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ABSTRACT

Function of attention in infants is explored. Assuming (1) that infants respond differently to novel situations than to familiar ones; (2) that the infant's pattern of response is a partial reflection of the process of acquiring a perceptual memory of the stimulus, and (3) that sex differences may occur in the rate of habituation, 120 infants either 12 or 18 weeks old received five presentations of a standard stimulus. After this, when the infant displayed a fixation of less than 3 seconds, the number of additional trials needed established their habituation criteria. Discrepancies of 0, 1, 2, or 3 arbitrary units were introduced on the next trial. Results indicate that while young infants took longer to habituate than older ones, they showed no differences in response to discrepancies. If a new stimulus is presented before habituation is complete, infants respond differently than they would otherwise do. Conclusions are (1) Sex differences may reflect differences in maturation rates, (2) Developmental processes during the first few months of life may influence memorizing more than using what is learned and (3) Infants may moderate discrepancies by ignoring those he is not ready to assimilate. (DJ)

# Habituation and the Response to Discrepancy: Implications for Memory, Retrieval, and Processing Perceptual Information[1]

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For several years research in our laboratory on the study of the distribution of attention in human infants has proceeded under a few working assumptions. First, we assumed infants respond differentially to novel relative to familiar stimuli, and that the intensity of response follows an inverted-U function of the magnitude of discrepancy (Figure 1). Second, if the familiar stimulus is presented repetitively to the infant as part of the familiarization process, the pattern of habituation which the infant displays (typically a progressive decline in response with repeated presentations) is a partial reflection of the process of acquiring a perceptual memory engram of that stimulus. Third, there may be sex differences in the rate of habituation and/or the response to discrepancies. Evidence supporting these working assumptions has been presented by McCall (1971). I want to take this opportunity to present some extensions and qualifications on these working hypotheses.

## The Relationship between Habituation Pattern and the Response to Discrepancies

McCall and Kagan (1970) gave 4-month infants five exposures to a standard stimulus prior to the introduction of a discrepancy. Subjects were a priori divided into three groups which we may call one-trial habituation, habituation, and no habituation groups. The results of that study (Figure 2) indicated that

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the more rapid the process of habituation the greater the response to new stimuli. One interpretation of this result is that the behavioral phenomenon of habituation reflects the acquisition of a perceptual memory: Those infants who habituated displayed behavior that testified to their acquisition of a memory for the standard which permitted them to respond differentially to a new stimulus, whereas infants who did not habituate did not display behavior that would indicate that they recognized the new stimulus as being different from the familiar stimulus. However, is the cause of the relationship between habituation rate and response to discrepancy the cognitive status of the memory engram for the standard or some presumably less cognitive individual difference that determines both behaviors?

To assess this possibility infants were presented the standard stimulus during the familiarization phase until they reached a behavioral criterion of habituation. Five presentations of the standard stimulus were required regardless of the infant's behavior. Thereafter, when the infant displayed two consecutive trials on which his fixation time was less than 3 seconds, the habituation criterion was said to be reached and a discrepancy of either 0, 1, 2, or 3 arbitrary units was introduced on the next trial. A total of 120 infants, either 12 or 18 weeks of age, were seen. The stimuli, pictured in Figure 3, were conceived to be on a dimension of graded similarity to one another, and infants were either presented with Stimulus A as their standard with Stimuli B, C, or D as the discrepant stimulus, or Stimulus D as their standard with Stimuli C, B, or A as the discrepant stimulus.

Age. The results indicated that while young infants took longer to habituate to the criterion than did older infants, there was no difference between the ages with respect to their response to discrepancies. Thus, whatever developmental processes transpired between 12 and 18 weeks, they apparently had a greater impact

on the process of acquiring a memory engram for the standard than they did on the retrieval and use of that engram in processing new stimuli.

Other data are consistent with such a hypothesis. For example, Papousek (1961) has shown that while there were marked age differences in the rate of conditioning head rotation, the process of extinction was remarkably similar across several ages in the first year of life. In addition, Siqueland (1969) gave infants access to a pacifier, which when sucked would present or terminate a visual stimulus. Once asymptotic responding was achieved, a new visual stimulus was suddenly introduced as a reinforcer. While the general level of response differed for one- and four-month infants, there was no interaction between age and the relative increase in sucking in response to the introduction of the new stimulus. These data support the current observation to the extent that they all demonstrate comparability across age for behavior which requires retrieval and use of an already learned perceptual or associative memory.

