INFANT VISION

Babies grasp the world first with their eyes and then with their hands. Vision is therefore a prime constituent in the development of the total child

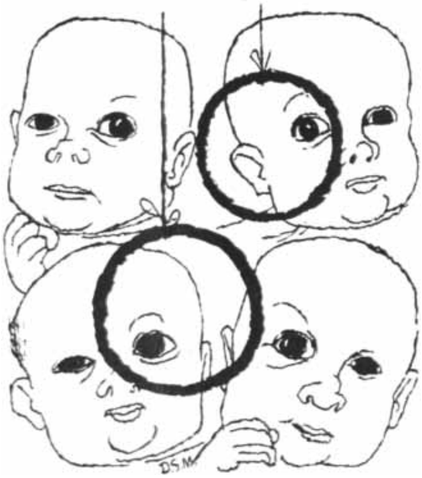
by Arnold Gesell

MAN is but a modified fish. Like the fish, he has a pair of eyes, and even his pair of hands is foreshadowed in the forward fins of the fish. But to understand the unique characteristics of human vision, we must at once emphasize the remarkable modifications in the vertebrate eye that have taken place since land animals began to evolve from the fish of ancient Devonian days.

The fish eye is equipped with a full set of extrinsic muscles—internal, external and oblique. They are amazingly like our own eye motor muscles in arrangement, but their function in the fish is extremely limited. They simply maintain a constant visual field so the fish may detect the movements that denote danger and food. The fish, not having a neck, turns its whole body in order to keep the object of interest within its very narrow binocular field; its eyes are gyroscopically stabilized. In a human being, on the other hand, the oculomotor muscles play an important role in complex mental acts of fixation, inspection and attention.

The fish's field of vision is narrow because it wears its eyes, as well as its ears, on the side. In the course of evolution the eyes of higher animals have moved forward to a frontal position. It has taken nature a few hundred million years to confer this particular advantage upon the human species. Our ears, however, remain in a lateral position, which places some limitations on the sense of hearing. It is interesting to speculate as to what would have happened to the architecture of the human mind if nature had placed the hearing receptors in our present eye sockets and compelled us to wear our eyes in the ancient lateral position. Such a transposition would have produced profound alterations, not only in the mechanisms of vision but also in the construction of the total action system of the body. For it is clear that the evolution of vision has been inseparably bound up with the evolution of the whole motor system, including the trunk, arms and legs. As the vertebrate eye, which originated in water, became adapted to new terrestrial and arboreal modes of life, other organs were modified with it. The sense of smell declined in importance; the sense of sight assumed increasing status. In due course the snout diminished; the neck became mobile; the forelimbs were freed for manipulation; and finally the human species acquired a pair of feet as arch platforms that enabled man to maintain an erect posture and to bestride the earth as a master of destiny, eyes front.

In Eocene times, about 50 million years ago, a prehuman primate, comparable to the modern *Tarsius spectrum,* sat upright and in feeding used its hands in a squirrel-like manner. Some seven million years ago a near-human being, *Plesianthropus,* came upon the scene. He walked erect, with frontal eyes under an arching forehead. Presumably the forelimbs of this creature, even though they did not flex freely at the elbow, were sufficiently mobile to release eyes and hands for another evolutionary advance which led to the utilization of tools.



FIRST LOOKS of the infant are monocular. He fixes one eye on an object and closes or relaxes the other.

All these evolutionary gains entailed enormous elaborations in the structure of the brain and of the retina, which is in fact an outpost of the brain cortex. The seat of vision is not in the eyeball but in the multimillion neurones of the central nervous system. The nervous system in turn controls and integrates the entire organism in its motor as well as its sensory aspects. As in fish, so in man vision has a motor basis. It is a complex sensory-motor response to a light stimulus mediated by the eyes but involving the entire action system. The seeing child sees with his whole being.

The development of vision in the individual child is extremely complex, because this development compresses into a short time the countless stages of evolution which brought vision to its present advanced state in the human species. The child's patterns of visual behavior go through progressive stages of maturity correlated with his changing postural control, his manual coordinations, his intelligence and even his personality. Indeed, vision is so completely identified with the whole child that we cannot understand the phenomenon without investigating the whole child.

OUR special researches in the field of child vision grew out of our general interest in the development of the total child. The studies of the Yale Clinic of Child Development, since its founding in 1911, have been mainly concerned with the growth aspects of early human behavior. The Clinic has charted the manifold behavior characteristics of children at 34 age levels, encompassing the first 10 years of life. This has been done by a variety of techniques: observations of the spontaneous behavior of infant and child at advancing ages; the detection of significant behavior patterns through periodic developmental examinations under standard conditions; observations of behavior in experimental situations. Much of the infant behavior was recorded by means of a one-way-vision dome equipped with motion-picture cameras. The films were later analyzed, frame by frame, to define the growth changes in the patterns of behavior. The basic data were amplified by stenographic reporting, interviews and records of home and school behavior.

