Some Comments on the Significance and Development of Midline Behavior during Infancy

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ABSTRACT: With the waning of the tonic neck reflex beginning with the 8th to 12th week, and disappearing, in most instances, by the 16th week, the infant begins to become bilateral and makes symmetrical movements and engages his hands in the midline usually over the chest while in a supine position. The developmental significance of such behavior is considered—for example, its participation in the emerging sense of self and its role in the consolidation of emerging ego skills. Consideration is given to the possible implications of faulty midline behavior for development, and to whether failure to engage in an optimal amount of midline behavior, in interaction with other factors, can be used to alert observers to possible future developmental disturbances.

This paper will examine the significance of midline behavior during infancy and the role it plays in the emerging sense of self and in ego skills that will aid the child in learning and mastering his surroundings. First we will consider the neuropsychological setting within which midline behavior first makes its appearance, which is around 12 to 16 weeks.

Significant modifications in neonatal behavior and neuropsychological functioning by the 3rd or 4th months have been noted by several observers of early child development. Spitz et al. [1] report initial findings of a psychobiological nature in their study of early infant development and maturation. Some of the variables that they are focusing on are: REM (rapid eye movement) state, quiet sleep,

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smiling, and fussiness. They note that approximately during the first 6 weeks of life neonatal sleep begins with a REM state. This continues until approximately the 10th or 12th week when this neonatal pattern begins to disappear and the "adult" pattern takes over. The early REM state is understood to represent central nervous system maturational processes that are not yet influenced by experience. By the 3rd month of life, the REM state "becomes firmly linked with the behavioral sleep and can no longer be confused with wakefulness."

The REM state during the first 6 weeks of life occurs during periods when the infant's eyes are closed—periods of drowsiness, nutritional sucking, fussing, and crying. Converging with this development of the REM state are changes in the electroencephalographic pattern of the neonate. The quiet sleep electroencephalogram (EEG) becomes more differentiated, and out of the chaotic pattern emerges so-called sleep spindles. Between the 8th and 12th week well-formed sleep spindle bursts are present, and an EEG takes on a more regular, organized appearance. Spitz et al. [1: pp. 423-424] suggest that "existing and partially functioning excitatory and inhibitory brain systems become capable of integrated, self-regulating *interaction.*" Thus, underlying the rearranged EEG pattern is an indication of greater central nervous system integrative capacity. Finally, after 3 months of age, the EEG pattern during quiet sleep becomes more like the adult types of deep, quiet sleep. Endogenous smiling wanes, and exogenous or social smiling, occurring during the first 6 weeks of life in response to a wide variety of stimulation, begins to occur with increasing frequency until about the 12th week when it becomes a regular response to the "essential sign Gestalt." As is commonly known, Spitz [2] elevates smiling as a sign of the emergence of the first organizer of the infant personality. Endogenous nonhunger fussiness was observed by Spitz et al. [1] to appear during the 3rd to 6th week of life, changing to intermittent bursts of fussiness, and finally by the 3rd month of life prolonged nonhunger fussiness begins to disappear.

A further suggestion that around the 12th to 14th week of life there is convergence of maturation and development is demonstrated by Gifford's [3] findings that by this age the neonate has achieved a sleep-wakefulness pattern that is adapted to the 24-hour periodicity of night and day. Gifford takes it "as evidence of ego functioning, the capacity for delaying immediate instinctual satisfaction, and a primitive awareness of time and external reality." Gifford points out that although the infant is not clearly separate in a psychological sense from the "mother," which would include all aspects of the caretaking environment that administer to his needs, the sleep rhythm is in some

way mediated through the relationship with the mother whereby the infant becomes adaptive to the "diurnal variations in responsiveness to his needs, and represents an early form of reality perception."

Willie Hoffer [4] considers the 3-month-old baby's intentional putting of a finger into his mouth as a way to relieve oral tension. In observing infants Hoffer was impressed with the "directness and resolution with which from the 12th week on the infant made the fingers approach and enter the mouth." Hoffer believes that the finger sucking of the 12- to 16-week-old infant suggests all the criteria by which we assess ego functioning, and he proposes the term *mouth-ego.* Hoffer [4: p. 21] states: "With the help of the hand the oral-sucking drive undergoes a transformation from an instinctual demand to an ego-controlled activity."

