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.

CARL EISDORFER
JOHN NOWLIN, FRANCES WILKIE
Center for the Study of Aging and Human Development, Duke University Medical Center, Durham, North Carolina 27706

References and Notes

1. C. Eisdorfer, *Gerontologist* **10**, 5 (1970).
2. ———, S. Axelrod, F. Wilkie, *J. Abnorm. Soc. Psychol.* **67**, 594 (1963).
3. C. Eisdorfer, *J. Genet. Psychol.* **107**, 15 (1965).
4. W. Troyer, C. Eisdorfer, F. Wilkie, M. Bogdonoff, *J. Gerontol.* **21**, 415 (1966).
5. R. Canestrari, *ibid.* **18**, 165 (1963).
6. D. Arenberg, *J. Abnorm. Psychol.* **70**, 419 (1965).
7. A. Powell, C. Eisdorfer, M. Bogdonoff, *Arch. Gen. Psychiat.* **10**, 192 (1964).
8. C. Eisdorfer, A. Powell, Jr., G. Silverman, M. Bogdonoff, *J. Gerontol.* **20**, 511 (1965).
9. C. Eisdorfer, in *Human Aging and Behavior*, G. Talland, Ed. (Academic Press, New York, 1968), pp. 189–216.
10. J. Black, W. Duncan, R. Shanks, *Brit. J. Pharmacol. Chemother.* **25**, 577 (1965).
11. D. Wechsler, *The Measurement and Appraisal of Adult Intelligence* (Williams & Wilkins, Baltimore, ed. 4, 1958).
12. J. Taylor, *J. Abnorm. Soc. Psychol.* **48**, 285 (1953).
13. L. L. Thurstone, *A Factorial Study of Perception* (Univ. of Chicago Press, Chicago, 1944).
14. V. Dole, *J. Clin. Invest.* **35**, 150 (1956).
15. D. Trout, E. Estes, S. Friedberg, *J. Lipid Res.* **1**, 199 (1960).
16. E. Lindquist, *Design and Analysis of Experiments in Psychology and Education* (Houghton Mifflin, Boston, 1953).
17. Supported by Public Health Service Research grant HD-00668 from the National Institute of Child Health and Human Development. Propranolol hydrochloride (Inderal) was supplied without charge by the Ayerst Laboratories, New York, N.Y.

25 September 1970

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.

Table 1. Characteristics of samples of interracial matings by race of mother. Results are mean ± standard deviation. Numbers in parentheses are the number of subjects.

Maternal education (years)	Paternal education (years)	Weight of child at birth (g)	Length of child at birth (cm)	Gestation (weeks)
		White mother		
10.9 ± 2.2 (61)	11.5 ± 2.3 (46)	3207 ± 573 (60)	49.8 ± 2.6 (59)	40.1 ± 2.5 (61)
		Negro mother		
11.0 ± 2.5 (27)	11.0 ± 2.5 (21)	3228 ± 567 (27)	50.1 ± 2.5 (27)	40.2 ± 2.6 (26)

Of the 186 liveborn offspring of interracial matings identified in the Collaborative Study only 88 had reached the age of 4 years and were tested with the Stanford-Binet, abbreviated Form L-M (*6*), at the time this study was undertaken. The IQ's come from only 10 of the 12 collaborating institutions since the two southernmost ones (Charity Hospital, New Orleans, and University of Tennessee) provided no cases. The IQ's were obtained routinely during the course of regularly scheduled testing for all children in the Collaborative Study.

In another study (*7*) the mean IQ for control children from uniracial matings matched for hospital of birth and socioeconomic and marital status to the present sample was 104.3 for the children of white matings and 97.4 for the children of Negro matings. The mean IQ for the present sample is 98.7.

The children were also measured and weighed at birth, and their gestational ages were calculated from the mothers' report of her last menstrual period. Interracial matings involved 61 white and 27 Negro mothers; 38 of the children were male and 50 female.

Table 1 shows comparative statistics of available data on maternal education, paternal education, birth weight, birth length, and duration of gestation by race of the mother of the interracial child. As judged by *t*-tests, none of the differences approach statistical significance, and there is, in particular, no suggestion that intrauterine experience or parental education favors the child of a white mother. However, it would be premature to exclude from further consideration differential infection rates or nutritional differences. Because of these close similarities, adjustment for the above variables in the statistical analysis of IQ differences is unnecessary.

Mean education of all white mothers in the Collaborative Study whose 4-year-old children were given the IQ test is 11.1 years, as compared to 10.9 years for the white mothers in Table 1. The 10.4 years for all Negroes in the Collaborative Study whose children were tested at 4 years of age is somewhat lower than the 11.0 years in Table 1 for Negro mothers (*8*). Comparative figures are not available for paternal education.

In the interracial sample 36 percent of the white mothers and 26 percent of the Negro mothers were unmarried at the time of registration. Comparative figures for the entire Collaborative Study are 12 and 23, respectively. Thus, in the present sample, interracial whites have a lower frequency of marriage and Negroes have a higher frequency.

