Table 2. Assortative mating coefficients for unwed and wed couples. Pearson product-moment correlations were computed for all variables except hair color, eye color, bone structure, facial shape, and skin complexion. Gamma was computed for these nominal variables, and their significance was evaluated with chi square. Assortative mating by unwed parents in our sample is largely independent of temporal factors. When we partialed out the year of the adopted child's birth from r, the coefficients never changed by more than .02. When age of the unwed couples was also partialed out, the coefficients were still within .05 of those reported in the table. Abbreviation: N, number of couples.

Variables	Unwed couples		Wed couples (*5*)	
	Coefficient	N	Coefficient	N
Physical				
Age	.70*	658	.86*	797
Height	.21*	660	.23*	799
Weight	.14*	606	.12*	797
Hair color	.10*	660		
Eye color	.17*	644	.10*	797
Bone structure	.09	384		
Facial shape	.30*	197		
Skin complexion	.34*	628		
Behavioral				
Education	.23*	646	.46*	795
Midparent education†	.05	239	.31*	764
High school grade average	.26*	183		
Occupational NORC rating (*11*)	.15*	373	.25*	212
Father's NORC rating†	.18*	378		
Musical ability	.23*	413		
Athletic ability	.33*	418		

*$P < .01$. †Refers to the biological grandparents of the adopted child.

mean coefficients for United States samples were .76 for age, .23 for height, and .20 for weight, none of which differs significantly from those we report. However, with respect to the behavioral variables for which there are comparison data, the assortative mating coefficients of unwed parents are lower than those of wed couples. The difference is significant ($P < .01$) (*6*) for the two education variables but not for occupational rating. This difference is not due to restriction of range; in fact, the variances are slightly greater for unwed than wed parents (*7*).

Assortative mating coefficients may vary considerably in smaller samples. We computed mate correlations for the two adoption studies for which raw data on unwed parents have been published. In the classic study by Skodak and Skeels (*8*), the correlation for education level was .62 for the 59 unwed couples for whom data were recorded. However, our analysis of Munsinger's (*9*) data showed little assortative mating by the study's 41 unwed couples for a social-education index ($r = .17$).

Two conclusions can be drawn from analyses of the large data set in our study. (i) Assortative mating occurs among unwed couples whose children are relinquished for adoption; and (ii) Correlations are similar to those of wed couples for physical, but perhaps not for behavioral, characters. Together, these conclusions suggest that future adoption studies should collect information on both biological parents so that genetic parameters may be estimated by regressing scores of adopted offspring on midparent values. Unlike correlations between parent and child, the regression of offspring on midparent scores is not a mathematical function of the mate correlation (*10*).

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References and Notes

1. See, for example, critics of behavioral genetics such as R. Lewontin [*Annu. Rev. Genet.* **9**, 387 (1975)].
2. If t is the correlation between the mates' phenotypes and h^2 is heritability in the narrow sense, then the correlation between single parents and offspring in an adoption study is ½ h^2 $(1 + t)$. Thus, the single parent–single offspring correlation will inflate heritability estimates by a factor of $(1 + t)$. A review of assortative mating for IQ provided a mean estimate for t of approximately .4 [J. N. Spuhler, in *Genetic Diversity and Human Behavior*, J. N. Spuhler, Ed. (Aldine, Chicago, 1967)].
3. J. N. Spuhler, *Eugen. Q.* **15**, 128 (1968); S. G. Vandenberg, *Behav. Genet.* **2**, 127 (1972).
4. Correlations were calculated separately for the 131 couples in which the father was actually interviewed. These correlations differed in no important respect from those obtained for the total sample.
5. J. C. DeFries, G. C. Ashton, R. C. Johnson, A. R. Kuse, G. E. McClearn, M. P. Mi, M. N. Rashad, S. G. Vandenberg, J. R. Wilson, *Nature (London)* **261**, 131 (1976). The coefficients for these Caucasian parents have not been published before.
6. G. W. Snedecor and W. G. Cochran, *Statistical Methods* (Iowa State Univ. Press, Ames, ed. 6, 1967), pp. 186–187.
7. We also considered other possible biases. For example, it might be hypothesized that the unwed parent correlations are lower for behavioral characters because information regarding such measures is less accurate. However, it seems unlikely that education and occupation are less accurately reported than variables such as age, height, and weight. Another possible problem concerns ascertaining paternity of the child. The fact that the assortative mating coefficients for physical characteristics are so similar for unwed and wed couples suggests that this is not a serious bias.
8. M. Skodak and H. M. Skeels, *J. Genet. Psychol.* **75**, 85 (1949).
9. H. Munsinger, *Behav. Genet.* **5**, 239 (1975).
10. The regression (b) of adopted offspring on unwed midparent scores ($b_{P_oP_m}$) yields an estimate of heritability (h^2) which is not a mathematical function of $(1 + t)$. Where P_o and P_m are the phenotypes of the offspring and midparents,
$$b_{P_oP_m} = Cov_{P_oP_m}/V_{P_m}$$
(Cov is the covariance and V is the variance.)
$$Cov_{P_oP_m} = \tfrac{1}{2} V_A(1 + t)$$
Where V_A is the additive genetic variance, and
$$V_{P_m} = \tfrac{1}{2} V_P(1 + t)$$
thus,
$$b_{P_oP_m} = V_A/V_P = h^2$$
11. The NORC occupational rating is an empirically derived evaluation of job status developed by O. D. Duncan for the National Opinion Research Center [A. J. Reiss, O. D. Duncan, P. K. Hatt, C. C. North, *Occupations and Social Status* (Free Press, Glencoe, Ill., 1961)]. Assortative mating coefficients were computed only for those couples in which both members were employed.
12. Supported by grants from the University of Colorado's Biomedical Research Grant, the Grant Foundation, and the National Institute of Mental Health (MH-28076).

