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19. Words were chosen by using the Battig-Montaque norms for frequency of association to a particular category.
20. E. Silbergelt, I. Kopin, and W. E. Bunney, Jr. gave helpful discussion of this study. Technical assistance was provided by D. McGreer, C. King, G. Schechter, R. Coppola, and C. L. Thompson.

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Newborn Minor Physical Anomalies Predict Short Attention Span, Peer Aggression, and Impulsivity at Age 3

Abstract. *From a 5- to 10-minute newborn examination, behaviors of males at age 3 could be predicted. The number of minor physical anomalies, assessed soon after birth, was significantly related to a cluster of behaviors that are frequently labeled hyperactivity.*

Hyperactivity is a label used for children who have short attention spans, behave aggressively toward peers, and are impulsive and restless (*1*). This behavioral syndrome is a major concern for teachers, parents, researchers, and, above all, for the children themselves. In our use of the word "hyperactive" we are not speaking about clinical populations, but of the upper range of a behavioral dimension that is normally distributed in a general population of young children. The cluster of behaviors making up this dimension, however, does include the same behaviors that are included in what is known as the "hyperactivity syndrome" in the literature referring to children in clinical treatment programs (*2*). The behaviors of children referred to clinics probably represent the most extreme end of this dimension.

As a set, the 17 minor physical anomalies used in this and previous studies are best known for their occurrence in Down's syndrome (*3*). Individual anomalies, however, are present in the general population with an average of two to four per person. It has been argued that the minor physical anomalies are developmental deviations that result from some form of genetic transmission, or from some insult in early pregnancy that mimics genetic transmission (*4*). The same factors producing deviation in the first weeks of pregnancy could influence the occurrence both of the anomalies and of some deviation in the development of that part of the central nervous system which is responsible for the hyperactive behaviors. The minor anomalies to which we refer are head circumference out of normal range, more than one hair whorl, fine electric hair, epicanthus, hypertelorism, malformed ears, low-set ears, asymmetrical ears, soft pliable ears, no ear lobes, high steepled palate, furrowed tongue, curved fifth finger, single palmar crease, wide gap between first and second toes, partial syndactalia of toes, and third toe longer than second (*5*).

In a sample of 74 normal preschool children attending a research nursery school, Waldrop *et al.* (*6*) found that hyperactive behaviors were related to the number of observed anomalies. Subsequent studies of boys, age 3 to 12, replicated this finding in another nursery school sample (*7*) and in three samples of elementary school boys (*8*). Waldrop and Halverson (*7*) demonstrated the stability of the anomaly score and of hyperactivity from age 2.5 to age 7.5 and found that anomalies at 2.5 predicted hyperactivity at 7.5. Within a clinic population of 81 hyperactive boys, a subgroup with high anomaly scores, when compared with a subgroup with low anomaly scores, had greater plasma dopamine β-hydroxylase activity, earlier age of onset of hyperactivity, more fathers with histories of hyperactivity, and more mothers who reported bleeding during the first trimester (*9*).

As a part of the Bethesda Longitudinal Study, National Institute of Mental Health, 30 male newborns were examined for the presence of 16 minor physical anomalies (fine electric hair was omitted from the list). Twenty-three of the 30 were seen 3 years later when they attended a research nursery school. An additional 36 boys were in the nursery school sample but had not been assessed for anomalies as newborns, thus making a total of 59 boys in the nursery school sample. Females were included in the larger longitudinal study, but because hyperactivity is far more prevalent among males than females (*10*), data on female subjects were not a part of this study. The anomaly score for each child at each age was the total count of anomalies plus, for some anomalies, extra weight when the anomaly was judged to be extreme (*5*).

The anomaly score was found to be stable between the newborn period and age 3. For the 23 males in this study, the correlation was .86.

At age 3 (± 3 months) the subjects attended a research nursery school for 4 weeks in mixed sex groups of five children. Observations and ratings were made of behavior in a playroom where the children were free to play with a variety of toys and in a room where there were no toys but the children were free to run about and interact (*11*).

Data analyses of nursery school behaviors (measuring short attention span, peer aggression, and impulsivity) involved the use of two factor analyses to derive a small number of composite scores. One was a factor analysis of 23 free play observations in the playroom; the other was a factor analysis of the 25 measures that correlated significantly with activity level as measured by a mechanical activity recorder (*12*). Principal component factoring and varimax rotation was used throughout. Each factor analysis was replicated on two randomly selected samples of the data. Only those variables with consistent factor loadings

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Table 1. Relation of minor physical anomalies and short attention span and peer aggression-impulsivity.