In assessing the postnatal effect of the race of the mother on the IQ of the 4-year-old child it seemed desirable to take into account the marital status of the mother and the sex of the baby since both these factors have been reported as being of importance (*9, 10*). The data showing the three-way combinations of maternal race, sex, and marital status in Table 2 were analyzed from two approaches. The first involved entering the data into a computer program that performed a three-way analysis of variance with least squares adjustments for disproportionality in sample sizes. Statistical interactions were not significant in this analysis and the significant main effects ($F = 4.2$ for 3 and 80 d.f.; $P = .008$) have additive interpretations.

The first member of each dichotomy, Negro or white mother, male or female child, and married or unmarried marital status, was assigned a score of zero and the second member a score of one. Application of regression procedures yielded the following slopes and standard errors for the main effects: 8.36 ± 3.75 IQ points for race, 8.14 ± 3.52 for sex, and 8.30 ± 3.73 for marital status. If the ratio of each coefficient to its standard error is treated as having a *t* distribution, all are significant in the 5 to 1 percent range.

However, the interaction between marital status and the mothers' race may be considerable, with marital status resulting in bigger differences among the children of Negro mothers. The maternal race–marital status effect is 13.6 ± 8.4 and, though not statistically significant, is so sizable that it merits further analysis. Similarly, the sex effect seems larger among the children of Negro mothers. In this case the slope is 14.1 ± 7.7, again not statistically significant, but sufficiently large to deserve continued study, especially since the failure to observe statistically significant interactions on these variables is very likely due to small cell sizes.

The data were therefore partitioned in a manner which focused on the two-way interactions, first ignoring sex (Table 3), then ignoring marital status (Table 4). The results indicate that if sex is ignored, maternal race is significant only among the children of unmarried mothers ($P < .05$), and that among Negro mothers it is the children of the unmarried with the low IQ's ($P < .05$). Alternatively, if marital status is ignored, maternal race is significant only among males ($P < .05$), and among Negro mothers, it is the male children who have the low IQ's ($P < .05$). Therefore, the male children of unmarried Negro mothers have the lowest IQ's. Among white mothers,

Table 2. The IQ scores of 4-year-old children categorized by race of mother, sex of child, and marital status. Married implies either legal or common law; unmarried implies single, divorced, separated, or widowed. Results are the mean ± standard deviation. The numbers in parentheses are the numbers for each sample.

Race of mother	Sex of child	Marital status	IQ scores
White	Male	Unmarried	94.7 ± 12.1 (7)
White	Male	Married	100.8 ± 18.3 (20)
White	Female	Unmarried	100.3 ± 15.7 (15)
White	Female	Married	103.8 ± 18.0 (19)
Mean			100.9 ± 16.8 (61)
Negro	Male	Unmarried	67.5 ± 23.3 (2)
Negro	Male	Married	88.4 ± 11.0 (9)
Negro	Female	Unmarried	88.6 ± 13.7 (5)
Negro	Female	Married	105.1 ± 14.1 (11)
Mean			93.7 ± 16.9 (27)
Mean of all			98.7 ± 16.8 (88)

Table 3. The IQ scores of 4-year-old children categorized by race and marital status of mother (see Table 2).

Race of mother	Marital status	IQ scores
White	Unmarried	98.5 ± 14.7 (22)
White	Married	102.3 ± 18.2 (39)
Negro	Unmarried	82.6 ± 16.1 (7)
Negro	Married	97.6 ± 12.8 (20)

Table 4. The IQ scores of 4-year-old children categorized by race of mother and sex of child (see Table 2).

Race of mother	Sex of child	IQ scores
White	Male	99.2 ± 17.0 (27)
White	Female	102.3 ± 17.0 (34)
Negro	Male	84.6 ± 12.9 (11)
Negro	Female	99.9 ± 14.0 (16)

the effects of marital status and sex are less, though always consistent with the findings for the children of Negro mothers.

Interpretation of the race effect should be tentative since the number of interracial subjects is small. The evidence presented here suggests that environmental factors may play an important role in the lower intellectual performance of Negro preschool children.

Despite no observed differences in mean educational attainment by race of mother, it is possible that child-rearing practices vary between the two groups. Racial differences in dialect usage would tend to militate against the children of Negro mothers on IQ tests, for example. Performance on intelligence and achievement tests might also reveal differences in favor of the white mothers.

The significant sex effect on IQ in favor of females has been reported before the Collaborative Study data (*10*) and is only one of many cognitive tasks which show females superior to males. Tasks involving relatively simple perceptual motor skills, such as speed of naming colors, reading, typing, and coding speed, all show female superiority (*11*). However, tasks requiring restructuring of the stimulus field, such as finding a simple pattern embedded in a more complex one, have shown consistent sex differences in favor of males (*11*). It was suggested that sex differences on cognitive tasks may be more adequately explained by physiological differences rather than by child-rearing differences between the sexes. Recent research suggesting a specific perceptual deficit associated with the absence or abnormality of one X chromosome in patients with Turner's syndrome is consistent with that hypothesis (*12*).