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Vibrotactile Pattern Perception: Extraordinary Observers

Abstract. *Two sighted people showed a remarkable ability to perceive vibrotactile patterns generated by the Optacon, a reading aid for the blind. These individuals were able to read at very high rates, 70 to 100 words per minute, through their fingertips. Additional testing showed them to be much better than other people at discriminating and recognizing vibrotactile patterns.*

While participating in experiments testing the ability of observers (O's) to identify vibrotactile patterns presented to their fingertips, two O's demonstrated an extraordinary talent for perceiving these patterns. The two were among a number of sighted O's who were tested on vibrotactile patterns generated by letters of the alphabet. They seemed to warrant the adjective "extraordinary" because they were able to discriminate between pairs of patterns when other O's could not, because they could readily recognize patterns when other O's could not, and because they could read at high rates through their fingertips when other O's could not.

The device used to generate the vibrotactile patterns is the Optacon (*1*), a reading aid for the blind that converts printed material to patterns of vibration presented to the user's fingertip. The Optacon consists of a camera containing a 6-column by 24-row array of photosensitive elements connected to a small, 6 by 24 array of tactile pins (*2*). A letter passing beneath the camera causes a pattern of vibration corresponding to the letter to be generated on the tactile array. The user places his or her index finger on the tactile array and feels the pattern of vibration move across the array as the camera is moved. The camera "sees" an area approximately the width of a single letter. After a formal 50-hour training period with the Optacon, blind users can read approximately 20 words per minute. After a year or two of experience, 85 percent of blind users surveyed reported they could read at rates between 30 and 60 words per minute (*3*).

To date, nearly 2000 blind people use the Optacon. Of this number, only one has been reported to have achieved reading rates as high as those of the extraordinary O's (EO's) (*3, 4*). This blind user required considerable training to reach high rates. After 45 hours of practice, she was reading at a rate of 30 words per minute (*5*). Of sighted O's, I know of only one person, in addition to the EO's, who can read with the Optacon. He can read at a rate of about 15 words per minute.

The two EO's were undergraduate women at Indiana University. One of them, J.L., had 16 hours of experience on a vibrotactile discrimination task and 1 hour of experience on a recognition task before being tested on reading material (*6*). At the end of the first hour of testing on reading material, J.L. was reading at 60 words per minute. After several hours of experience, she was reading at 70 to 80 words per minute with 100 percent comprehension. The second, V.B., had 20 hours of experience on a discrimination task and 10.5 hours of experience on a recognition task; she showed even more rapid progress than J.L. did, reading at 90 words per minute within 2 hours of the start of reading training. Within another hour of experience, she was reading at 100 words per minute with 100 percent comprehension. By contrast, the normal O's (NO's) in the laboratory who had similar experience with the discrimination and recognition tasks were able to pick out only short words such as "the" and "and"; these were read at 10 words per minute.

Additional measurements showed that the ability of the two EO's extended to other tactile pattern-perception tasks. For one set of measurements, O's were asked to discriminate between pairs of trigrams, for example, EVR followed by EHR. The trigrams were composed of randomly selected uppercase letters of the alphabet. The O's task was to say whether the second pattern was the same as or different from the first pattern. In half of the pairs, the patterns were identical; in half they differed by a single letter. Display time, the time it takes a particular point on a letter to pass across the tactile array, was varied (*7*). In a second set of discrimination measurements, pairs of patterns consisting of six letters each (hexagrams) were presented to the O's. Not only are the EO's clearly superior to the NO's (chance is 50 percent) at both discrimination tasks, but also the EO's showed almost no change in their performances as a function of display time (Fig. 1).