Nursery school behaviors at age 3	Correlations with minor anomalies assessed at			
	Newborn period (N = 23)		Age 3 (N = 59)	
	r	P	r	P
Short attention span (factor from free play observations)	.57	<.001	.35	<.01
Rating of play involvement	−.48	<.01	−.24	<.05
Rating of attention to story	−.43	<.05	−.30	<.01
Peer aggression and impulsivity (factor from correlates of a mechanical activity recorder)	.51	<.01	.32	<.01
Sum of two factors	.67	<.0005	.35	<.01

were then included in the final factor analyses (*13*).

There were 23 reliable observation variables coded during free play in the playroom. The following variables characterized the first factor, labeled short attention span: positive loadings (≥ .50) on number of play bouts, number of different play categories, time spent in gross motor activity, and time spent exploring (defined as spending less than 10 seconds focusing on any activity; if more than 10 seconds was spent at some activity it was coded a play bout); and a negative loading (< .50) on duration of play bout at the third quartile when lengths of play bouts were rank-ordered. Two daily ratings, made by the teachers and summed across 4 weeks, were also measures of attention span: play involvement and attention to story.

To index gross motor activity, all measures correlating significantly with data from a mechanical activity recorder (*12*) were factor-analyzed. The following variables had positive loadings (≥ .50) on the first factor, labeled peer aggression-impulsivity: counts of negative peer interactions in the room without toys, counts of negative peer interactions in the playroom, instigations of peer conflict in all settings (4-week sum of daily records), and ratings of negative peer interaction, induction of intervention, frenetic and impulsive behavior, assertiveness, and nomadic behavior (*14*).

Measures of short attention span were significantly related to minor physical anomalies assessed both at the newborn period and at age 3 (Table 1). The same results were true concerning measures of peer aggression and impulsivity. In order to obtain one score for hyperactivity, each child's scores on the two factors, short attention span and peer aggression-impulsivity, were summed. Correlation between the resulting composite score and the newborn anomaly score was 0.67. Thus, close to half the variance of the nursery school measure of hyperactivity was accounted for by its relation to newborn minor physical anomalies.

A small number of false positives is the critical element in prediction. This is especially true for investigators wishing to select infants at risk for hyperactivity for purposes of intervention. Scatterplots of standardized factor scores against standardized newborn anomaly scores showed that only one boy whose anomaly score was higher than the mean was lower than the mean on short attention span. Two boys with above average anomaly scores were lower than the mean on peer aggression-impulsivity. When both scatterplots were considered, no score fell in the false-positive quadrant beyond 0.5 standard deviation. In other words, there were very few false positives and none of these was extreme. There were, however, four false negatives for short attention span and five for peer aggression-impulsivity. This indicates that it was not unusual for boys who were seen as hyperactive to have had low newborn anomaly scores, but it was very unusual for boys with high newborn anomaly scores not to be seen as hyperactive at age 3.

A check was made to see if the low number of false positives held true for the larger sample seen at nursery school. Scatterplots using this sample (N = 59) showed that one child's score was in the extreme portion (> 1 standard deviation) of the false-positive quadrant on short attention span; none was in the extreme portion of the false-positive quadrant on peer aggression-impulsivity.

An important implication of this study is that an early anomaly assessment makes possible the early detection of some boys who are likely to exhibit hyperactive behaviors (defined as being inattentive, aggressive toward peers, impulsive, and motorically active) at the preschool age. Since hyperactivity at the preschool age has been found to be related to hyperactivity at the elementary school age (*7*), it would be reasonable to expect the newborn anomaly assessment to predict hyperactivity for boys at the elementary school age. This is yet to be done. The results of this study indicate there is a congenital contributor to some frequently occurring behavior problems in the general population of young boys. A subgroup of hyperactive boys whose behavior may have a congenital basis can be identified soon after birth with considerable accuracy.

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used in this study. Those for the assessment of anomalies ranged from .73 to .96.
12. Use of the mechanical activity recorder is described by R. Q. Bell [*J. Exp. Child Psychol.* **6**, 302 (1968)].
13. The nursery school sample was composed of children both with and without anomaly scores computed shortly after birth. When the nursery school sample with newborn anomaly scores was compared with the nursery school sample without such scores, there were no significant differences in the distributions of scores for the variables used in this study or in the magnitude of the correlations with the anomaly score.
14. A manual giving detailed definitions of all the variables is available upon request.

