Psychological and Electroencephalographic Changes with Aging in Relation to Aircrew Performance

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The study was aimed at identifying any perceptible difference in certain selected perceptuomotor and cognitive functions amongst some preselected age groups, viz., 20-34 yrs, 35-40 yrs and 41-55 yrs. All the subjects were administered suitable psychological tests. Their electroencephalograms were recorded in the resting awake state as well as under provocation. The higher age group showed a significant slowness to respond where speed of performance was a main factor. Cognitive functions, psychophysiological indices and flight oriented psychomotor tests did not discriminate between different age groups. In the higher age group, alpha index showed a significant decrement and alpha attenuation following visual stimulation was poorer.

REALMS of childhood have been surveyed and chartered extensively by Freud, Spock and Piaget[20]. Erikson mapped the adolescent crisis and the different life stages of man[6]. However, all these studies and philosophical approaches were overloaded with a concern for the social, psychological or personality aspects of the individuals. Studies on the effects of aging on perceptuocognitive and psychomotor functions have been few and far between. The main difficulty is that aging itself defies definition. Since the process is both insidious and progressive, accompanying changes in physical and mental functions tend to be irregular and variable for each individual[14]. Nevertheless, it is well known that chronological aging produces a decline in certain psychological functions although improvements in certain other functions also have been reported. There has been much evidence, however, to show that at a particular point in the chronological scale performance efficiency starts declining. Hayflick[9] put this figure at 30 years which for all purposes could be of only theoretical importance. The problem becomes more complicated since different countries have different and widely varied life expectancies. This factor makes the formulation of an universally acceptable norm difficult.

Aim of Study

Most of the studies pertaining to aging centre around the "really" aged subjects. The aim of this study was somewhat restricted. It was not gerentological or geriatric in its emphasis. The aim was to find out if there existed a perceptible difference in certain selected perceptuomotor and cognitive functions amongst some preselected age groups, viz., 20 to 34 years, 35 to 40 years and 41 to 55 years. The functions chosen were principally relevant to flying. The question whether decline, if any, in a particular function is detrimental to flying success is largely hypothetical because it is the integrated whole of all the functions covering conative, affective, cognitive and physical aspects of the man that decides efficiency in any field of activity. However, it is safe to assume that a significant decline in a particular vital function could serve as a sufficient warning to the flier even if he has not been involved in any incident so far.

Method and Materials

Three sets of healthy male subjects belonging to 3 age groups, viz., 20 to 34, 35 to 40 and 41 to 55 years constituted the sample. The educational qualifications of these subjects were widely varied as were their experiences in different disciplines of work. The sample included military aircrew, ground duty personnel including the staff of the Institute of Aviation Medicine (IAM) Bangalore, and an Airline Pilot (in the highest age group). As the study was intended to be a cross sectional one, the same set of subjects was not taken for all the test situations although certain subjects were common for all the tests. Electroencephalograms (EEG) of all the subjects were recorded and they were administered the following psychological tests.

Psychological Tests

(a) *Flicker Fusion Frequency Test (FFF).* This is the classical critical fusion frequency test employed to find out the psychophysiological status of the individual[12]. Three readings were taken for each subject and the average flicker rate per second of these readings constituted the score. Higher the firker rate, better the functional status of the subject.

(b) *Choice Reaction Time Test (CRTT).* This is the IAM version of the classical choice reaction time test where variously coloured visual stimuli were presented to the left hand and right hand sides of the subject and the subject was expected to execute the response with both the hands alternatively. The subject's reaction time was recorded on a chronoscope milliseconds. Six readings, 3 for ea side, were taken for each subject. T average time in milliseconds formed t reaction time. Lower the time better t performance.

The above 2 tests were intended to assess t psychophysiological status of the individual.

c) *Digit Symbol Substitution Test (DSS* This test is part of Wechsler Adult Intel gence Scale (WAIS)[18]. The standard la down procedure of giving one mark one correct substitution was adopte Higher the score, better the performanc

d) *Block Design (BD).* This is a constitue of Bhatia's Battery of Performance Tests Intelligence[1]. Standard time based sco ing procedure was used. Higher the sco better the performance.

e) *Paired Associate Learning (PAL).* Th test forms part of the Wechsler Memo Scale Form I[12]. The number of corre recall after three presentations of th stimuli divided by 2 formed the scor Higher the score, better the learnin ability.