In classical psychoanalytic formulations, by the 12th week of life it is proposed that the infant has moved from the phase of autoerotism to the phase of primary narcissism [5, 6]. This move is characterized by the unification of component libidinal instincts, the development of the ego or self, and the cathexis of the self as an object of the instincts. In Margaret Mahler's [7: p. 10] formulations about the different stages of separation-individuation, the so-called symbiotic stage begins around the 3rd month when primary narcissism is not so absolute so that there begins to emerge a dimly perceived object that is separate from the self that is still a need-satisfying part object in Anna Freud's [8: p. 65] sense. The preobjectal stage formulated by Spitz [2] is also said to emerge around the 3rd month of life. Spitz takes as proof of the existence of the preobject the presence of exogenous smiling to the sign Gestalt. Spitz believes there must have been a convergence of several ego functions having reached a complex level of development in order for entry into the preobjectal stage to have taken place. For example, he suggests that "perception" begins to take predominance whereas "reception" of stimuli once did, the reality principle begins to function, rudimentary thought processes are suggested by the ability to shift cathexes from memory trace to memory trace, and so on.

In Piaget's system, by the 3rd month of life the infant should be nearing completion of the second stage (1-4 months) of the sensorimotor period of intelligence [9]. During this second stage the various reflex activities undergo separate modifications with experience and become interrelated and coordinated in very complex ways. Thus, there are coordinations between hand and mouth occurring during this stage, although such coordinations lack intentionality at this level of development of sensorimotor intelligence. Primary circular reac-

tions occur. These refer to repetition or series of repetitions of sensorimotor response, with the first response in such a series being unintended. As a result of intelligent activity the infant repeats the chance adaptation over and over. Eventually a new response becomes strengthened and consolidated, and a new schema is established.

We would suggest, as the result of our systematic observations of a series of normal infants during the 1st year of life, that there also occurs another extremely significant modification in neonatal behavior during the 3rd to 4th month of life that has not been mentioned above. We refer here to the waning of the tonic neck reflex beginning with the 8th to 12th week and disappearing, in most instances, by the 16th week [10]. Prior to the disappearance of the tonic neck reflex the neonate is essentially unilateral with one arm extended in the same direction the head is turned, while the other hand is flexed and useless. With the disappearance of this reflex, the infant becomes bilateral and begins to make symmetrical movements and engage his hands in the midline. We believe that the emergence of symmetrical movements and midline engagement of the hands has great significance and heralds the emergence of an inchoate representation of a cohesive self, still very primitive and poorly organized and still predominantly a "bodily self." We suggest that the manifestation of engaging the hands in the midline can be conceptualized as a sign of the emergence of an organizer of the self similar to the presence of the exogenous smile as a sign of an organizer of essentially object relationships. We use the concept "organizer" in Spitz's [1, 2] sense as a *modus operandi* that is a signal that integration and organization of discrete ego functions have occurred, permitting further adaptation. The ego functions that are coordinated in midline behavior involve, among other things, prehension and visualization. Hence, as midline engagement of the hands becomes more complicated, one can observe, in a sequentially prescribed way, mouth-hand coordination, eye-hand coordination, hand-hand coordination, and eye-hand-mouth coordination.

In Selma Fraiberg's [11] work with blind infants it was observed that there was a delay in creeping behavior. With sighted children the reaching with the hands for an out-of-range object is what propels the baby forward. Sustained mutual fingering at the midline was not observed in totally blind infants, something readily observed in sighted infants by 16 weeks. This suggested that vision facilitated finger play at the midline and that this tactile event requires a visual accompaniment to encourage a pleasurable repetition. As Fraiberg points out, it is the possibility of sustained regard of the hands alternated

with regard of the inanimate object that permits the coordination of vision and prehension, which in turn permits the infant to intentionally reach for an object in later stages, which in turn propels the child to creep toward an object.