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Interaction of Critical Periods in the Visual Cortex of Kittens

Abstract. *The critical period for modifying the preferred direction in cat cortical units occurs earlier than that for monocular deprivation. The independence of the effects of these two types of deprivation from each other was tested by rearing six kittens with both reverse suture and reversed directional deprivation. The kittens were placed in a drum rotating in one direction with one eye open at ages 2½ to 5 weeks; the drum rotation was reversed and the other eye opened when they were 5 to 12 weeks old. Recordings were then made in the visual cortex. The results were the sum of the effects of reverse suture and reversal of directional deprivation: most cells were driven by the eye that was open second, and most unidirectional cells preferred the direction to which the animals were exposed first. Consequently, many unidirectional cells preferred the first direction but were driven by the eye open second—a combination that the animal never saw during rearing. There was also an effect of ocular deprivation on directional properties and vice versa: reverse suture reduced the overall percentage of unidirectional cells, just as directional deprivation has been shown to affect the ocular dominance histogram. This result suggests that the same cells may be affected by both forms of deprivation.*

The critical periods for different kinds of visual deprivation are not the same (*1*). In animals reared with only the left eye open until 8 to 10 weeks and only the right eye open after that, nearly all the cells in the visual cortex will be driven by the left eye, whereas reverse suture at an earlier age leads to a substantial number of cells driven by the right eye. Thus, the critical period for monocular deprivation in the kitten is largely over by 8 to 10 weeks (*2*). Similar experiments with directional deprivation (animals reared in a drum with vertical stripes continuously rotating around them to the left until a certain age, and subsequently to the right) show that the critical period for this kind of deprivation is largely over by 5 to 6 weeks. In fact, the critical periods are sufficiently different that in a monocularly deprived animal with reverse suture at 5 weeks, more than three-quarters of its cells will be dominated by the eye that was open second, whereas in a directionally deprived animal with reversal of direction at 5 weeks, twice as many cells will prefer movement in the direction seen first, as will prefer movement in the direction seen second (*1*).

We have now studied the interaction between two kinds of visual deprivation. We reared a group of kittens that were both monocularly and directionally deprived, with reversals at 5 weeks. The results were compared with those from (i) normal kittens, (ii) one previous group of animals that had experienced only reverse suture, and (iii) another group that was only directionally deprived. Two questions arise. (i) Are the results of reverse suture plus directional deprivation with reversal of direction simply the sum of the results of these two deprivations taken separately? (ii) Does reverse suture affect the properties of directionally sensitive cells, and does directional deprivation affect the ocular dominance histogram?

In order to discuss the possible outcomes of the experiment, let us consider a kitten that, until the age of 5 weeks, has only its left eye open and is exposed to a leftward-moving set of stripes. At 5 weeks, the right eye is opened and the left eye sutured shut; from then until 12 weeks, the kitten sees only a pattern of stripes moving to the right. When the kitten is not being exposed to the moving stripes it is in the dark. Our previous experiments on monocular deprivation with reverse suture suggest that the majority of the cells should be dominated by the right eye (which was open second), and the experiments on directional deprivation with reversal at 5 weeks suggest that the majority of cells with directional sensitivity would prefer movement to the left (the direction that the kitten was exposed to first) (*1*). This is the result one would expect if the effects of the two kinds of deprivation simply sum. In a kitten so treated, the majority of cells would be specific for leftward movement seen through the right eye—a combination that the kitten was never exposed to simultaneously during its rearing. On the other hand, if there is some interaction between the two types of deprivation, one would expect a different result.

We reared six kittens from three litters with such a double deprivation. In general, cells in the left cortex tend to be dominated by the right eye and prefer rightward movement (*1, 3, 4*); consequently, we reared kittens with all four possible combinations of deprivation (left eye, left direction first; left eye, right direction first; and so forth). The kittens were kept in the dark until they were 2½ weeks old, then one eye was sutured shut and they were exposed to moving stripes for 1 hour per day until they were 5 weeks old. After reverse suture at 5 weeks, they were exposed to drum movement in the opposite direction until 12 weeks. They were then kept in the dark until recordings were made. The total amount of visual experience was approximately 50 hours, which should be adequate to develop a normal cortex in the absence of any other kind of deprivation (*5*).

Since various combinations of left and right were used in the rearing, it was not necessary to record from both sides of the cortex, and all recordings were made in the left visual cortex. We did not know the circumstances of rearing until all the kittens in a litter had been studied, although we could usually guess which eye had been opened second. Precautions taken to avoid statistical artifacts from the columnar organization of the cortex were (i) long penetrations down the medial bank of the lateral gyrus and (ii) movement of the electrode for at least 150 μm after a cell was characterized before looking for another cell (*1, 6*). Other recording procedures have been described (*1*).

Cells were assigned to one of seven ocular dominance categories (*3*). On the basis of their responses to moving stimuli, they were also characterized as unidirectional, bidirectional, omnidirectional, or visually unresponsive (*1*); unidirectionality was defined by preference for a particular direction of movement, with little or no response for movement at 180° to this. We also noted the rate of spontaneous activity, preferred speed of movement, position of responses to leading and trailing edges of a bar, the extent of the receptive field plotted with stationary flashed spots, and the existence or

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