Habituation pattern. A second result was the difference between rapid and slow habituators, where these groups were defined by relatively few or many trials of the standard before the criterion of habituation was attained. The distribution of looking times to the several magnitudes of discrepancy for rapid and slow habituators are presented in Figure 4. Note first that both groups showed a differential response to discrepancies versus the familiar standard. This indicates that if slow habituators are allowed to reach the same behavioral criterion of habituation as rapid habituators, they too respond positively to the introduction of a new stimulus. Blending this observation with the previous result one hypothesizes: If a new stimulus is presented before habituation is complete, infants do not respond to such stimuli in the same way as they would if they were thoroughly familiarized with the standard stimulus.

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Second, the response pattern for the rapid habituators is a quadratic trend that clearly supports the inverted-U prediction of the discrepancy hypothesis. Although there is an apparent inflection in the curve for slow habituators, the only significant trend in their pattern is linear. Thus, slow habituators responded relatively more to the largest discrepancy than did rapid habituators. This may be interpreted to mean that somehow slow habituators, having had more familiarization trials with the standard had a "better" memory of that standard and therefore were more capable of taking in information in the form of extreme discrepancies than rapid habituators. Alternatively, one might speculate that rapid habituators may also habituate more rapidly to extreme discrepancies which their perceptual-cognitive system cannot process and are therefore showing a more mature response pattern. I favor the latter hypothesis, largely because of data to be presented below.

Long-term Familiarization

Let us turn to another set of studies. In 1967, McCall and Kagan familiarized infants between their third and fourth month birthdays in their home with a stimulus and then tested with a series of stimuli including that same familiar standard plus three graded discrepancies from it. The behavior of these experienced infants was compared with that of non-familiarized controls. The results (Figure 5) indicated that the experienced females responded with greater cardiac decelerations to discrepancies in a manner consonant with the inverted-U prediction of the discrepancy hypothesis, whereas boys did not show any differential response to the stimuli as a function of familiarization. Since infants were required to remember the familiar standard over a span of as much as one to two days between familiarization and testing, perhaps 4 months of age was a lower limit for performing such a task and girls were more advanced than boys in this regard.

This interpretation was tested in a subsequent study in which infants were given an initial exposure to the test stimuli followed by a two-week (rather than one-month) home familiarization experience with the standard stimulus. The posttest was given at 4 and 5 1/2 months of age. In addition, mothers were outfitted with a stopwatch and asked to record how much their infant actually looked at the standard stimulus during the home familiarization. On the basis of these records infants were classified into two groups, one composed of infants who did not look very long at the standard and displayed rapid habituation to it during the home familiarization period and one group of infants who looked a long time at the standard and did not show habituation during the home phase.



The stimuli used in the experiment are displayed in Figure 6. The difference between the response to the standard and three graded discrepancies from it on the posttest minus the response on the pretest is plotted as a function of habituation group, sex, and age in Figure 7. Notice that for boys short looking-rapid habituating infants responded positively to the discrepancies relative to the familiar standard whereas long looking-nonhabituating infants either did not respond differentially or actually avoided perceptual exposure to moderate discrepancies. These results were more emphatic at 5 1/2 than at 4 months. The same was true for younger girls, and with the exception of the general level of response, the relative response pattern for 4-month girls was identical to that for 5 1/2-month males. There appears to be a six-week developmental phase difference for boys and girls. However, both habituation groups of older girls showed an inverted-U pattern of response in accordance with the discrepancy hypothesis. Note that the difference between rapid and slow habituators is quite analogous to the difference between these groups in the short-term familiarization context presented earlier in Figure 4.



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These data have several implications. First, many of the sex differences observed in the literature may be reflections of differences in developmental rates between males and females rather than an indication of enduring or pervasive qualitative differences between the sexes. Second, the inverted-U prediction of the discrepancy hypothesis appears to be a developmentally more mature pattern since it was displayed by the older and presumably more advanced females. Specifically note in this regard that avoiding perceptual exposure to relatively extreme discrepancies may be a developmentally older response. Third, the short looking-rapid habituation pattern also may be a more mature response pattern for two reasons: a) these infants displayed a developmentally older response to discrepancy and b) the parents of these infants averaged two more years of education than the parents of long looking-nonhabituating infants. Fourth, some infants displayed "gaze avoidance" to moderate discrepancies whereas other infants showed perceptual approach behavior to these same stimuli. If it is assumed that short looking-rapid habituation is a more mature habituation pattern and that such behavior evidences the acquisition of a mature memory engram, then it may be that moderate discrepancies from an immature memory are perceptually avoided whereas those same discrepancies from a maturely formed memory engram are perceptually approached. This would suggest that the infant "tunes out" stimuli that might interfere with weakly formed or emerging memories.