The children's specific visual functions were investigated by tests of visual skills, reading-readiness and performance tests, and examinations with certain instruments—the phoropter, the stereoscope and the retinoscope. The accumulated evidence from the various studies of development demonstrated that the organization of the child's vision is intimately identified with the growth of his total behavior equipment.

The underlying principles and methods of observation are illustrated in the following outline of a typical examination of a 28-week-old infant. The mother brings the infant to the reception room. She is familiar with the surroundings, and her interest and confidence are bolstered by the fact that she made previous visits when the baby was 16, 20 and 24 weeks of age. The examiner begins an informal conversation with the mother; the baby, hearing their conversational voices, is aided in making an emotional adjustment to the new situation. When rapport is established, the examination begins in an adjoining room.

The mother places the infant in a small Morris chair facing a test table mounted on the side panels of a crib. The mother then withdraws to an inconspicuous location near the head of the crib, and the examiner takes over. He places a red one-inch cube on the test table to elicit a reaction. In a moderate voice he dictates a running description of the baby's behavior to a stenographer concealed behind a one-way-vision screen. A similar procedure is followed in a standardized sequence for a series of test objects, which include two cubes, three cubes, 10 cubes, cup and cubes, pellet, hand bell, ring and string, mirror and so on.

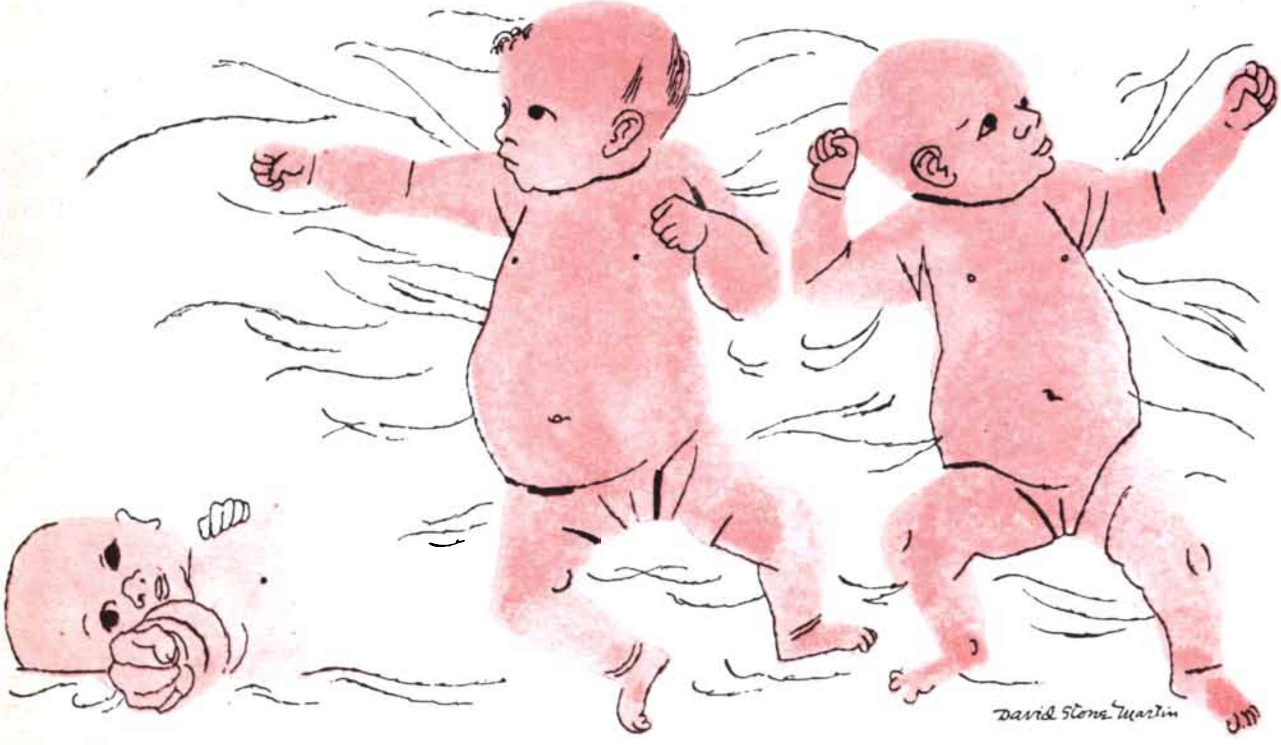
Next the test table is removed and the baby's postural behavior and incidental reactions are observed in various positions: supine, free sitting, prone, and standing with support. Then the infant is restored to the mother and another conference follows. The total session consumes approximately an hour. Four weeks later the infant may be returned for another examination.

