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ABSTRACT

Studies of the infant's distribution of attention to stimuli of varying complexity, and of his differential attention to familiar versus novel stimuli (discrepancy), have attempted to shed light on the development of cognitive structures in the non-verbal infant. The subjects have typically been normal infants ages 4 to 6 months. For testing, the infant is placed in an infant seat on a table in a small room, with the mother seated to the side and rear of him. Visual or auditory stimuli are presented to the infant and his response behavior is recorded. Two dependent variables measured have been first fixation (the length of the infant's first visual fixation to the stimulus during any single presentation), and cardiac deceleration (the degree to which the infant's heart rate slows during a fixation). Past studies are cited regarding their differing emphases on particular aspects of attention and their findings on individual differences. Typically, the infant habituates (responds less) to repeated presentations of stimuli. Work in this area is just beginning, but study results thus far indicate that habituation and response to discrepancy may be important indices of cognitive functioning. (NH)

Issues and Implications of the Distribution of Attention in the Human Infant

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There is quite a flurry of interest among psychologists over how the human infant distributes his attention to stimuli that impinge upon him. Quite simply, why does an infant look at some stimuli and not others, or respond to some melodies more than others. A portion of the excitement over this field resides in the hope that we might be able to learn something about the process of mental development in the non-verbal infant.

Why should we study the distribution of attention and in what way might it be related to cognitive development? First, attention is a pervasive component of a young infant's waking behavior. Second, attention to certain stimuli seems to be necessary to most learning. For example, the attentional system acts as a filter and those stimuli that pass through can be encoded, remembered, and used to guide future behavior. Consequently, the attentional system must be in harmony with the infant's ability to interact cognitively with the environment.

There have been two major research foci that have emerged. First, how does the infant distribute his attention to stimuli of different levels of complexity? If the infant progressively pays more attention to stimuli of greater complexity as he matures, perhaps we can infer the emergence of cognitive structures from this behavior -- or their failure to emerge with development.

A second research emphasis has been on the differential deployment of attention to familiar versus novel stimuli. Assume that two stimuli have equal *a priori* power to recruit attention. Now suppose that one stimulus is presented several times in a row

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to the infant and then without procedural interruption the other stimulus is presented. The stimulus that is shown over and over again is called the standard, while the stimulus that is suddenly introduced later, now being a novel event to the infant, is called a discrepancy. Presumably, with repeated exposure to a given stimulus, the infant develops some type of memory engram (or "neuronal model") for that stimulus. When the discrepancy is suddenly introduced, and if the infant attends to it differently than the last presentation of the standard, one might be able to infer that the infant learned about, remembered, and retrieved some representation of the familiar stimulus and compared that memory engram with the now available discrepant stimulus. Otherwise, it would seem that there would be no basis for the infant's differential attentional response. Thus, one might be able to develop a method of assessing the parameters of rudimentary learning and memory in a nonverbal infant by studying his differential attention to familiar and novel stimuli.

A Typical Experimental Context

The experimental subjects are usually young infants, from 1 to 8 months of age, but most work has been done with 4 to 6 month normal infants. The experimental situation that we use is typical of other laboratories. The infant is placed in an infant seat resting on a table located in a very small room. His mother is seated to the side and rear of him. In front is a panel which has a place for stimuli (visual or auditory) and small windows through which observers may record the infant's behavior.

Although many dependent variables have been measured in this context, we will concern ourselves with only two. "First fixation" refers to the length of the infant's first visual fixation to the stimulus during any single presentation. Cardiac deceleration represents the degree to which the infant's heart rate slows during a fixation relative to its level prior to looking. The construct validity for using cardiac deceleration in this context has been presented by Graham and Clifton (1966). The cardiac measure has been found to be more sensitive than looking time in reflecting stimulus differences (e.g., McCall & Kagan, 1967b) and it can be used as a dependent measure for both visual and auditory stimuli.

Parameters of Attention

Stimulus attributes. In the search for the determinants of the attention of infants, some scientists have placed primary emphasis on the properties of the stimulus. For example, Salapatek (Salapatek, 1969; Salapatek & Kessen, 1966) has shown that the newborn fixates on the corners of a triangle and as he grows older he participates in a more systematic scan over the outside of a form, but it is not until approximately 10 weeks of age that any meaningful focus on the characteristics of the stimulus within its outside boundary occurs. The fact that there appears to be a somewhat clear developmental course to the infant's scanning strategy over the first few months of life not only may provide us with clues to the development of perceptual cognitive behavior early in infancy but may constitute a basis against which several abnormalities in these systems can be evaluated and detected.