Midline engagement of the hands, it would seem then, is an important cornerstone for prehension. We will briefly review the development of prehension up to the age when midline behavior usually starts to appear with greater frequency. Piaget observes the second stage of the sensorimotor phase of intelligence to begin roughly around 1 month and to end roughly around 4 months of age [9]. During this stage there are changes taking place in prehension that can roughly be subdivided into five parts. During the first substage prehension is a reflex insofar as the neonate will close his hand when the palm is stimulated. Around 1 month of age primary circular reactions involving prehension alone begin to appear. Hand-mouth coordinations begin to appear, and the infant shows interest in looking at his own hand actions. The infant will touch and grasp parts of his own body, particularly the face. Hand movements seem to come under control of the sucking schema during this substage, but this is not the case in terms of visual schemas. The infant has difficulties keeping his hands within the visual field in order to look at them, and he is unable to grasp what he sees. The eye-hand relation thus lags behind the mouth-hand relation. This is consistent with Hoffer's [4, 12] observations that the ego is very much a mouth-ego in the beginning and that the first adaptation of the ego is the ability to insert the finger in the mouth. During the third substage in the development of prehension, the child begins to bring to his mouth things grasped as well as grasping things placed in his mouth. By approaching objects by means of two schemas, namely, prehension and sucking, the infant furthers his objective understanding of his world. Progress is then made between the coordination of prehension and vision, so that the infant can now keep his hand in view if it has by chance entered his visual field. Eventually the child learns that via his hand movements he can transform or modify visual images, for example, see things at different angles, and then we can speak of reciprocal assimilation between the schemas of vision and prehension. Next the infant can deliberately grasp with his eyes, but only if the hand that grasps and the thing being grasped are perceived in a common visual field. Finally the infant learns to grasp with his hands whatever he sees and to see whatever he grasps.

The gradual disappearance of the tonic neck reflex has its contribution from maturation. The myelinization of neural pathways and

increased corticalization and suppression of lower brain centers permit the reflex to disappear. Hence, the tonic neck reflex will reappear following a cerebral stroke. Bilaterality now becomes possible. Maturation also makes a contribution to increasingly more complicated midline engagement of the hands; for example, the maturational ability to sit up may facilitate midline engagement of the hands. Experiential factors also play a role in enhancing midline behavior, assuming the necessary prerequisite central nervous system maturation involved in midline behavior has been achieved. Normal routine child care seems to provide the neonate with a frame of reference that is symmetrical. This is suggested first by the sign Gestalt of the face which is a symmetrical Gestalt. Most mothers present their face directly over the baby who is supine in his crib, they assist the baby into a sitting position on their knee, and hold the baby firmly with two hands providing a "symmetrical experience."

The Progressive Development of Midline Behavior

The child's approach to his outer world begins first with the asymmetry of the tonic neck reflex. This is then transcended with a symmetrical, bilateral approach. Finally, the child transcends this phase of symmetry and again makes a unilateral approach, but this time on a higher, more integrated level that that of the first unilateral approach to the world. Gesell and Amatruda [10] point out how prehension emerges out of posture. The tonic neck reflex attitude, which is seen to be "one of the most conspicuous behavior patterns" during the early postnatal weeks (1-12 weeks), provides the foundation from which prehension emerges. In their words: "During much of his waking life the four week old infant lies in this attitude (t-n-r) which resembles a fencing stance:—his head rotated to one side, one arm extended to the same side, the other tonically flexed at the shoulder. This attitude promotes and channelizes visual fixation on his extended hand. By gradual stages it leaves the hand inspection, to active approach upon an object, and to manipulation of the object" [10: p. 33].

It is not until around the 8th week that the infant can hold onto an object that is placed in his palm of the extended hand. Four weeks later the infant is able to both hold and glance at the object. At 16 weeks he can look at it for an extended period of time, and by 20 weeks of age the infant will make a bilateral reach for an object that he sees and prehension is relatively facile. The tonic neck reflex appears to be the fundamental building block out of which this sym-

metrical bilateral approach to the world emerges. Postural control of both the head and the eyes aids this bilateral approach and coordination of grasping and vision. The infant who is still under the influence of the tonic neck reflex fixes his roving eyes at something and stares, and the range of his vision is limited by the position of his head which is facing the direction of the extended arm. Eventually this range of vision is extended, and by 12 weeks of age it is 180 degrees. We notice that by 16 weeks the infant seems to prefer to look at the midline. There is a parallel development in the degree of attentiveness and the discriminativeness of this attention which converges with advances in oculomotor and postural control. Hence, the infant goes from a total reaction pattern at 4 weeks of age; for example, there may be a reduction of general activity to the sound of a bell or a massive total demand on attention from visceral stimuli. As the infant matures, attention and responses become more discriminative [13: pp. 26-27]. Gradually the infant becomes less absorbed with internal stimuli and less reactive to all kinds of stimuli in a total way, and becomes more attentive to external stimuli and selective and more organized in his response, so that by 12 weeks of age the infant may vocalize and is reliably smiling to the sign Gestalt of the face of his caretaking adults.