In other experiments, the ability of O's to recognize letters in the presence of masking stimuli was measured. The O's were asked to identify randomly selected letters of the alphabet. These target letters were presented singly and in the presence of additional, masking stimuli. The masking stimuli were presented either just before the target letter (forward masking), just after the target letter (backward masking), or both before and after the target letter (double). The masking stimuli were black rectangles the same size as the letter "H" (*8*).

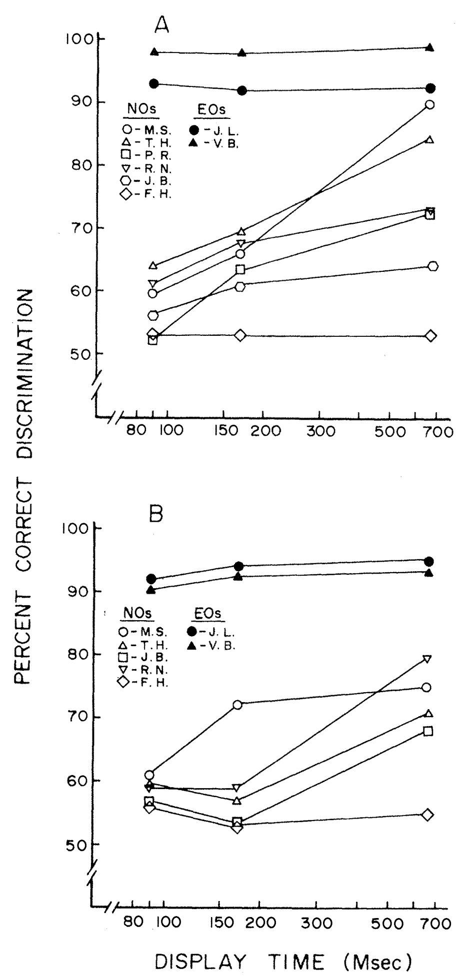

Fig. 1. Accuracy of discrimination as a function of display time. The data from normal observers (*NOs*) and extraordinary observers (*EOs*) are presented. (A) Data from pairs of trigrams (three letters each). (B) Data from pairs of hexagrams (six letters each).

In a number of different experiments, the EO's showed much less masking than the NO's did. In one experiment, for example, across the four conditions of masking (none, forward, backward, and double) J.L.'s percentages correct were 98, 100, 98, and 95, respectively. In contrast, across the same conditions, the mean responses of the NO's were 83, 74, 56, and 43 percent. In a second experiment, in which lowercase letters were the targets, J.L.'s percentages correct across the four conditions were 96, 92, 92, and 88. The mean percentages correct for the NO's across the same conditions were only 47, 29, 20, and 14. The results from the second EO showed a similar relative lack of masking.

Given the correlation between the ability of the EO's to read and their performance in the presence of masking stimuli, it might be expected that Optacon users would show similar performances in the presence of masking stimuli. To test this possibility, several blind users of Optacons were tested on the letter recognition and masking task. The blind users could read with the Optacon at rates between 15 and 40 words per minute. Unlike the EO's, both the blind O's and the NO's show considerable masking (Fig. 2). The difference in accuracy between the no-mask and double-mask conditions for the blind O's and the NO's is about 40 percent; the difference for the EO's is less than 8 percent.

The EO's superior tactile ability does not seem limited to their fingertips. A series of eight patterns was presented to their abdomens by means of the kinotact (*9*), a device similar to the tactile vision substitution system (*10*). The kinotact generates patterns of vibration on a 10 by 10 array of vibrators. Each pattern in the series consisted of a square with a different design inside the square. The patterns were designed to force O's to use internal detail to identify each pattern. On the basis of other results (*9–11*), one would predict that the O's would have difficulty identifying these patterns, and they do. Three NO's who had had several months of experience on letter recognition tasks on the abdomen were each tested for 240 trials. The NO's were correct on only 34 percent of the trials. In contrast, the two EO's, who had had no

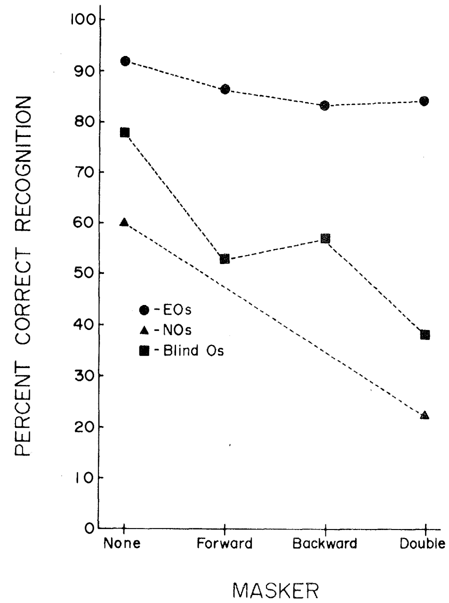

Fig. 2. Mean percentage correct letter recognition as a function of the nature of the masking stimulus.

previous experience on the kinotact, were performing with nearly 100 percent accuracy at the end of 15 trials (*12*).

