusion frequency in healthy subjects of various age groups. To compare changes in critical fusion frequency in healthy subjects of both gender groups.

Materials and Method

The study was conducted in a sample of hundred healthy individuals within the age group of 20-70 years in Kolar. They had been divided into five age groups as follows- Group I; 20-29 years, group II; 30- 39 years, group III; 40-49 years, group IV; 50-59 years and group V; 60-69 years. In each group, 20 subjects were included. Subjects were selected based on inclusion and exclusion criteria.

Inclusion criteria [study group]

Hundred healthy individuals of both the sex aged between 20 and 70years were included.

Exclusion criteria

History of Neuro endocrine disorders

History of Musculo-skeletal disorders

History of audio-visual pathology and or surgery

History of visual acuity more than ± 5D spherical or ± 2D cylindrical

History of Hypertension

History of Diabetes Mellitus

Methodology

The subjects were selected by a detailed history & thorough physical examination. The experimental protocol was fully explained to the participants to allay apprehension. Informed consent was taken from all the subjects. The study was approved by Institutional Ethical Committee. For all the subjects, basic vital data i.e. name, age, sex, address was noted. History of tea, caffeine, alcohol intake was also noted.

Each subject was given 10 trial sessions to get familiarized with both the techniques i.e. audio-visual reaction time and critical fusion frequency measurement. Auditory and visual reaction time was measured by the audio-visual reaction time apparatus (PC1000, software based instrument designed by one of the authors. Software used is Audacity; freely available). Here, subject has to respond to the auditory and visual stimulus as quickly as possible by pressing the switch. Best of three measurements was considered as the subject's auditory and visual reaction time respectively.

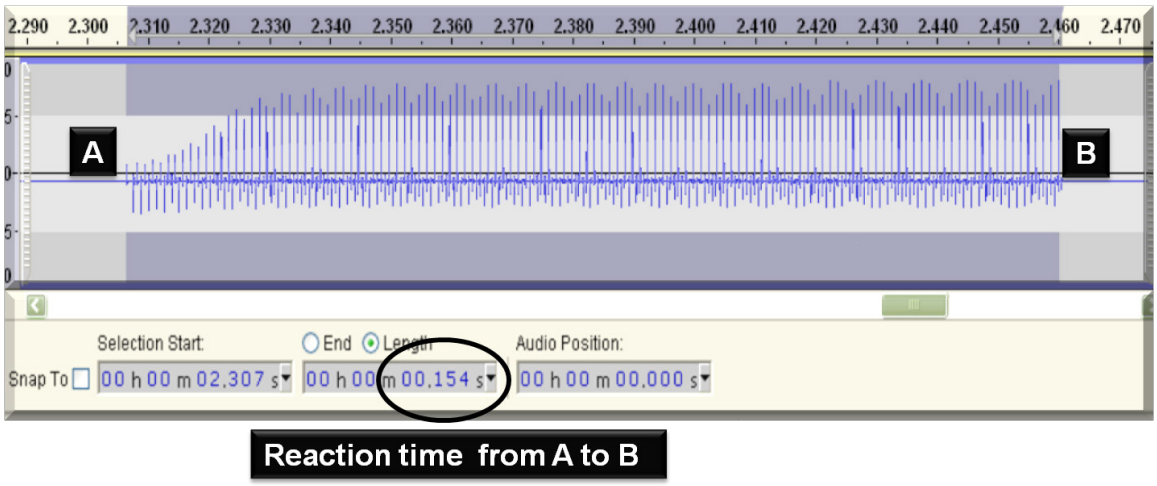

Figure1: *Recording of visual reaction time. (A) Onset of stimulus; (B) End of Response by the subject. Distance between A and B is visual reaction time in msec as marked at the bottom of the screen.*

CFF apparatus was also a portable software-based apparatus designed by in house Bio-medical Engineer. Software used was SweepGen which was freely available on the net. Red LED of 5 mm diameter was used against the white background as a light source. It was kept at a distance of 30 cm from the subject's eye at the eye level. Flicker frequency was gradually increased by the rate of 1.5 Hz/sec. The frequency at which stimuli appear continuous was noted. Also by gradually decreasing the frequency of stimulation, the point at which flicker is felt was noted. Mean of such six frequencies was considered as CFF.

Data was statistically analyzed by using one way ANOVA for group wise changes in RT and CFF. Relationship between visual RT and CFF was found out by Pearson's coefficient of correlation.

Results

As shown in table 1, both VRT and ART in male subjects showed progressive increase whereas CFF was decreased. Increase in VRT and ART was statistically significant from the age-group 40-49 years onwards when compared with the younger age groups. Decrease in CFF was statistically significant in all the age-groups when compared with 20-29 years age-group.

Table 1: Comparison of VRT, ART & CFF in different age groups in males

Age group (years)	N	VRT (msec)	ART (msec)	CFF (Hz)
20-29	20	179.87 ± 25.75	143.55 ± 20.09	38.80 ± 1.00
30-39	20	208.48 ±24.48	157.44 ± 19.34	37.17 ± 0.88*
40-49	20	236.28 ± 34.39*	183.83 ± 52.98*	36.33 ± 1.02*
50-59	20	270.05 ±30.47*	214.65 ±33.56*	35.64 ± 1.35*
60-69	20	276.00 ± 44.35*	229.58 ± 34.81*	35.84 ± 1.47*
F Value		31.01	24.65	24.31
P value		0.0000*	0.0000*	0.0000*

In females, as shown in table 2, findings of CFF were similar to that of males. But VRT and ART were significantly higher at from the age group 50-59 years onwards when compared with the previous age-groups.