A commonly investigated stimulus property is "complexity." Typically, complexity has been manipulated by constructing stimuli composed of various numbers of checks in checkerboard patterns or by randomly generating solid black polygons of various numbers of sides with the presumption that the number of checks of sides reflects the complexity of the figure. More recent evidence (Karmel, 1969; McCall & Kagan, 1967a; McCall & Melson, in press) has implicated the role of the length of contour, that is, the total length of black-white edge in these visual patterns, as being the major determinant of attention. Further, Cohen (1969a) has suggested that the amount of contour relative to the total expanse of the stimulus is the important variable. Karmel (1969) has proposed a synthesis of some of these data which is presented in Figure 1. This integration suggests that for very young infants fixation time is an inverted-U function of the square root of contour in the visual form and that as the infant grows older, more and more complex stimuli are capable of eliciting large amounts of fixation time.

These data suggest that the amount of contour relative to the general expanse of the stimulus may be a prime determinant of attention, and that as the child grows older he pays more attention to patterns having relatively more contour. The developmental course of this behavior may reflect the infant's acquisition of sensory-perceptual strategies of processing rudimentary information and that failure to show such a developmental pattern may reflect retardation in perceptual-cognitive development.

Another application of these procedures is assessing visual acuity in young infants. Fantz, Ordy, & Udelf (1962) used differential attention to striped vs. gray patterns and optokinetic nystagmus to moving stripes and determined that the infant is quite sensitive to visual pattern. Under one month of age, the infant has a minimum separable acuity of 40 min. which improves to between 3.5 and 5 min. by six months.

Discrepancy. A second research emphasis has been on the infant's relative attention to novel versus familiar stimuli. In this context, it has been proposed that the similarity between the novel and the familiar stimulus plays a role, and that attention ought to be an inverted-U function of the magnitude of discrepancy (lack of similarity) that exists between the familiar standard and the discrepant stimulus. McCall & Kagan (1967b) attempted to test this proposition by sending a given stimulus home with infants between their third and fourth-month birthdays. At the end of this time, these infants and a group of non-experienced control subjects viewed several presentations of each of four stimuli including the stimulus that had been experimentally made familiar to them. The test stimuli were conceived to be graded discrepancies from that standard. The girls who were familiarized with the standard stimulus displayed a pattern of cardiac deceleration to the discrepancies that conformed with the discrepancy hypothesis, but the boys did not. The author has recently replicated this sex difference. In another study, McCall & Melson (1969), familiarized 5½-month infant boys to a standard stimulus by presenting it 8 times in a row. Without interruption of procedure, a discrepancy of either 1, 2, or 3 units was introduced, and the relative amount of cardiac deceleration to the discrepancy versus the standard stimulus was observed. The results are presented in Figure 2. These data conform nicely to the discrepancy hypothesis which suggests that stimuli of a moderate departure from what is familiar to the subject provoke the maximum amount of attention while stimuli too discrepant from that standard may elicit even less attention than that paid to the standard. Other studies (McCall & Kagan, 1969; Melson & McCall, in press) have also shown effects for the magnitude of discrepancy using different visual stimuli as well as auditory stimuli.

These data suggest that magnitude of discrepancy is a variable in the deployment of attention and that the relationship between attention and discrepancy may be an inverted-U function. Theoretically, it could be the case that the infant attends to those stimuli that represent a moderate departure from what he knows well because those stimuli represent new information, but information that the infant is capable of processing. Stimuli that he is quite familiar with provide no new information, while stimuli that are very discrepant may be so deviant from his capacity to process their information that he does not see them in relation to stimuli he knows well. If this analysis is accurate, then the study of attention to discrepancies may provide us with a basis of tapping rudimentary cognitive processes in infants.

Individual Differences

In some of the studies of attention cited above, a standard stimulus is presented several times followed by a discrepancy. Typically, the infant habituates to the repeated presentation of the standard. That is, he responds less and less with repeated presentations of the same stimulus. It has been proposed by several authors that habituation reflects the acquisition of a memory engram of that stimulus. If attentional habituation reflects the acquisition of a memory and is a cognitive process, then infants who habituate should respond to discrepancies, whereas infants who do not habituate (and presumably do not have a memory of the standard) should not be able to judge the discrepant stimulus as being "different" from the standard and consequently not respond differentially to it.