The association of single marital status with lower IQ performance has been documented before with interpretation based on increased disorganization in one-parent families (*9*). Since females tend to do most of the child-rearing during the early years even in two-parent families, the relationship remains to be clarified. Lewis (*13*) pointed out that negative effects on children associated with one-parent families tend to diminish when socioeconomic status is controlled. If maternal education can be taken as an index of socioeconomic status, the unmarried group differs only slightly from the mean for the entire sample given in Table 1 [white mothers, 10.5 years ($n = 22$); Negro mothers, 11.3 years ($n = 7$)]. Since the designation of marital status is assigned during pregnancy and there is no information available on whether the postnatal years of the child did in fact agree with this original designation, no firm conclusions can be drawn.

LEE WILLERMAN*
ALFRED F. NAYLOR
NTINOS C. MYRIANTHOPOULOS
Perinatal Research Branch,
National Institute of Neurological
Diseases and Stroke,
Bethesda, Maryland 20014

References and Notes

1. H. Simmons and P. Schoggen, in *The Stream of Behavior*, R. G. Barker, Ed. (Appleton-Century-Crofts, New York, 1963), p. 70.
2. T. E. Reed, *Science* **165**, 762 (1969).
3. M. J. Herskovits, *Pediat. Semin.* **33**, 30 (1926).
4. A. Damon, *Soc. Biol.* **16**, 69 (1969).
5. H. W. Berendes, in *Research Methodology and Needs in Perinatal Studies*, S. S. Chipman, A. M. Lilienfeld, B. G. Greenberg, J. F. Donnelly, Eds. (Thomas, Springfield, Ill., 1966), p. 118. The Collaborative Study, supported by the National Institute of Neurological Diseases and Stroke, has the following participants: Boston Lying-in Hospital; Brown University; Charity Hospital, New Orleans; Children's Hospital of Buffalo; Children's Hospital of Philadelphia; Children's Medical Center, Boston; Columbia University; Johns Hopkins University; Medical College of Virginia; New York Medical College; Pennsylvania Hospital; University of Minnesota; University of Oregon; University of Tennessee; Yale University; and the Perinatal Research Branch, NINDS.
6. L. M. Terman and M. A. Merrill, *Stanford-Binet Intelligence Scale* (Houghton Mifflin, Boston, 1960).
7. L. Willerman, A. F. Naylor, N. C. Myrianthopoulos, J. A. Churchill, unpublished data.
8. S. H. Broman, J. Khanna, J. Weber, in preparation.
9. M. Deutsch and B. Brown, *J. Soc. Issues* **XX**, 24 (1964).
10. J. E. Singer, M. Westphal, K. R. Niswander, *Child Devel.* **39**, 103 (196→ L. Willerman, S. H. Broman, M. Fiedler, *ibid.* **41**, 69 (1970).
11. B. M. Broverman, E. L. Klaiber, Y. Kabayashi, W. Vogel, *Psychol. Rev.* **75**, 23 (1968).
12. J. Money, *J. Psychiat. Res.* **2**, 223 (1964).
13. H. Lewis, in *The Moynihan Report and the Politics of Controversy*, L. E. Rainwater and W. L. Yancey, Eds. (M.I.T. Press, Cambridge, Mass., 1967), p. 314.

* Present address: Department of Human Genetics, University of Michigan, 1137 E. Catherine Street, Ann Arbor 48104.

10 August 1970; revised 2 October 1970

Stromatolites Used to Determine the Time of Nearest Approach of Earth and Moon

In recent articles (*1*, *2*) and discussion (*3*, *4*) in *Science*, the use of fossil stromatolites to determine the time of closest approach of the moon to the earth has been considered. Cloud (*1*) interpreted his stromatolite data as consistent with the view that this time was about 3500 million years ago, a time that he favored for other reasons. Alfvén and Arrhenius (*2*) interpreted the same data as indicating the latest Precambrian (600 to 700 million years ago) as the time of closest approach. These interpretations are based on the belief that, although some presently growing stromatolites are subtidal (*5*), "stromatolites that rise conspicuously above the surface on which they grow have so far been found only in the intertidal environment," and, furthermore, that their maximum growth relief equals the tidal amplitude (*1*). This, in turn, follows from Logan's interpretation (*6*) of modern stromatolites in Shark Bay, Western Australia.

Figures quoted by Cloud are interpreted by him as showing that domal Precambrian stromatolites, and especially those older than 1000 million years, had a greater growth relief than younger forms. This, he concludes, is consistent with the hypothesis of moon capture and closest approach during the Early Precambrian. The largest stromatolites mentioned by Cloud are 6 m high and occur in the Otavi "Series" in southwestern Africa. Cloud gives the age of these only as Proterozoic, but they probably are latest Precambrian (*7*); this is one reason why Alfvén and Arrhenius (*2*) think that Cloud's stromatolite data fit meteorite evidence suggesting to them that closest approach of the earth and moon was about 600 to 700 million years ago. Alfvén and Arrhenius state (*2*) that