nine Purkinje cells during waking (Fig. 3 and Table 1), it was found that the number of secondary waves was entirely independent of the immediately preceding activity of the SS. This observation is inconsistent with the hypothesis of Eccles *et al.* (*2, 9*) that the number of secondary waves reflects the level of Purkinje cell excitability, and suggests a more important role of presynaptic factors (*10*) in determining the number of secondary spikes occurring in each CS.

Marchesi and Strata (*11*) recently reported the observation of Purkinje cell activity in the intact cat in relation to sleep and waking. Changes found in SS activity in S-REM in the present study are essentially the same as their report for the cat, and are also consistent with other reports on several other parts of the central nervous system (*12*). It is of note that SS activity represents most of Purkinje cell activity and that the Purkinje cell is the first indentified inhibitory neuron (*13*) in the central nervous system in which the highest activity during S-REM has been observed.

As to the CS activity, however, there are some differences between the report of Marchesi and Strata in the cat and the present results in the monkey. Marchesi and Strata reported higher firing rates of CS during desynchronized sleep when the rapid eye movements were absent, and occasional lower firing rates when they were present in desynchronized sleep, than the rates during S-SW. In the present study it was not possible to find any relation between the firing rate of CS and the existence of phasic events such as the rapid eye movement or muscle twitch. Whether these different observations are due to a difference in the sleep patterns of different species or due to some other factors cannot be assessed at the present time.

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Improvement of Learning in the Aged by Modification of Autonomic Nervous System Activity

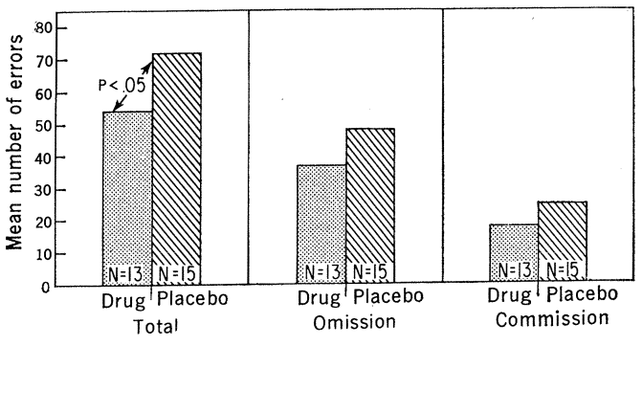
Abstract. *Partial blockade of beta-adrenergic end-organ response to the autonomic nervous system was effected in a group of older men by administration of propranolol. The result was improved performance in a learning task. The data support the hypothesis that the learning decrement found among older men is not simply a manifestation of structural change in the central nervous system but is, at least in part, associated with the heightened arousal of the autonomic nervous system that accompanies the learning task.*

Studies of verbal learning in older men have consistently demonstrated a prominent decrement in performance with advancing age, presumably indicative of a decline in a higher order cognitive functioning. Increasing evidence indicates, however, that such a decline cannot be attributed solely to the structural changes in the central nervous system that are known to accompany aging (*1*). Instead, differences in learning performance appear related, in part, to the failure of older persons to respond where rapid response is required. In situations where the pace of a learning task is slowed, the older person improves in performance significantly and responds relatively rapidly (*2–6*). Another age-related difference found in the learning situation is the more pronounced extent and persistence of plasma free fatty acid (FFA) mobilization among older subjects than among younger controls (*7*). It has been demonstrated that this age-related physiologic response is not simply a difference in ability to metabolize plasma FFA or to respond to infused catecholamine (*8*). Further, with plasma FFA mobilization again used as an indicator of autonomic arousal, evidence of a curvilinear relationship between autonomic activation and learning task performance was found (*4*). Therefore, it has been suggested that the heightened and prolonged autonomic arousal found during learning task performance in the older person is directly implicated in the tendency of older persons to commit more errors of omission, indicative of response suppression, in the rapidly paced learning situation (*9*).

Although the autonomic arousal found in conjunction with the learning task might merely reflect activation of the central nervous system associated with cognitive functioning, feedback from the peripheral manifestations of this arousal might, in itself, actively contribute to performance decrement. If this were the case in older persons, the masking of such autonomic effects should result in improvement in learning scores.

Propranolol (Inderal), by producing partial blockade of autonomic beta-adrenergic receptor sites in peripheral end organs, largely mitigates most physiologic concomitants of central nervous system arousal. Although small amounts of the drug might cross the "blood-brain barrier" (*10*), there is no evidence of resulting central nervous system activation or deactivation. With the use of this drug, it is therefore possible to test our hypothesis about the influence of autonomic arousal on learning in older persons. The impact of propranolol on learning performance could be interpreted as the effect of partial blockade of autonomic end-organ response. As a monitor of the drug effect, all subjects could be assessed for autonomic reactivity, with heart rate, plasma FFA level, and galvanic skin response serving as indices of physiologic arousal.