McCall & Kagan (1970) presented 4-month infants with five presentations of a standard stimulus composed of three elements (e.g., a Christmas bow, a toy clown, a sponge-rubber bird, etc.). A discrepancy was defined by replacing either one, two or all three of these elements with a new stimulus object. Infants were classified into three groups on the basis of their first fixation to the repeated presentation of the standard stimulus: short lookers, rapid habituators, and slow habituators. The short looking group was used because there were some infants who never did look very long at the stimuli and categorizing them as rapid or slow habituators did not make a great deal of sense. The response of these three groups of infants to discrepancies is presented in Figure 3. It can be seen that the short-lookers responded consistently with an increase in fixation time to each of the three discrepancies (labelled C for "Change" in Figure 3), the rapid habituators responded similarly to the first discrepancy but then "habituated" in their response to discrepancies, while the slow habituators did not respond at all differentially to the standard and discrepant stimuli. Further, some infants smiled to the presentation of a discrepancy. It was found that 27% of the short lookers, 19% of the rapid habituators, but not one of the slow habituators smiled to a discrepancy. Furthermore, there were four infants who smiled only to the discrepancy and never to a standard and all four of these were short lookers.

Similar findings have been reported for auditory stimuli (Melson & McCall, in press). The standard stimulus was an 8-note tonal sequence and the discrepancy was composed of the same 8 notes rearranged in another sequence. Infants who displayed rapid cardiac habituation to the repeated presentation of the standard responded more to the discrepancies than did infants who did not evidence habituation. It would appear that habituation predicts the response to discrepancy in both the visual and auditory modality and that under some circumstances habituation may be a behavioral index of the acquisition of a memory engram.

It is likely that habituation does reflect a cognitive process. For example, it has been shown that habituation is not usually a simple function of fatigue (Cohen, 1969b), younger infants habituate more slowly and require a shorter inter-stimulus interval than do older infants (Lewis, 1969), habituation is slower among infants from poorly educated parents (Lewis, 1967), infants having lower Apgar scores at birth habituate more slowly in later infancy than do normals (Lewis, Bartels, Campbell, & Goldberg, 1967), and premature infants do not habituate as rapidly to simple stimuli during the first month or even later in infancy compared with full-term babies (Polikania & Probatova, 1958). Further, there have been some reports that rate of habituation correlates with simple concept formation and two-choice discrimination tasks and with Binet IQ at age 44 months (Lewis, 1970). Finally, differential attention to familiar and novel visual stimuli discriminated between home- and institution-reared infants at two to three months of age, but the standardized Griffiths Baby Scale did not do so until 15 months (Fantz & Nevis, 1967). Consequently, it would appear that habituation and response to discrepancy may be important indices of cognitive events and more potent predictors of concurrent and later cognitive functioning than traditional methods.

These procedures may also be able to detect abnormalities. We saw a 21-week female with Downs Syndrome in our laboratory and compared her attentional responses to visual and auditory stimuli with a group of 13 normal females of the same age. To a series of several visual stimuli, her average first fixation was longer than any normal (5.84 versus 4.0 seconds) and she had the least number and shortest duration of return looks after the first for any stimulus presentation. When auditory stimuli were presented and her heart rate monitored, it was observed that she had a very stable heart rate, less lability than all but one normal infant. Further, she had the smallest mean deceleration over all presentations of the standard, and displayed almost no differential cardiac response to the discrepancies. Unfortunately, this child died at 7½ months of a respiratory infection, but there was no evidence, either clinically or as a result of an autopsy, of heart disease which is common in these cases. While this is only one instance, the fact that this child differed on five aspects of attentional behavior from normal infants, suggests that these procedures may have power in reflecting differences in cognitive performance.

There are many methodological issues involved in this research (see for example, McCall, 1970). To illustrate, first fixation and cardiac deceleration do not correlate perfectly and we do not know the differential meaning of these separate variables. Furthermore, we have no theory of the dynamics of attentional behavior to guide our search. It is not clear that long looking implies "greater attention" -- the short-looking infant may have encoded and remembered the stimulus more efficiently than the long looking infant. Also, habituation to simple stimuli may reflect the acquisition of an engram for that stimulus and thus be a clinically "good" sign of cognitive performance, whereas the same infant may show relatively less habituation when the stimulus is more complex. That is, a "bright" infant may show rapid habituation to a simple stimulus that does not provide him with much information, but that same infant may perseverate in his attentional behavior to a more complex stimulus that does provide him with a great deal of information.

While work in this area is only beginning and is fraught with methodological and conceptual difficulties, it is possible that the study of the distribution of attention in young infants may permit sensitive assessments of rudimentary cognitive functioning in non-verbal infants. Although most of what I have talked about are promises, anticipations, and maybe even fantasies, I hope I have conveyed to you a small amount of the enthusiasm shared by the people working in this area.

