Reports

Cerebral Dysfunction and Intellectual Impairment in Old Age

Abstract. There is a marked decline in some intellectual abilities in old age. It is frequently hypothesized that impaired cerebral physiology accounts for some of this deficit. In old age the critical flicker frequency, a measure sensitive to cerebral dysfunction, is correlated with aging intellectual abilities. This is interpreted as evidence supporting the above hypothesis.

The average performance of the elderly on tests of certain intellectual abilities is markedly inferior to the average performance of the young. Old people usually experience particular difficulty with tests involving the acquisition of new knowledge and the utilization of new work methods (*1*). It is commonly alleged that alterations in cerebral physiology are one of the causes of this inferior performance. Although this is a plausible hypothesis, it is a difficult one to test, because detailed post-mortem examination of the brains of "normal" elderly people is a time-consuming process beset with sampling and technical problems. However, an alternative approach would be to utilize in vivo procedures which are sensitive to subtle alterations in cerebral physiology. One such measure is the critical flicker frequency for intermittent light.

An extensive literature demonstrates that flicker-fusion frequency is lowered in many cases of dysfunction of the central nervous system. It is also well established that flicker-fusion frequency declines with age, the rate of decline resembling that of some intellectual abilities (*2*). The lower frequency in old age cannot be explained by changes in the optical system of the eye, but appears to be due in substantial part to changes in the neuroretina, optic tract, and geniculocalcarine system (*3*). This suggests a relationship between critical flicker frequency and declining intellectual ability. Elderly individuals with a comparatively high critical flicker frequency should have less impairment of the central nervous system and therefore less intellectual deficit than those of the same age with low flicker-fusion frequency. But a number of studies have failed to demonstrate a relationship between the critical flicker frequency and intellectual ability in healthy young adults whose intelligence ranges from dull normal to very superior (*4*). Therefore, if such a relationship exists in old age, the interpretation of its meaning is not so ambiguous as might first appear; it would be presumptive evidence for the role of cerebral dysfunction in the impairment of intellectual ability in old age.

While studying the effect of age on flicker-fusion frequency in a group of 40 men (65 to 95 years), Colgan (*5*) correlated the frequency with scores from the Wechsler-Bellevue intelligence test. When the influence of age differences within the sample was removed by the partial correlation technique, the r between critical flicker frequency and Wechsler-Bellevue was 0.36 ($p <$ .05). We sought to substantiate Colgan's finding, employing 50 elderly women in a more restricted age range (74 to 80), carefully eliminating those with ophthalmological and other diseases known to affect flicker-fusion, and using only psychological tests with a marked age decline. In this study (*3*) scores from the Digit Symbol subtest of the Wechsler Adult Intelligence Scale (WAIS), the Primary Mental Abilities (PMA) Reasoning Test, the Raven Progressive Matrices, and the Wisconsin Card Sorting Test (WCST) correlated significantly with the critical flicker frequency, while the Porteus Maze did not.

The present report concerns the attempt to confirm our findings in a comparable group of male subjects, to provide an over-all evaluation of the combined data from the two studies, and to consider the implication of the results for the view that cerebral dysfunction accounts for some of the intellectual deficit of old age.

Detailed descriptions of the female subjects, the instrument used for measuring the critical flicker frequency, and the testing procedures have been presented elsewhere (*3, 6*). The male sample consisted of 36 men (68 to 80 years old) drawn either from the same residential homes as the women or from three day-centers for the aged in New York City. Because of irregularity in attendance at the day centers, the number of men who completed the various tests ranges from 16 to 32. The greater difficulty in obtaining male subjects is typical in gerontological studies. However, it was considered inadvisable to lower the rigid selection criteria, especially those excluding individuals with eye diseases known to affect flicker-fusion. Thus, more than 40 men were eliminated because ophthalmological examination revealed such pathology as cataracts, glaucoma, vitreous opacities, and macula degeneration (*7*).

Pearson product-moment correlation coefficients were computed between critical flicker frequency and scores from the five tests of intellectual abilities. Table 1 lists the correlations obtained in the male, female, and com-

Table 1. Pearson product-moment correlation coefficients between critical flicker frequency and five tests of intellectual abilities. (Tests of significance are one-tailed. Italics indicate partial correlation coefficients, removing the influence of age differences where both the test and critical flicker frequency were correlated with age in the sample.)

Test	Female	Male	Combined
Digit Symbol	0.36*	*0.30*†	*0.33**
Porteus Maze	.17	.22	*.20*†
PMA Reasoning (untimed)	.29†	.06	.23†
PMA Reasoning (timed)	.27†	.51†	.32*
Raven Progressive Matrices	.32†	*−.05*	*.07*
WCST, categories completed	.22	.39†	*.29**
WCST, perseverative errors	−.54*	−.40†	*−.46**

* $p < .01$. † $p < .05$.

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Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to contributors" [*Science* **125**, 16 (1957)].

Table 2. Intercorrelations and centroid factor loadings.