WHEN the records for a large series of successive examinations of this kind were compared to define growth trends, they showed that the interaction of eyes and hands plays a master role in the development of the behavior patterns of the individual child, as it did in human evolution. This development begins in the uterus and continues throughout the first 10 years of life and beyond.

Nature has given top priority to the sense of sight. Six months before birth the eyes of the fetus move sketchily and independently beneath their sealed lids. In time the eyes move in unison, so the child is born with two eyes partly yoked in a single organ—"a physiological binoculus." Accordingly the newborn infant is able to move his eyes conjugately, and to fixate momentarily and monocularly. Sustained fixation of a nearby object occurs in the first week, fixation of more distant objects at the end of the first month. Binocular convergence comes later.

The infant takes hold of the world with his eyes long before he does so with his hands—an extremely significant fact. During the first eight weeks of life the hands remain predominantly fisted, while the eyes and brain are busy with looking, staring, seeking and, in a rudimentary manner, apprehending. The young infant when awake lies in an asymmetric attitude simulating a fencing position, with the head averted to one side, the arm on that side extended and the opposite arm flexed at the shoulder. This tonic-neck-reflex posture is fundamental in the patterning of eye-hand behavior.

The first true looking of the infant is monocular. He fixates the near object of interest by aligning the active eye and relaxing or closing the subordinate eye. At a later stage the monocular fixation alternates rapidly between two eyes, with a rhythmic excursion of the head from right to left to right. This eventually leads to teaming of the two eyes, which at about eight weeks of age simultaneously converge upon an object of interest. At 12 weeks we find that the infant still prefers the tonic-neck-reflex attitude and gazes in the direction of his extended arm as though regarding his hand. At 16 weeks his head favors the mid-position and his hands tend to come together at the mid-plane—a symmetro-tonic-reflex pattern. Placed in the examining chair, this 16-week-old infant proves to



EYES AND HANDS are joined in a pattern of behavior during the first eight weeks after birth. At this stage of development the infant keeps its hands clenched and its head to one side. One fisted arm is extended in front of its eyes and the other is bent upward to the shoulder. The position resembles that which is taken in fencing.

HAND GRASP begins to develop at 16 weeks after birth. The infant looks intently at his hands, the table top and the cube. He may even scratch at the table top a little, but he is still unable to grasp and lift the cube.

be avid for visual experience: he looks intently at the table top, then at his own hand, then at the cube, and again at his own hand. He may scratch the surface of the table by flexing his fingers, but he cannot as yet seize the object of interest.

By 28 weeks a dramatic gain in eye-hand coordination is achieved. When a cube is presented on the test table, the infant seizes it almost before it is placed; after a swift glance he brings the cube to his mouth and senses its surfaces orally; speedily he withdraws the cube, rotates it with a twist of the wrist, remarking the motion visually; soon the cube goes to mouth or table top for further exploitation. The cycle of eye-hand behavior repeats with variations. Repeatedly he transfers the cube alternately from one hand to the other—a pattern reminiscent of the eye movements which passed through a similar phase of alternation some five months earlier.

SUCH is the logic of visual development. The basic patterns and sequences are untaught, for they are the functional expression of gene effects operating at appropriate stages of maturity. Ocular prehension precedes manual. A 20-week-old infant at the test table unquestionably can pick up a white pellet, seven millimeters in diameter, with his eyes. He doubles his age before he picks up this pellet with his fingers. At 44 weeks he plucks it with precise finger prehension and neat thumb opposition.

As the child grows older his visual tasks become increasingly symbolic, although they always retain a concrete core. He has to associate visual experiences with words. He "learns," as we say, to build a tower, a wall, a bridge with his blocks. He learns to make vertical, horizontal and curved strokes with a crayon. He identifies pictures, drawings, letters and words. But his ability to handle them does not depend upon mere visual acuity. By the test chart he may show 20/15 acuity, which permits him to identify small type. Nevertheless this same boy may be backward in his reading. All of which reminds us again that the ability to see really depends upon the total behavior equipment.

