Original Article

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

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ABSTRACT

Background: Aging in humans is a multidimensional process. One of the changes commonly seen in elderly persons is slowness of the movements. Correct and timely response to the auditory and visual stimuli is necessary in day to day life situation. Critical fusion frequency is the frequency at which an intermittent light stimulus appears to be completely steady to the observer.

Aims and Objectives: To study changes in auditory and visual reaction time and critical fusion frequency in healthy subjects of various age groups and to investigate the relationship between reaction time and critical fusion frequency.

Material and Methods: Study was conducted on healthy individuals of age between 20 to 70 years. Auditory and visual reaction time was measured by the audio-visual reaction time apparatus. CFF was measured by a portable software-based apparatus.

Statistical analysis: Data was analyzed statistically 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 and Conclusion: From the present study it can be concluded 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.

Key words: Auditory reaction time, visual reaction time, critical fusion frequency, old 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] Correct and timely response to the auditory and visual stimuli is necessary in day to day life situation. It is brought about by reflex mechanisms involving cerebral cortex. Many studies concluded that RT increases with age.[2] But relationship between the age and changes in RT needs further elaboration.

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 a single continuous stimulus. 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]

Hence, the present study was designed to investigate changes in audio-visual RT and CFF in various age groups. The study also investigated the

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relationship between RT and CFF in various age groups.

AIMS AND OBJECTIVES

1. To find out age wise changes in auditory and visual reaction time in healthy subjects.
2. To study changes in critical fusion frequency in healthy subjects of various age groups.
3. To investigate the relationship between reaction time and critical fusion frequency in the above subjects as a function of age.

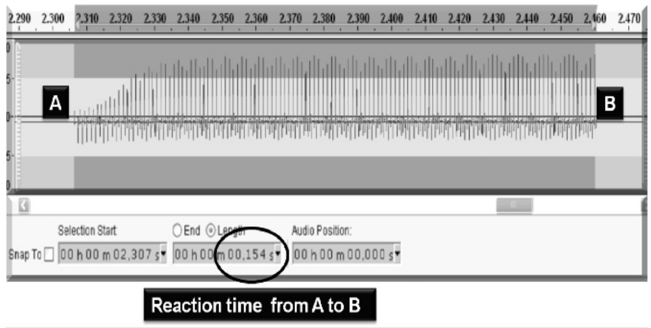
MATERIALS AND METHODS

The proposed study was conducted on healthy individuals of age between 20 to 70 years. Exclusion criteria included subjects suffering from any neuro-endocrine, musculo-skeletal disorders, audio-visual pathology and or surgery, visual acuity more than 5D spherical or 2D cylindrical, and the subjects with uncontrolled hypertension and diabetes mellitus. For all the subjects, basic vital data i.e. name, age, sex, address was noted. History of tea, caffeine, alcohol intake was also recorded.

Subjects were 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.

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 was Audacity; freely available). Here, subject has to respond to the auditory and visual stimulus as quickly as possible by pressing the switch. The computer records the event and shows the time as shown in figure 1. 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 one of the authors. Software used was SweepGen which was available free of cost for research purpose. 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. Subjects were instructed to raise the finger when the light appears continuous. This frequency at which light stimuli appeared continuous was noted. Then the frequency of stimulation was decreased and subjects were instructed to raise the finger when the light appeared flickering. The frequency at which flicker appeared was noted. Mean of such six frequencies was considered as CFF.

Data was analyzed statistically 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.

OBSERVATION AND 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 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 as shown in table 5.

Table5: Correlation of CFF with VRT & ART in males & females

	N	VRT (msec)	ART (msec)	Std. alpha
Male	100	-0.43	-0.40	0.38
p value		0.0001*	0.00004*	
Female	100	-0.28	-0.25	0.20
p value		0.004*	0.01*	
Both	200	-0.37	-0.34	0.29
p value		0.000*	0.000001*	

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 [2]. According to Spirduso WW most of the slowing of responses in the aged is attributable to CNS processing. [1]

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. and Keys A.[4] 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 in a study undertaken by Kate Lambourne.[10] It is also suggested that CFF value increases 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]. Also 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

From our study it can be concluded 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.

REFERENCES

1. Spirduso WW. Reaction and Movement Time as a Function of age and Physical Activity Level. Journal of gerontology. 1975; 30(4): 435-440.

2. James L. Fozard, Max Vercruyssen, Sara L. Reynolds, P. A. Hancock, and Reginald E. Quilter. Age Differences and Changes in Reaction Time: The Baltimore Longitudinal Study of Aging. Journal of Gerontology. 1994; 49(4): 179-189.

3. Azcona M. J. Barbanoj, J. Torrent & F. Janei. Evaluation of the central effects of alcohol and caffeine interaction. Br J Clin Pharmacol. 1995; 40: 393-400

4. Brozek, J., Keys A. Changes in flicker-fusion frequency with age. Journal of Consulting Psychology. Mar 1945; 9(2): 87-90.

5. Misiak, Henryk. Age and sex differences in critical flicker frequency. Journal of Experimental Psychology. Aug 1947; 37(4): 318-332.

6. Simonson, E. Enzer, N. Blankstein, S. S. The influence of age on the fusion frequency of flicker. Journal of Experimental Psychology. Sep 1941; 29(3): 252-255.

7. McFarland, Ross A., Warren, A. Bertrand, Karis, Charles. Alterations in critical flicker frequency as a function of age and light:dark ratio. Journal of Experimental Psychology. Dec 1958; 56(6): 529-538.

8. Misiak, Henryk. The decrease of critical flicker frequency with age. Science. 1951;113: 551-552.

9. J.Richard Simon, A. Reza Pouraghabagher. The Effect of Aging on the Stages of Processing in a Choice Reaction Time Task. Journal of Gerontology. 1978; 33(4) : 553-561.

10. Kate Lambourne, Michel Audiffren, Phillip D. Tomporowski. Effects of Acute Exercise on Sensory and Executive Processing Tasks. Med Sci Sports Exerc. 2010; 42(7): 1396-1402.

11. Vani PR, Nagarathna R, Nagendra HR, Telles S. Progressive increase in critical flicker fusion frequency following yoga training. Indian J Physiol Pharmacol. Jan 1997; 41(1):71-4.

12. Bernhard J. Lachenmayr, Sigrid Kojetinsky, Nikolaus Ostermaier, Klemens Angstwurm, Patrick M. Vivell, and Markus Schaumberger. The Different Effects of Aging on Normal Sensitivity in Flicker and Light-Sense Perimetry. Invest Ophthalmol Vis Sci. 1994; 35: 2741-2748.

13. Curcio CA, Millican CL, Allen KA, Kalina RE. Aging of the human photoreceptor mosaic: Evidence for selective vulnerability of rods in central retina. Invest Ophthalmol Vis Sci. 1993; 34: 3278-3296.

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