For this study the subjects were 28 paid male volunteers, 60 years of age or older (mean age, 68.6 years; range, 60



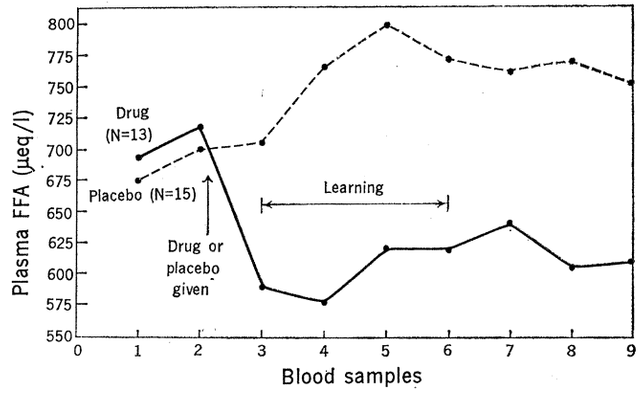


Fig. 1 (left). The mean number of errors on a verbal learning task among aged men while under the influence of either 10.0 mg intravenous propranolol hydrochloride (drug) or an equivalent amount of intravenous isotonic saline (placebo). Fig. 2 (right). Plasma free fatty acid (FFA) level among aged men exposed to a verbal learning task after having been given either 10.0 mg intravenous propranolol hydrochloride (drug) or an equivalent amount of intravenous isotonic saline (placebo).

to 78 years). Prospective subjects were told that the investigators were evaluating the effect of a drug on "blood chemistry" while they performed a "learning test"; they were also told to anticipate no subjective drug effect. Several days before the actual drug study, each subject was interviewed, received a physical examination, and was given a set of psychologic screening tests. Persons on long-term medication were excluded from the study group, as were individuals with a medical history or findings of emphysema, diabetes, or arteriosclerotic cardiovascular disease. At the time of the pretest interview, they were familiarized with the laboratory and its staff members. The physician who performed the physical examination during the screening visit also administered the drug in the subsequent experimental situation. Psychologic screening at this time included the Vocabulary and Digit Symbol subscales of the Wechsler Adult Intelligence Scale [WAIS (*11*)], the Taylor Manifest Anxiety Scale [an indicator of "state anxiety" (*12*)], and the Figure Embedment Scale [a test sensitive to change in cognition accompanying organic brain syndromes (*13*)]. Only individuals who attained a raw score in the range of 7 to 12 on the WAIS Vocabulary subscales were included as subjects. Subjects took no food from the midnight preceding the study to ensure maximum plasma FFA response. They reported to the laboratory at 8:30 a.m. and were seated in a comfortable chair within a sound-attenuated, air-conditioned chamber. Chest wall electrodes were affixed for continuous electrocardiographic recording and an indwelling venous catheter was placed in the right arm, under local anesthesia, for blood sampling and drug administration. Silver–silver chloride electrodes were placed on the palmar surface of the left index finger and over the triceps muscle mass of the left upper arm.

The experimental design called for the collection of two blood samples 15 minutes apart for baseline plasma FFA determination; then, on a random basis, subjects were given either an intravenous solution of 10.0 mg of intravenous propranolol hydrochloride or an equivalent amount of isotonic saline. Except for the foreknowledge of the physician injecting the solutions, the drug or saline was given in double blind fashion; the technical staff responsible for conducting the learning task were unaware of the nature of the injection. The learning task, described in detail elsewhere (*3*), requires the serial rote learning of a list of eight high association words. In this study, the words were projected in order on a screen for a 4-second exposure interval with a 1-second interval between words; there was a 45-second interval between each list of eight words. The first word was preceded by an asterisk. The subject was instructed to repeat the word immediately succeeding the one being projected. Each subject performed 15 of the eight-word trails. A third blood sample for FFA determination was collected immediately before the learning task began, and additional samples were taken after the 5th, 10th, and 15th learning trials. The final blood samples were collected 10 and 20 minutes after conclusion of the learning.

The drug and placebo groups each included 15 subjects. However, a subject preselection error was detected, with the resulting exclusion of two members of the drug group from the statistical analysis.

Heart rate was averaged for the 4th, 8th, and 12th minute after each blood sample was collected; these values afforded two sets of baseline heart rate levels, before intravenous infusion of propranolol or placebo. During the learning task, heart rate was determined over each of the eight-word trials and then averaged for each block of five trials. Change in galvanic skin response was evaluated by extent of deviation from basal level at the time heart rate was being monitored. Plasma FFA determinations were by the method of Dole (*14*) modified by Trout, Estes, and Friedberg (*15*).