Table 2: Comparison of VRT, ART & CFF in different age groups in females

Age group (years)	N	VRT (msec)	ART (msec)	CFF (Hz)
20-29	20	213.32 ± 38.26	170.87 ± 30.45	38.17 ± 1.00
30-39	20	245.08 ± 43.10	174.62 ± 39.92	36.77 ± 0.83*
40-49	20	243.04 ± 52.47	192.02 ± 29.12	36.19 ± 1.23*
50-59	20	261.57 ±42.97*	204.10 ± 31.41*	35.95 ± 1.31*
60-69	20	269.15 ± 44.70*	220.22 ± 36.00*	35.57 ± 0.47*
F Value		4.86	8.04	21.30
P value		0.001278*	0.000012*	0.00000*

Table 3 shows the result of unpaired t test. When compared the male and female of same age-groups, VRT and ART were significantly higher in females of age-group 20-29 and 30-39 years only. In higher age-groups the change was not significant. CFF results also do not show any significant change between the male and females of same age-groups.

Table 3: Gender-wise comparison of VRT, ART & CFF in different age groups

Age group (yr)	N	VRT (msec)		p value	ART (msec)		p value	CFF (Hz)		p value
Total	200	Male	female		Male	female		Male	female	
20-29	20	179.87 ±25.75	213.32 ± 38.26	0.0027*	143.55 ± 20.09	170.89 ± 30.45	0.002*	38.80 ± 1.00	38.17 ± 0.1	0.056
30-39	20	208.48 ±24.92	245.08 ± 43.10	0.0026*	157.44 ±19.34	174.62 ± 39.92	0.095*	37.17 ±0.88	36.77 ± 0.83	0.139
40-49	20	236.28 ±34.39	243.04 ± 52.47	0.63	183.83 ±52.98	192.02 ± 29.12	0.55	36.33 ±1.02	36.19 ± 1.23	0.70
50-59	20	270.05 ±30.47	261.57 ±42.97	0.48	214.65 ±33.56	224.10 ± 31.41	0.31	35.64 ±1.35	35.95 ± 1.31	0.46
60-69	20	276.00 ±44.35	269.15 ± 44.70	0.6172	229.58 ±34.81	220.22 ± 36.00	0.39	35.84 ±1.47	35.57 ± 0.47	0.44

As depicted in table 4, VRT and ART were positively and significantly correlated with age whereas CFF was significantly and negatively correlated with age in male and females separately as well as when combined together.

Table 4: Correlation of age with VRT, ART & CFF in males & females

	N	VRT (msec)	ART (msec)	CFF (Hz)	Std. alpha
Male	100	0.75	0.71	-0.64	0.38
p value		0.000*	0.000*	0.000*	
Female	100	0.43	0.52	-0.63	0.2
p value		0.000007*	0.0000*	0.0000*	
Both	200	0.58	0.62	-0.63	0.29
p value		0.0000*	0.0000*	0.0000*	

We have also found statistically significant but negative correlation of CFF with VRT and ART in both male and female group, separately as well as when combined together.

Discussion

In our study we have found that there is a progressive increase in VRT and ART in both males and females with age. James L. Fozard *et al* also found slowing of simple RT in both male and female subjects across the decades. According to Waneen Wyrick Spirduso most of the slowing of responses in the aged is attributable to CNS processing.[8]

J. Richard Simon *et al* proposed that aging affects stimulus encoding but not response selection in elderly subjects when tested with choice RT. They have also shown that information processing is affected prior to the encoding stage but the encoding stage was the primary locus of the slowing which accompanied aging.[9]

In our study CFF showed a small but consistent decrease with age. Similar results were found by Brozek, J Keys. CFF is one of the measures of cortical processing capacity and central fatigue. This was evident by increase in CFF value with exercise induced arousal [10] as well as with the regular yogic practices including meditation.[11]

It has been shown by many researchers that with advancing age, there is degeneration of the optic nerve and cerebrum.[5]Aalso there is an accelerated increase of lens absorption and scatter or an accelerated loss of cellular elements of the retina, the afferent visual system,

or the combination of both.[12] According to Curcio the number of rods decreases linearly with increasing age, whereas cone density is not reduced significantly throughout adulthood. [13] Hence, decrease in CFF across the age groups can be attributed to decrease in neurons in visual pathway or in the visual cortex.

As shown in table 3, both VRT and ART were significantly higher for females in younger age groups when compared with males of same age groups but not after the age of 40 years. Also the difference in CFF values was not significant in any of the age groups. This suggests that aging related decrease in cortical processing may be responsible for these changes in both males and female subjects. VRT and ART were positively and significantly correlated with age whereas CFF was significantly but negatively correlated with age. Also the CFF is significantly and negatively correlated with VRT and ART. This suggests that changes in RT with age are partly associated with prolongation of central processing speed.

Conclusion

In our study we conclude that the RT increases and CFF decreases with age. These changes are similar in both male and female subjects. As CFF is negatively correlated with RT, and also the age, it can be the reason for changes in RT as age advances.

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