Our observations suggest that the tonic neck reflex begins to go by 12 weeks, and is fairly gone by 16 weeks so that midline positioning of the head and symmetrical posturing of the arms and the legs become evident. The infant at 16 weeks engages his hands in the midline and usually over his chest while he is in a supine position. He looks at the mutual fingering that he is engaging in. By 20 weeks of age there are a lot of hand movements and a bilateral approach of the hands to objects extended over him or to objects presented to him on a tabletop. We have found some of our infants to become intently interested in inanimate things at 20 weeks of age. If infants have been precocious in motor development, by 16 weeks of age some of them may extend great effort to roll over in order to grasp an inanimate object placed just out of their reach. By 28 weeks of age, the infant is unilateral again, showing a preferred approach and grasp with the left or right hand without this necessarily meaning future dominance. As mentioned earlier, this unilateral approach is at a higher level than that observed during the first 12 weeks of life. At this later stage the infant can regard with attention for a prolonged period of time things that he has grasped with his hand. He can unilaterally approach to grasp something while holding onto something else with the other hand. In a sitting position, transfer in the midline is possible. Bilater-

ality reappears at 40 weeks of age with infants matching things held in either hand. For example, they may bring together two spoons in the midline, or they can begin to participate in patty cake. They now can pick up two inanimate objects, whereas the earlier bilaterality at 16 weeks of age permitted them only to engage their hands in the midline; now they can engage two inanimate objects being held, one in each hand. This seems to be a behavioral manifestation of an integrative capacity. (In our observations the variable of state is not controlled. Insofar as our observations are longitudinal we would expect state to be randomized. We see value for future research to systematically examine the effects, if any, of different states on the emergence and development of midline behavior during infancy.)

Clinical Example of Midline Behavior

N., at 11½ weeks of age, was observed displaying precocious midline behavior in the form of engaging his fingers when lying on his back. He clutched and grasped at his clothing, something usually not observed until 16 weeks of age. (We have used Gesell and Amatruda's [10] schedule of norms in our observations.) Interestingly, when his clothes were removed some disorganization was observed. He appeared less mature with arms and legs in spread-eagle fashion. We speculated that the disorganization was due to the disruption resulting from having an "extended layer" removed when his clothes were shed [14: pp. 67-68]. In the supine position he held his head predominantly in the midline position, and his extremities predominantly were symmetrical (standardized at 16 weeks). Very little tonic neck reflex positioning was seen.

N. was regularly changed by mother on a kitchen counter. Directly overhead fixed on the underside of a cabinet (22½ cm above his face) was a mirror put there to entertain him. A lot of time was therefore spent looking at himself during awake and alert states. We wonder whether this type of stimulation can account for this infant's advanced posturing and engagement of his hands in the midline. The visual image directly above him in the midline may have been a powerful inducement to keep his head in the midline; he would have been unable to see his mirror image if his head was to either side. (During test situations, when held sitting facing a mirror, N. looked with an expression of great interest, smiled, and vocalized, moving his arms excitedly, reaching toward the mirror with his lips moving as if he wanted to bring his mouth against the image in front of him. This interest in a mirror image, observed in infants as early as 12 weeks of age, was not particularly prominent in N.'s behavior, despite the above experiences.)

During a home visit when N. was 12½ weeks old, mother was observed after the nursing to casually pick lint from N.'s palm and between his fingers (while his hands were together), thereby offering stimulation to his hands and presumably facilitating their cathexis by him, another possible determinant for precocious midline behavior (along with the advanced postural control of the head in the midline). When mother nursed N. she held his two hands together rather

than tucking his arm under hers, something commonly observed in nursing couples.*

At 17 weeks N. was on the verge of rolling over from prone to supine (expected at 16 weeks). No bilateral approach was observed to either the bell or the rattle, an event that would have been precocious had it occurred (expected at 20 weeks of age). But N. was fussy that day and had to be left with relative strangers while his mother parked the car.