(f) *Perceptual Speed Test (PST).* This test intended to measure the speed of pe ception of a complex detail[17, 21]. Th number of correct answers within th stipulated time constituted the scor Higher the score, better the performance

g) *Immediate Memory Span Test (IMST* This is the digit memory span test stan dardised by Bhatia[1]. The number o digits correctly reproduced (in 3 attempts formed the score. Higher the score better the memory span.

The above five tests (c to g) generally asses the perceptuo-cognitive areas.

h) *Spatial Orientation Test (SOT).* This is one of the Flight Oriented tests which assess ones ability to orientate in space[11]. Sixteen stimulus diagrams were presented to the subjects and the number of correct responses was taken as the score. Higher the score, better the performance.

j) *NRC Stresslyser*. This is a subject paced step input pursuit tracking task used to measure psychomotor skill[4]. The average total response time of trials calculated in seconds formed the score. Lower the time, better the performance.

k) *Flight Oriented Psychomotor Test (FOPT)*. This flight oriented psychomotor test was designed and fabricated at IAM and found useful in many areas of research where psychomotor skill was studied[5]. The average time (in seconds) of the last 10 trials constituted the score. Lower the time, better the performance.

The above 3 tests (h, j and k) were flight oriented types and as such were included in this study.

Electroencephalographic (EEG) Studies.

Thirty healthy subjects in the selected age groups were chosen for this study. A 16 channel EEG of each subject was recorded on a Grass Model-6 Electroencephalograph in the resting awake state as well as under provocative measures like hyperventilation and photic stimulation. The electrode placement was done as per the 10-20 system. Bipolar and monopolar montages were selected for the recording. AP and transverse runs were done in the bipolar montages. The records were analysed visually.

Paired 't' test for the significance of the differences between the groups and the x^2 method were used wherever applicable.

Results

The results are projected in tables I to V. Table-I shows that there is no significant difference amongst the different age groups with respect to flicker fusion frequency and choice reaction time. Table II shows that the highest age group gives lower performance in perceptual speed compared to the youngest group. DSST, BD and PAL revealed no significant information. Much the same can be said about digit span memory also. The memory span, while adequate, was slightly lower for the higher age group as compared to that for the younger group.

Table IV shows that the performance of the higher age group on the tests, viz., spatial orientation test and NRC stressalyser was at a significantly lower level compared to their younger colleagues.

Table V shows that there is a significant decrease in Alpha Index with increase in age. Alpha attenuation in response to visual stimulation was poorer in the higher age group.

Discussion

From Table I it is seen that Flicker Fusion Frequency does not discriminate between different age groups. A low FFF threshold is assumed to result both from pre-retinal factors (thickening of lens) and central factors (stimulus persistence in the neurons). However, these factors do not seem to have contributed adversely to the older age group taken for this study. Possibly, these subjects were not old enough to be afflicted by any of the above conditions. Almost similar results were found with regard to choice reaction time also. Here again statistically, the highest age group stands at par with the others, although in absolute terms this group suffers. The lack of statistical significance may be due to the wide variability of the scores in each group. It is a widely believed fact that old age brings in a slowness of activity. As the reaction time (RT) measured here could probably have included portion of the execution time also, in the overall task context, the delineation of RT as such was difficult. Hence, not much meaningful conclusion can be drawn from the results. Interestingly, average RT of all age groups was found to be within generally accepted normal limit, i.e., between 200 and 300 milliseconds.

Digit symbol substitution test (table II) is a cognitively loaded test which involves a large amount of comprehension and some motor ability.

TABLE-I

Mean and standard deviation (Sd) values and the significance of difference between the groups

Age Group / Test	I 20–34 yrs n mean Sd	II 35–40 yrs n mean Sd	III 41–55 yrs n mean Sd	Mean difference between the age groups and their significance ("t" test)	
FFF*	20 33.55 3.13	14 33.56 3.27	11 33.36 2.58	I~II II~III I~III	+ 0.01 NS — 0.20 NS — 0.19 NS
CRTT**	14 235.71 43.06	11 246.72 46.72	9 271.00 44.92	I~II III~II I~III	— 11.01 NS — 24.28 NS — 35.29 NS