Test	1	2	3	4	5	6	7	I	II	h^2
1) Critical flicker frequency		.37	.23	.23	.12	−.49	−.12	.47	−.38	.36
2) Digit Symbol			.43	.65	.55	−.53	−.27	.78	.08	.61
3) Porteus Maze				.44	.48	−.45	−.20	.61	.07	.38
4) PMA Reasoning (untimed)					.67	−.40	−.18	.73	.39	.69
5) Raven Progressive Matrices						−.38	−.32	.72	.39	.67
6) WCST, perseverative errors							.34	−.71	.35	.62
7) Age								−.40	.16	.19

bined samples. The results with the male sample generally confirm those of the earlier study, the most striking exception being the failure of the Raven Progressive Matrices to correlate with flicker-fusion frequency. When the data from the two studies are pooled to provide a larger sample, all the tests except the Progressive Matrices correlate significantly with critical flicker frequency. A centroid factor analysis of the correlations from the combined sample is presented in Table 2. The analysis yielded only one significant factor, a general intellectual one in which both critical flicker frequency and age have significant loadings.

In the combined sample the perseveration score on the Wisconsin Card Sorting Test correlated the highest with critical flicker frequency. This test measures rigidity in concept formation, and it is tempting to draw similarities between conceptual perseveration and the neurophysiological perseveration reflected in flicker-fusion. However, the failure of the factor analysis to uncover a perseverative factor somewhat inhibits such speculation.

More than 20 percent of the variance in conceptual perseveration can be accounted for by flicker-fusion, presumably because both functions are sensitive to alterations in cerebral physiology. This relationship in the elderly might be explained by the comparative absence in some, and presence in others, of varying degrees of subclinical cerebral dysfunction. The relationship was probably attenuated by the exclusion of subjects with ophthalmological and neurological diseases and those in poor health. It is likely that these latter groups contained a disproportionate number of individuals with both low critical flicker frequency and severe intellectual impairment.

The results of the present study indicate the desirability of including measures of the flicker-fusion in longitudinal studies of aging. Repeated measurements throughout the life span of an individual would elucidate with less ambiguity the precise relationship between an individual's decline in intellectual ability and his decline in critical flicker frequency—and (presumably) in neural functioning.

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References and Notes

1. J. Brozek, *Geriatrics* **6**, 221 (1951).
2. H. Misiak, *Science* **113**, 551 (1951).
3. A. W. Loranger and H. Misiak, *J. Gerontol.* **14**, 323 (1959).
4. ———, *Am. Psychologist* **16**, 372 (1961).
5. C. M. Colgan, *Am. J. Psychol.* **67**, 711 (1954).
6. A. W. Loranger and H. Misiak, *J. Clin. Psychol.* **16**, 189 (1960).
7. George McDonald performed the ophthalmological examinations. We are indebted to the officials of the following institutions in New York City for providing the subjects for this experiment: the Mary Manning Walsh, Josephine Baird, and St. Patrick's homes, and the homes of the Little Sisters of the Poor in Manhattan, the Bronx, and Brooklyn; and also the Hodson, Sirovich, and Forest Community Day Centers. This research was supported by grant No. M-1283 from the National Institute of Mental Health, U.S. Public Health Service.

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Humming: A Vocal Standard with a Diurnal Variation

Abstract. The process of humming can be used as a basal vocal measurement which can be repeatedly obtained with an accuracy comparable to that of other physiological variables. Studies have shown a diurnal fluctuation of the hum frequency. Data were collected by employing automatic telephone-answering equipment.

Various studies have been made in an attempt to find correlations between vocal response and physiological change. A review of these studies suggests that one possible obstacle in this field has been the difficulty in establishing a standard vocal response which can be repeated with some consistency.

In order to achieve a vocal base line, it is important to reduce the number of variables associated with the functioning of the vocal mechanism. For example, during phonation the vocal cavities are altered by the relative positions of the tongue, mouth, and lips and also, to some extent, by the facial expression. In the study reported here, vocal samples were recorded in the laboratory and over the telephone to test the hypothesis that the process of humming can be used as a vocal standard. Subjects were asked to hum—while seated in a relaxed position with the mouth and lips closed—one continuous note for up to 10 seconds. The response was recorded on a continuous loop of tape. This procedure insured that the positions of the oral and nasal cavities at the time the vocal samples were taken were relatively constant.

The fundamental frequency was measured in the following way. The hum sample was played back on the tape recorder. The output of the recorder was displayed on the vertical axis of a cathode ray oscilloscope, while the output of the audio oscillator was fed to the horizontal axis, the two curves forming a Lissajous figure. Because vocal samples fluctuate, in some cases by a few cycles per second, about a mean frequency, the average hum frequency was determined when the oscillator was adjusted so that the twisting Lissajous figure turned approximately one way for half the duration of the cycle and in the reverse direction for the remainder of the cycle. To determine the relative intensity for each recorded sample, the average signal level was read from the standard VU meter.

Statistical analysis of the results (from 33 subjects) showed that when samples of the fundamental hum frequency were taken over periods up to 179 days, the coefficient of variation of the hum frequency ranged from 3 to 18 percent. Intensity readings for the same group over the same period gave coefficient-of-variation values of 32 to 300 percent. Table 1 shows the means and the standard errors for coefficients of variation of these results as compared with the calculated coefficients of variation of biochemical determinations; the data indicate that a basal vocal hum frequency can be repeatedly established with accuracy comparable to that obtainable for biochemical determinations.

The coefficient of variation for hum