At 23 weeks N. continually looked from inanimate objects to his mother. In a supine position his approach to a rattle was bilateral. Grasping the rattle, he immediately brought it to his mouth. N. played with his fingers at the midline; both hands were taken to that position. He was not observed to roll over from his back to his belly. Genuine interest was shown to the inanimate object. In a sitting position at a tabletop there was a bilateral approach to a cube, and then he brought his hands and the cube to his mouth.

All of the above behavior is expected for this age but was more richly elaborated than is ordinarily seen.

At 32 weeks, N. seemed to show stranger anxiety; he appeared very discriminating. While sitting in a supportive chair, he made a unilateral approach to the cube with his right hand, something already observed at 27½ weeks, with his left hand joining in so that bilaterality seemed present again. Early matching of cubes (something usually not seen until 40 weeks) was observed in the midline, another indication of precocious midline behavior in N.

At 40 weeks N. demonstrated an ability to deal with and integrate multiple stimuli that can be handled. Our impression is that this is a precocious elaboration of midline behavior. Hence, at one moment he had a cube in his mouth, one in each hand (one of which was brought up to his mouth to touch the one there), and one on the tabletop. He was observed stacking cubes by bringing the one in his hand against and on top of the one on the tabletop, without releasing it.

N., at 52 weeks, voluntarily and on command let go of cubes, but not yet with the precision to build a tower, as expected for this age.

Further Implications of Midline Symmetrical Behavior

It is our hypothesis that the increasing development of midline behavior permits the infant to develop his initial representation of himself, at first the bodily self, a prerequisite for eventual cathecting of the external world and hence a facilitator for the unfolding of separation-individuation. When the infant can bring his fingers together over

*We have not systematically investigated the effects of different patterns of mothering on the development of midline behavior, although observations such as above suggest such variations would be significant, at least in interaction with genetic neurophysiological endowment. On the basis of Provence and Lipton's [15] classical study of institutionalized infants, it would seem that midline engagement of the hands makes it expected maturational appearance in neurologically intact infants in the 3rd or 4th month even under conditions of minimal parenting, although further elaboration of midline behavior may be stunted or retarded.

his chest in the supine position and engage in mutual fingering play, he is capable of touching and being touched simultaneously, and it is this activity that aids in self-discovery. It is only with his own body as an object that the infant can experience touching and being touched simultaneously. Earlier the infant could perceive his hand at the end of his extended arm, but it is unlikely that the perception of the hand is any different from the perception of any other object or thing. Touching the body, however, elicits two sensations of the same quality which can help lead to a distinction between the self and the nonself, between the body and what is not part of the body. Hoffer [4] has pointed out how the directed and resolved finger sucking from the 12th week on permits the infant to experience these two sensations of the same quality so that the hand, like the mouth, is perceived as part of the self. He goes on to point out that, simultaneously, the oral sucking drive is transformed from an instinctual demand to an ego-controlled activity. Presumably with "good-enough" mothering and prerequisite neurological maturation, the midline fingering that the 16-week-old infant engages in permits the libidinization or cathexis of the hands which in turn go on to explore and discover other parts of the body.

It would seem that this midline mutual fingering would provide a sense of body boundary on both the left and on the right that would facilitate the sense of self and help distinguish the self from the environment and from the object. Transfer from one hand to the other is observed in a supine position at 24 weeks and in a sitting position at 28 weeks. The proprioceptive, tactile, kinesthetic, and visual sensations provided by prehension of something with one hand, and then transfer to the other hand, further self-discovery and left- and right-sidedness. The coordination of the eyes and the hand, that is, the coordination of the schemas of prehension and vision, experienced in the midline, facilitated by the maturational postural control of the eyes and of the head, not only is essential for the infant's discovery of his own body [16] but also is essential for him to become interested in things separate from his body [11]. The cathexis can then shift from the body to the external world. Reception is transformed into perception. Interest in the inanimate object develops in the context of the developing libidinal object relationships.