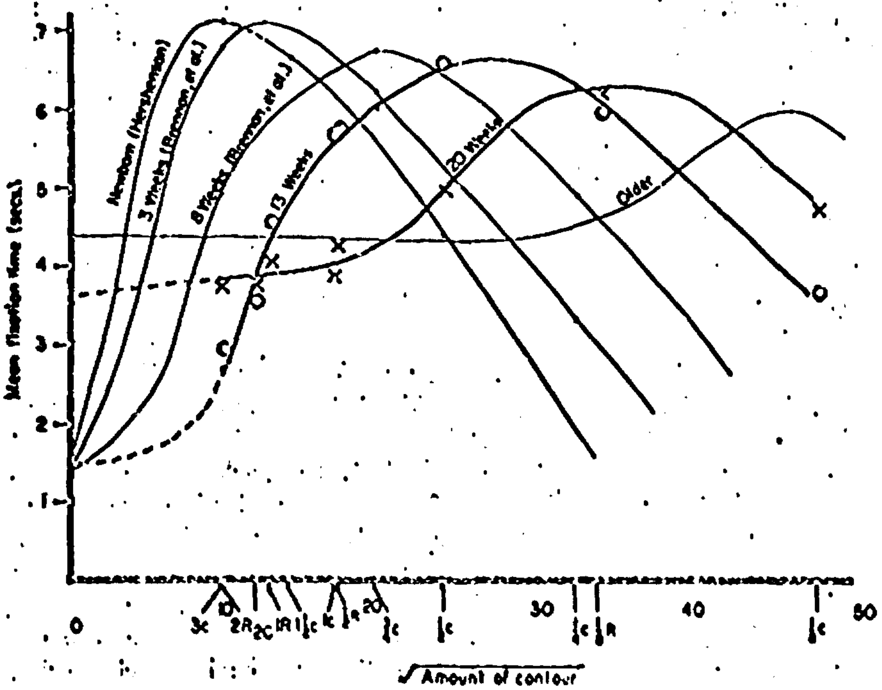

FIG. 1. Mean looking time for each stimulus plotted with respect to the square root of the amount of contour contained in the stimulus for different aged *Ss*. The letters (C) and (R) represent redundant and random patterns, respectively. Number prefix indicates size of element used for construction. (Example: ½C represents the ½-inch redundant pattern.) A lower case (c) represents the redundant character of elements of patterns used by Brennan et al. (1966) or Hershenson (1964). The number preceding the lower case (c) would be equivalent to the check size used by these investigators.

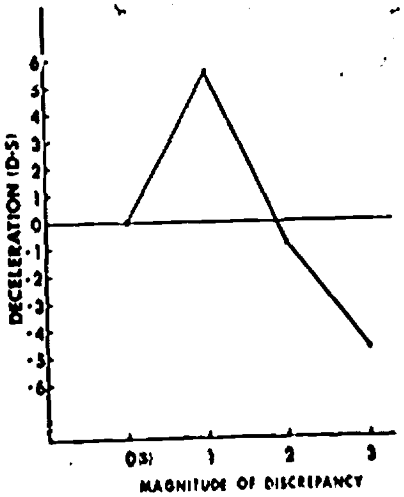

Fig. 2. The relative cardiac response to discrepancy as a function of the magnitude of discrepancy.