At birth the visual system of the child is very incomplete; it continues to develop throughout infancy, preschool and school childhood into the adolescent years. The intricacy of this development indicates that the refractive condition of the eyes is only one factor in the total effectiveness of the child's visual behavior. Superimposed upon a basic delimiting refractive state there is a margin of adaptability which is under the dynamic controls of the cerebro-spinal and autonomic nervous systems. The total visual apparatus has three closely interacting components: skeletal, visceral and cortical. The skeletal component comprises the body musculature and the oculomotor muscles; it seeks and holds the visual image. The visceral component comprises the focus mechanism; it discriminates and defines the image. The cortical component comprises the highest nerve centers; it unifies and interprets the image. Nowhere else in human behavior do we see such an intimate linkage between postural, viscero-sympathetic and cerebral reactions. The cortex functions as the master tool of synthesis and integration. It funnels and mediates the electrodynamic forces that culminate in adaptive visual behavior.

THERE is no device that permits us to observe directly the course of such ultramicroscopic forces. But the retinoscope brings us into the near-presence of these forces and their immediate consequences. The retinoscope projects a beam of light upon the reflecting surface of the retina. In the Yale research it was found that the returning light in the young retina varied significantly in relation to identifiable moments of the visual act. The variations were manifested in the motion, the direction, the speed, the brightness and sometimes the color of the retinal reflex. Characteristically an increase of brightness in the reflex occurs at the moment when the infant identifies an object of interest.

All this becomes somewhat understandable when one thinks of the eye not as a camera but as the most direct corridor to the vast networks of the brain cortex, where billions of neurones engender and organize the energies that issue in vision. The seeing eye is a reaching, groping, grasping organ—a teleceptive prehensory apparatus. In league with the growing brain it manipulates visible objects, cues and symbols. At every stage of growth during infancy, childhood and youth the visual mechanism undergoes changes which serve to reorient the ever-transforming individual. For him the space-world is not a fixed and static absolute. It is a plastic domain which he manipulates in terms of the growing powers of his total behavior equipment.

Our civilization is becoming increasingly eye-minded. The demands upon the eyes of growing children are multiplying and intensifying. The conservation of vision, therefore, has become a task of vast social dimensions. This task includes the care of the visually handicapped and the prevention of industrial, highway and household accidents; but, above all, it concerns the mental health and developmental welfare of school children and preschool children.

Arnold Gesell, retired director of the Yale Clinic of Child Development, is presently in charge of the Yale Child Vision Research project. He is a co-author of the recent book Vision: Its Development in Infant and Child.

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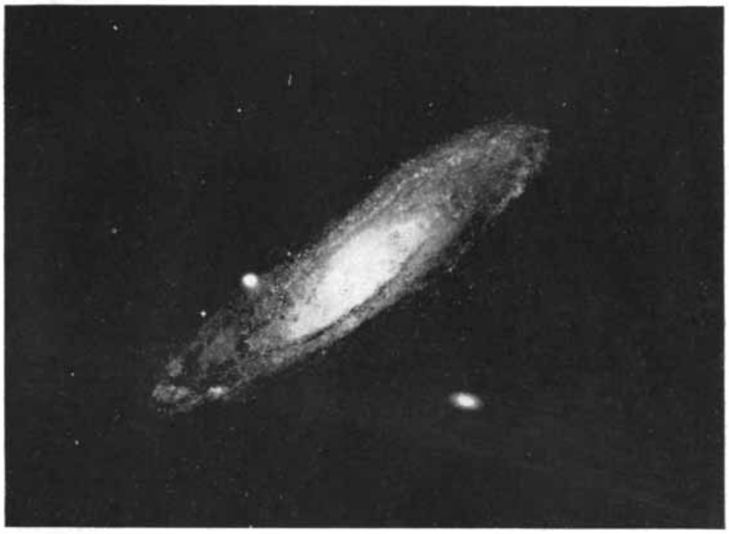

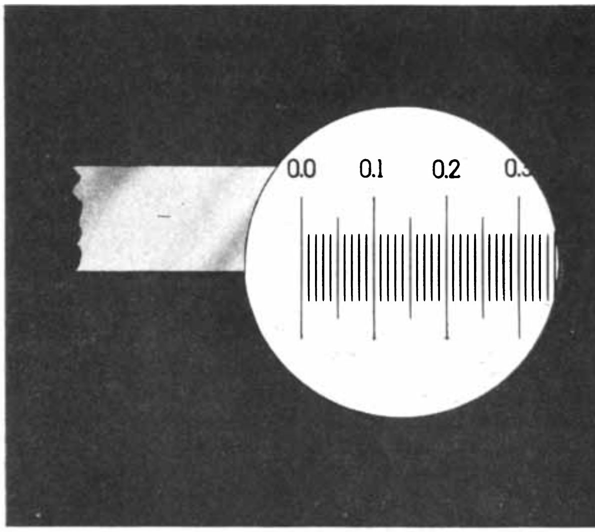

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