Thus, the gradual disappearance of the tonic neck reflex and the emergence of the midline behavior are a signal that an organizer of the self has had its inception. At first this bodily self-representation is primitive and not cohesive, though with further development and integration of experiences brought about by the exploration of the

body with the hand(s) it becomes more cohesive and more organized. With further postural control and sitting up this body image is developed even further. A sense of body balance having been achieved, another unilateral attitude toward the world can now take place, within a firm context of self-boundary and underlying symmetry. It is likely that this sense of bodily self, bounded on either side of the center of gravity of the body, is an essential prerequisite for "hatching" out of the symbiotic phase, as described by Mahler [7]. By 40 weeks of age bilaterality again comes to the forefront and now permits the infant to participate in such social behavior as patty cake. Midline behavior, which at the earliest stage helped to bring about the differentiation of self from object, at the later stage helps the child to socially engage the object. Thus, it would seem to us that midline behavior has great significance first for the development of the self and, secondly, for the development of object relationships.

Cerebral Specialization and Laterality

It is beyond the scope of this paper but briefly to mention recent work investigating specialized cerebral hemispheric functions and learning disturbances primarily due to disturbed laterality. Reviews of this work exist in both the professional [17, 18] and popular [19] literature.

Work done by Sperry and his colleagues [20, 21, 22, 23] with patients who have undergone commissurotomies, that is, where connective fibers (corpus callosum) between the two hemispheres have been severed (e.g., to control seizures), has demonstrated that each hemisphere continues to function structurally independent from the other. These studies, along with others based on different research techniques, strongly suggest left and right cerebral specialization, an economical use of the brain in man. The evidence is in favor of a cerebral specialization for different cognitive styles, the right hemisphere for a holistic cognitive mode, as would be suitable for spatial relations, and the left hemisphere for a more analytic cognitive mode, wherein words, grammar, and language adhering to logical cognitive processes would be particularly suitable, as in abstract thinking and conceptualization. Galin [17], based on the findings with "split-brain" patients, has proposed some interesting hypotheses as to the implications for dynamic psychiatry.

It should be kept in mind regarding cerebral specialization, for our purposes, that neural pathways from and to one side of the body and one-half of the visual field cross over and connect with the opposite

hemisphere, so that sensations arising in the right hand and right visual field are neurologically projected to the left hemisphere, while those arising in the left hand and left visual field project to the right hemisphere.

Disturbances in laterality, that is, disturbances of the internal psychological sense of left-sidedness and right-sidedness, presumably partly due to central nervous system dysfunctioning (e.g., faulty lateral specialization of the two cerebral hemispheres), seem to be implicated in diverse learning disturbances. We have children in our Day Treatment Service, for example, who have difficulties crossing their midline, presumably due to disturbed laterality. Such children cannot reproduce numbers that cross a midline, such as the number 8, whether it crosses their own body midline or not. If such children are asked to draw a horizontal line that crosses their body midline, they cannot and instead may switch hands when they get to a point corresponding to their own midline or move their entire body in the horizontal plane in order to complete the task. If asked to draw a circle, they may stop at the midline point and change hands. Such children may have trouble reading from left to right, necessitating crossing the midline; reversals are common when writing numbers or letters. Remediation often requires going back to basic experiences of crossing the midline, for example, requesting the child to touch his left knee with his right hand.

It has been suggested [24] that autism may be primarily due to a failure to establish hemispheric specialization in a number of areas. Presumably, cerebral hemispheric specialization does not exist at birth but emerges with central nervous system maturation [18: p. 377]. We have speculated as to what role midline behavior in infancy might play in this unfolding. Unilaterality is the initial mode, as manifested in the tonic neck reflex, which gives way to primitive bilaterality around 16 weeks. We wonder if the engagement of the hands in the midline at this time promotes synchronization of the two hemispheres, eliminating early dominance by one hemisphere in neuronal development. Put another way, does midline behavior in infancy prepare the two hemispheres so that they can economically specialize at a later age? By "preparation," we have in mind research [25, 26, 27, 28] that suggests that external stimulation facilitates myelinization, vascularization, and dendritic arborization of the brain, all considered necessary for realization of genetic potential and optimal functioning of the brain. We wonder whether midline behavior in infancy would provide such stimulation. Perhaps failure to engage in an optimal amount of midline behavior in early infancy is a forerunner of diffi-

culties in later life which, when interacting with other factors, unfold as disturbances in laterality, which might deleteriously affect learning, or in extreme cases, in severe atypical development, such as autism.

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