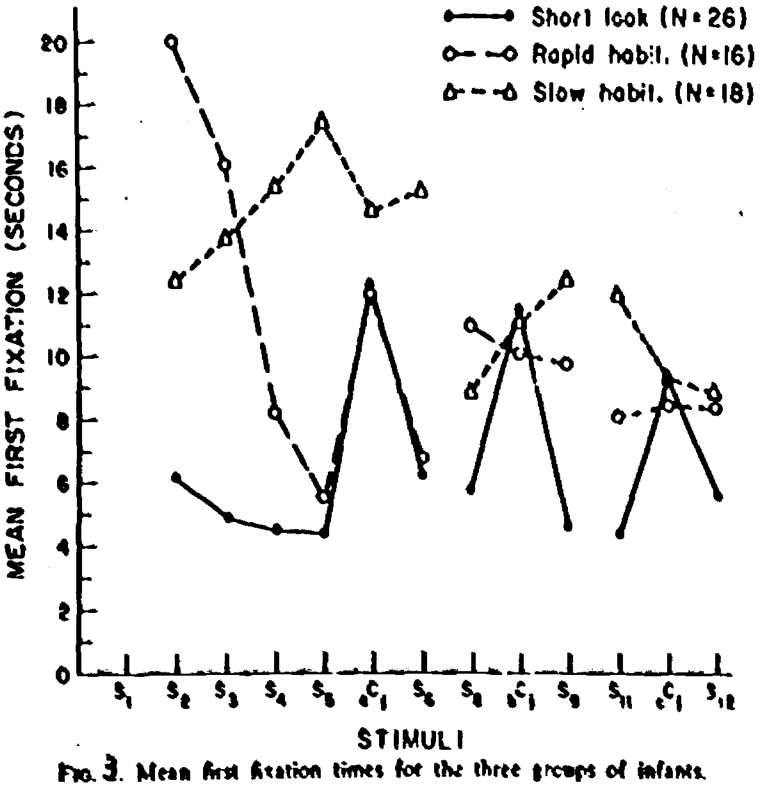

FIG. 3. Mean first fixation times for the three groups of infants.

References

Cohen, L. B. Observing responses, visual preferences, and habituation to visual stimuli in infants. *Journal of Experimental Child Psychology*, 1969, 7, 419-433. (a)

Cohen, L. B. Alternative measures of infant attention. Paper presented at SRCD, Santa Monica, California, 1969. (b)

Fantz, R. L., & Nevis, Sonia. The predictive value of changes in visual preferences in early infancy. In Jerome Hellmuth (Ed.) *The Exceptional Infant*, Vol. 1. Seattle: Special Child Publications, 1967.

Fantz, R. L., Ordy, J. M., & Udelf, M. S. Maturation of pattern vision in infants during the first six months. *Journal of Comparative and Physiological Psychology*, 1962, 55, 907-917.

Graham, Frances K., & Clifton, Rachel K. Heart-rate change as a component of the orienting response. *Psychological Bulletin*, 1966, 65, 305-320.

Karmel, B. Z. The effect of age, complexity, and amount of contour on pattern preferences in human infants. *Journal of Experimental Child Psychology*, 1969, 7, 339-354.

Lewis, M. Infant attention: Response decrement as a measure of cognitive processes, or what's new, Baby Jane? Paper presented at SRCD, New York, 1967.

Lewis, M. A developmental study of information processing within the first three years of life: Response decrement to a redundant signal. *Monographs for the Society of Research in Child Development*, 1969, 34, (133).

Lewis, M. Individual differences in the measurement of early cognitive growth. In J. Hellmuth (Ed.), *The Exceptional Infant*, Vol. 2, Bainbridge Island, Washington: Brunner Mazel, Inc., 1970.

Lewis, M., Bartels, Betty, Campbell, Helen, & Goldberg, Susan. Individual differences in attention: The relation between infants' condition at birth and attention distribution within the first year. *American Journal of Diseases in Children*, 1967, 113, 461-466.

McCall, R. B. Attention in the infant: Avenue to the study of cognitive development. Paper presented at the Conference on Self-Regulatory Behavior, College of Human Development, Pennsylvania State University, University Park, Pennsylvania, 1970.

McCall, R. B., & Kagan, J. Stimulus-schema discrepancy and attention in the infant. Journal of Experimental Child Psychology, 1967, 5, 381-390. (a)

McCall, R. B., & Kagan, J. Attention in the infant: Effects of complexity, contour, perimeter, and familiarity. Child Development, 1967, 38, 939-952. (b)

McCall, R. B. & Kagan, J. Individual differences in the infant's distribution of attention to stimulus discrepancy. Developmental Psychology, 1970, 2, 90-98.

McCall, R. B., & Melson, W. H. Attention in infants as a function of magnitude of discrepancy and habituation rate. Psychonomic Science, 1969, 17, 317-319.

McCall, R. B., & Melson, W. H. Complexity, contour, and area as determinants of attention in infants. Developmental Psychology, in press. (a)

Melson, W. H., & McCall, R. B. Attentional responses of five-month girls to discrepant auditory stimuli. Child Development, in press.

Polikania, R. I., & Probatova, L. E. On the problem of formation of the orienting reflex in prematurely born children. In L. G. Voronin, A. N. Leontiev, A. R. Luria, E. N. Sokolov, & O. S. Vinogradova (Eds.) Orienting reflex and exploratory behavior. Moscow: Academy of Pedagogical Sciences of RSFSR, 1958.

Salapatek, P. The visual investigation of geometric pattern by the one and two month old infant. Paper presented at American Association for the Advancement of Science, Boston, 1969.

Salapatek, P., & Kessen, W. Visual scanning of triangles by the human newborn. Journal of Experimental Child Psychology, 1966, 3, 155-167.