One indication that the ability of the EO's to read is not the result of some superior general cognitive ability comes from some visual pattern-recognition measurements. In one experiment, both EO's and NO's viewed the visual monitor of the Optacon. The monitor, which consists of a 6 by 24 array of light-emitting diodes, shows which pins on the tactile array are turned on. As the camera of the Optacon is moved across printed material, the same material passes across the screen of the monitor, producing an effect similar to that of the Times Square news display. The limited field of view, one letter, prevents rapid reading. As the camera was passed slowly across the printed material, both EO's and NO's could read the material visually. As the camera was moved more rapidly and display times became shorter than approximately 120 msec, both EO's and NO's began to make errors in reading, a result in agreement with a similar experiment performed by Taenzer (*13*). Neither of the two EO's performed better than the three NO's tested. At display times shorter than 90 msec, the accuracy of the NO's had dropped to 92 percent, whereas J.L.'s score was 82 percent. The accuracy of V.B. dropped to less than 18 percent. For those accustomed to categorizing the skin as one of the "minor senses," there is the unusual phenomenon of V.B.'s being presented identical information through two different displays—one visual, one tactile—and being able to read the tactile display at rates higher than those at which she could read the visual display.

A number of other measurements of basic tactile sensitivity have not revealed differences that would seem to account for the tactile pattern perception performance of the EO's. Measurements of vibrotactile thresholds on the fingertip showed one EO to be somewhat more sensitive than the NO's tested and the other EO to be slightly less sensitive. Both EO's showed masking as measured by changes in detectability of vibrotactile signals, although in amounts somewhat less than the NO's showed. Both EO's showed spatial summation on the skin and attenuation of spatial summation in the presence of masking stimuli similar to those of NO's (*14*). Measurements of temporal order for tactile stimuli (*15*) showed one EO to have a relatively small threshold for temporal order and one to have a relatively large threshold. Whatever the ability or abilities of these EO's that may underlie their extraordinary tactile performances, they are not revealed by these kinds of psychophysical measurements. Moreover, we do not yet know whether the measurement of such abilities would prove useful in screening potential users of the Optacon or whether, in fact, such abilities can be trained.

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4. M. W. Moore and J. C. Bliss, *Educ. Visually Handicap.* **7**, 15 (1975). There have been informal reports of two additional blind users who read at high rates.
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6. The O's were blindfolded throughout all testing sessions. As the Optacon was used in these experiments, the camera was moved across the material to be read (or letters to be discriminated) at a controlled rate by an automatic page scanner. Before their reading with the Optacon, one of the two EO's, J.L., had a very brief exposure (less than an hour) to some vibrotactile lowercase letters. The other EO had no prior exposure to vibrotactile lowercase letters.
7. With reading material consisting of both uppercase and lowercase letters of the alphabet, a display time of 90 msec corresponds to a rate of approximately 92 words per minute; a display time of 170 msec, 46 words per minute; and a display time of 670 msec, 11 words per minute.
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16. Supported by NIH grant NS-09783.

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Monosodium Glutamate Administration to the Newborn Reduces Reproductive Ability in Female and Male Mice

Abstract. *Monosodium glutamate (MSG) administered during the neonatal period (days 2 to 11) resulted in a sequence of events that were manifested in adulthood. Reproductive dysfunction was seen in both female and male animals. Females treated with MSG had fewer pregnancies and smaller litters, while males treated with MSG showed reduced fertility. The MSG-treated mice showed increased body weight and decreased pituitary, thyroid, ovary, or testis weights.*

Monosodium glutamate (MSG) produces lesions in the brains of various mammals (*1–3*). This damage occurs primarily in structures contiguous with ventricular cerebral spinal fluid and is best demonstrated in the arcuate nucleus of the hypothalamus. Concomitant with this damage to the central nervous system (CNS), there are reports of a number of somatic and behavioral dysfunctions including stunted skeletal growth, obesity, abnormal activity levels, sterility in female mice, and learning deficits (*1, 4–6*). While several investigators have reported impaired reproductive capacity in MSG-treated mice (*1, 3, 7*), there are no systematic and quantitative reports of reproductive dysfunction after administration of MSG to the newborn. In contrast, several studies have reported failure to find reproductive deficits in rats treated with MSG during the neonatal period (*8, 9*).

We present evidence of reduced fertility in both male and female mice treated with MSG during the first 10 days after birth. Animals treated with MSG also show reduced endocrine gland weights at autopsy. These results along with our finding of delayed vaginal canalization