Performance on the learning task was evaluated by the number of errors made during the testing. Total errors were further analyzed as either commission errors (inappropriate or incorrect responses) or omission errors (failures to respond). The learning data are depicted graphically in Fig. 1. The between-group difference for total errors was significant at the 0.05 level of confidence (t test for independent groups = 2.3, d.f. = 26). Fewer omission errors were committed among the drug group than among the control group, but the group difference was not significant ($t = 1.7$, d.f. = 26). Finally, the drug group also made fewer commission errors than did the placebo group; again the between-group difference was not statistically significant ($t = 1.6$, d.f. = 26).

Plasma FFA response during the learning task is presented in Fig. 2. After intravenous infusion, the drug group showed a decrease in FFA level, with only minimal rise during the learning task itself. Conversely, the control group FFA levels remained at a comparatively higher level and responded to the learning situation with an increased plasma FFA mobilization. This

divergent response, evaluated by the group-by-trial interaction term in a repeated measures analysis of variance design [2-by-9 Lindquist model (*16*)], was highly significant ($F = 31.6$, d.f. = 8/208, $P < .01$). Heart rate presents a similar response pattern. After the intravenous infusion, the heart rate of the drug group was consistently lower than that of the control group. The same statistical analysis that was applied to plasma FFA level showed the interaction term assessing the group difference in patterning of heart rate response to be highly significant ($F = 12.0$, d.f. = 7/175, $P < .01$). The difference in galvanic skin response between drug and placebo groups did not present overall statistical significance in the analysis of variance format; however, there was a consistent trend for galvanic skin response to be lower among subjects receiving propranolol. Finally, there was no between-group difference found in age or in the pretesting results of intellectual function; nor was there evidence of impaired cognitive function secondary to central nervous system structural change, or of "state anxiety." Therefore, the contrast in learning performance between the drug and control groups is not likely to stem from any obvious differences between the two groups. The data show that propranolol was effective in establishing at least a partial blockade of the beta-adrenergic receptors as measured by heart rate, plasma FFA mobilization, and galvanic skin response. In this situation, the effect upon learning in older men was significant. Subjects receiving the drug performed better than those receiving the placebo. Moreover, the autonomic response patterns within the placebo group are similar to those reported in an earlier study (*7*), which employed the identical learning task but without intravenous infusion. This similarity of response would indicate that the impact on the subjects of receiving an intravenous infusion did not bias patterns of autonomic arousal in the learning task situation. However, the learning performance of both the drug and placebo groups in this study was markedly superior to that found in previous studies (*2–4, 7, 9*), where the same technique was used but without drug or placebo. The importance of placebo effect on this learning task, particularly in relation to the instructions given, is worthy of note.

The findings from this study are significant in two respects: first, they confirm the contention that learning in older persons can be improved by pharmacologic modification of autonomic nervous system state. Second, and perhaps more important, these findings support the hypothesis that a state of heightened rather than depressed autonomic end-organ arousal is responsible for the decrement of learning performance found in older age groups.

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Intellectual Development of Children from Interracial Matings

Abstract. *Interracial offspring of white mothers obtained significantly higher IQ scores at 4 years of age than interracial offspring of Negro mothers, suggesting that environmental factors play an important role in the lower intellectual performance of Negro children.*

If racial differences in intelligence test performance are determined by additive genetic factors which are not sex-linked, then test scores for children of interracial crosses might be independent of maternal race. But if test differences between races are largely environmental in origin, the mothers' race should have an effect on children's performance since she is the primary socializing agent during the preschool years (*1*). In our analysis we assume (in the absence of data) that the mean intelligence of the parents does not differ with either maternal or paternal race combination.

Dichotomous assignment of individuals to either the Negro or white group is inaccurate and suspect on both genetic and social grounds because American Negroes share approximately 21 percent of their genes with non-Negroes (*2*) and because 70 percent of a sample of American Negroes has reported a white ancestor (*3*). Nevertheless, such designations have proven useful in providing insights concerning the occurrence of many biological and social phenomena (*4*).

The Collaborative Study of Cerebral Palsy, Mental Retardation, and other Neurological and Sensory Disorders of Infancy and Childhood provides data which may be useful in disentangling some of the genetic and environmental interactions. This study is currently following the children born to approximately 42,000 women who registered during pregnancy in 12 institutions throughout the United States (*5*). These children are routinely given standardized neurological and psychological examinations at various intervals during the first 8 years of life.

Among the information collected before birth of a child is the race and schooling of the father and the race, schooling, and marital status of the mother. The degree of underreporting of fathers of a different race probably depends on the mother's race; white women would tend to report that the father was Negro because it would become obvious at birth; Negro mothers might not report a white mate because light skin is common in Negro infants.

The frequency of interracial mating (disregarding marital status) in the Collaborative Study is approximately 0.38 percent. This should not be taken to be indicative of the rate for the United States since the current sample is approximately 50 percent Negro and is drawn from urban hospital registrants rather than from less-biased census data.