**FFF : Flicker Fusion Frequency test—Higher the score, better the performance.

**CRTT : Choice Reaction Time Test—Lower the score, better the performance.

TABLE—II

Mean, standard deviation (Sd) and the significance of difference between the different age groups

Age Group / Test	I 20—34 yrs n mean Sd	II 35—40 yrs n mean Sd	III 41—55 yrs n mean Sd	Mean difference batween the age groups and their significance ("t" test)
DSST*	12 59.83 6.50	10 58.30 6.27	9 56.22 8.85	I ~ II — 1.53 NS II ~ III — 2.61 NS I ~ III — 5.14 NS
BD**	14 16.64 2.53	11 17.27 3.25	10 16.20 2.97	I ~ II + 0.63 NS II ~ III — 1.07 NS I ~ III — 0.44 NS
PAL***	13 11.88 1.66	11 12.09 1.95	9 10.72 2.03	I ~ II + 0.21 NS II ~ III — 1.37 NS I ~ III — 1.16 NS
PST****	15 65.26 13.68	10 56.80 7.05	— 11 50.36 3.37	I ~ II — 8.46 NS II ~ III — 6.44 NS I ~ III — 14.90 (P ~ 0.0

Note : a) * DSST — Digit Symbol Substitution Test
** BD — Block Design
*** PAL — Paired Associate Learning
**** PST — Perceptual Speed Test

b) Higher the score, better the performance in all the tests.

TABEL—III

Immediate Memory Span (Digits)

Digit Span	Age groups and n		
	I 20 — 34 yrs n — 12	II 35 — 40 yrs n = 10	III 41 — 55 yrs n = 9
	No. of subjects who obtained the particular digits span		
5	1	2	2
6	3	3	5
7	3	3	1
8	3	1	1
9	2	1	—

Note : Higher the digit span, better the short term memory.

TABLE—IV

Mean and Sd values and the significance of difference betwcen the groups

Age Group / Test	I 20—34 yrs n mean Sd	II 35—40 yrs n mean Sd	III 41—55 yrs n mean Sd	Mean difference between age group and their significance ("t" test)
SOT*	13 10.69 2.28	12 9.75 2.66	9 8.11 2.26	I ~ III —0.94 NS II ~ III —1.64 NS I ~ III —2.58 ($P < 0.05$)
FOPT**	21 12.05 2.89	11 12.68 3.02	10 13.18 3.09	I ~ II 0.63 NS II ~ III 0.50 NS I ~ III 1.13 NS
NRC Stressalyser***	10 144.80 10.48	9 150.00 11.80	10 168.44 10.35	I ~ II 5.20 NS II ~ III 18.44 ($P < 0.01$) I ~ III 23.64 ($P < 0.001$)

Note : *SOT — Spatial Orientation Test. Higher the score better the performance.
**FOPT — Flight Oriented Psychomotor Test. The lower the score, better the performance.
***Lower the score (time), better the performance.

TABLE—V

Electroencephalographic Changes

	I 20 — 34 yrs n = 14	II 35 — 40 yrs n = 7	III 41 — 55 yrs n = 9	Difference in alpha index between the groups and their significance
Frequency range in Hz	10 — 11	11 — 12	12 — 12.5	
Amplitude range in mv	45 — 50	40 — 45	35 — 40	
Alpha Index with Sd	80 + 15	79 + 25	55 + 37	I ~ II — 1 NS II ~ III — 24* I ~ III — 25 (P <0.01)

*Despite the magnitude of difference (—24) between the II and III group the difference was not statistically significant owing to the high variances in mean values.

Type of alpha rhythm (number of subjects in each group)

	I	II	III
Well defined	10	4	2
Fairly ,,	1	2	2
Poorly ,,	3	1	5

Response to visual stimulus (number of subjects in each group)

	I	II	III	
Good	10	3	2	$X^2 = 8.51$ ($P < 0.05$) with 4 d.f.
Fair	2	3	1	
Poor	2	1	5	

No group difference was seen in the results of this test, although cognitive functions are assumed to be affected by age. Another cognitive test — block design (table—II) bears the fact that subjects selected for this study were generally of an equal mental calibre in spite of the wide disparity in their educational achievements. Like the substitutional ability of abstract symbols the analytical and integrative aspects involved in the performance of block design also formed part of that composite ability called intelligence.

Paired associate learning (Table-II) reveals no significant age discrimination. The same is somewhat true in the case of digit span memory also (table III). Although in absolute terms the higher age group had a lower memory span, it was well within the acceptable limits. It is hardly disputable that the results of the laboratory studies and everyday social experience show that memory declines with old age. Does the learning ability also suffer the same fate? In a laboratory situation learning and memory are intertwined in such a way that without the aid of the other one cannot be studied, Possibly with a "really" aged group we may see a performance decline, Of course, the area is a controversial one because while Gilbert[5] and Botwnick[8] reported a decline in performance with age, workers like Canestrari[4] and Eisdorfer *et al*[7] controverted the above findings. The results of perceptual speed indicate that the highest age group turns in a significantly lower performance ($P<0.01$) compared to the youngest group. This test assesses, among other things, the General Speed Factor of Intelligence[10]. The question whether the older subjects took more time in verifying the accuracy of items concerned or in the actual motor function of writing down the answers is difficult to explain.

The oldest age group shows a significantly ($P\ 0<.05$) lower performance compared to the youngest group in the Spatial Orientation test (table-IV). This pattern of results is somewhat intriguing because orientation ability itself is amenable to learning and experience and, as such, the oldest age group is expected to perform better. The test situation was one of a rapidly changing stimulus environment and, therefore, a reluctance to venture in to response —cautiousness— could result in careful behaviour and this could possibly have slowed down the performance of the older age group. Welford[22] cited this cautiousness as a characteristic of old age. It would, therefore, be slightly hazardous to hypothesise that old age affects spatial orientation ability *per se* although the end result of a test situation may make it appear so.

Age seems to have affected the performance of the NRC stressalyser. Here, the differences in average total response time (TRT) taken between the youngest and oldest groups, and between the middle group and the highest group have been highly significant ($P<0.001$ and 0.01 respectively). TRT is constituted by its components — reaction time, movement time, overshoot correction time and error correction time. Which specific parameter of the test has been affected by age, is difficult to tell. However, from the earlier results of choice reaction time test, it is seen that there exists no significant difference between the groups. Then the slowness in the performance of this test could have occurred in other spheres. One possible factor may be the error correction time which is largely contributed by the signal position probability. Cautiousness in venturing in to response has been seen as a characteristic of old age. Calculating the odds in the signal probability could have been affected by this cautiousness which Korchin and Bazowitz[11] have called "recognition inadequacy".

Flight oriented psychomotor test does not discriminate between the groups.

There is a statistically significant decrease in alpha index in EEG of the highest age group when compared in the youngest group (table V). This phenomenon is somewhat difficult to explain, for age and maturity are expected to level off some of the ups and downs in the emotional status of the individuals and bring in more relaxation with its indicant alpha. It is possible that the elderly age group taken for this study might have to cope up with greater stresses and strains of day-to-day life compared to their younger colleagues. Alpha blocking response to light and eye opening, decreases with age in normal subjects[15] as well as in psychiatric patients [19, 20]. Our findings of significant difference ($P<0.05$) among the higher age groups in attenuation of response visual stimulation (poorer attenuation in the higher age group) are, therefore, in agreement with others' findings. In other words, response to visual stimulation is not equally distributed among the 3 age groups, although a significantly higher proportion of poor response ($x^2 = 8.51$ with 4 d f.— significant at 5% level). No subjects showed slow wave response to hyperventilation and no change was seen in response to photic stimulation in majority of the cases.

Conclusions

a) The higher age group showed a significant slowness to respond to some stimulus environment where speed of performance was a main factor. The lowering of ability vis-a-vis advancing age has been seen in orientation, perception of a complex detail and the finer psychomotor skills as involved in the performance of NRC stressalyser.

b) Cognitive functions like analytical and integrative ability, comprehension, associate learning and memory span do not seem to be affected by aging atleast within the context of this study.

c) Psychophysiological indices like flicker fusion frequency and choice reaction time do not discriminate between different age groups.

d) Flight oriented psychomotor test gives off no significant information regarding aging.

e) A statistically significant decrement in the alpha index has been noticed in the higher age group.

f) Alpha attenuation in response to visual stimulation was poorer in the higher age group.

g) The slowness to respond observed in the performance of certain tests by the higher age group might not be of any neural origin. It could be due to an inability to take decision lest that decision should go wrong.

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