Conclusions

These data represent several extensions and qualifications on our working set of assumptions. First, it may be instructive to study the sexes developmentally since some observed sex differences may reflect contrasting rates or phases of development. Second, developmental and maturational processes during the first few months of life may have greater impact upon the process of acquiring a memory engram than on the retrieval and use of that engram in processing new stimuli.

From an evolutionary standpoint, it seems quite reasonable to protect young organisms from cluttering their memory store with engrams which are not absolutely necessary for their survival. However, if a stimulus is so imposing that it does become encoded, the young as well as the older infant apparently is capable of retrieving and using that stimulus to process new stimuli. Third, it may be just as important for us to study what the infant chooses not to look at as it is for us to study what he will look at. It is possible that with development infants tune out extreme discrepancies because they cannot readily relate those stimuli to existing memory engrams. Further, some infants perceptually avoid moderate discrepancies whereas other infants perceptually approach those same discrepancies, perhaps as a function of the maturity of the memory engram to which the infant relates the new input. If that memory is immature, he may avoid looking at moderate discrepancies, whereas he may approach those same stimuli if the standard is firmly encoded.

It is now hackneyed to deny William James's famous belief that the perceptual world of the infant is a "blooming, buzzing confusion." Actually, his world appears highly structured and consummately adaptive. The blooming, buzzing confusion was (and probably still is) in the eye of the adult beholder -- the infant is undoubtedly doing fine.

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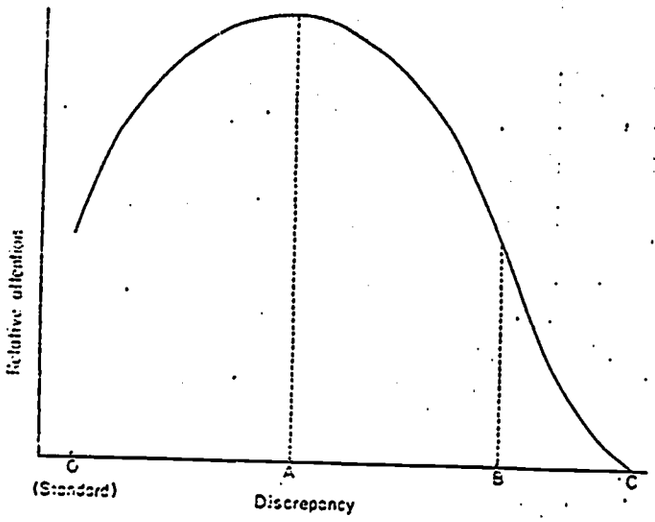



Figure 1.

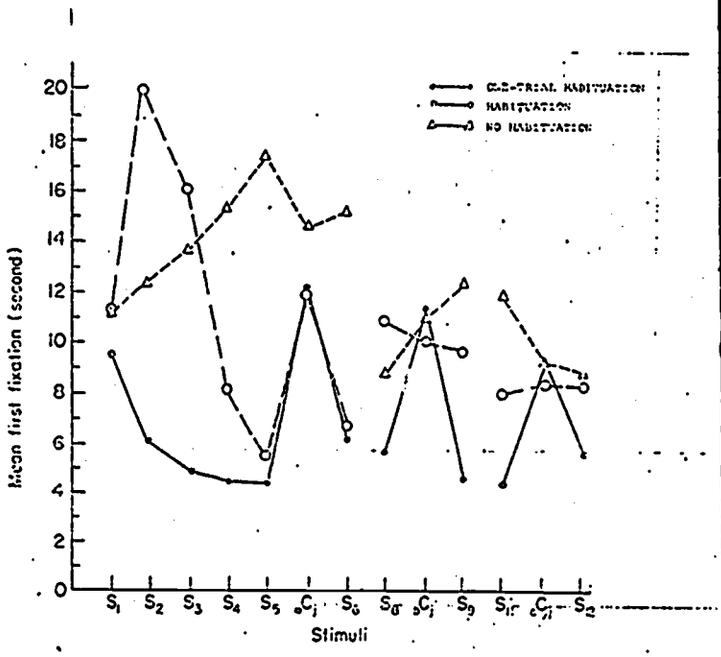



Figure 2.

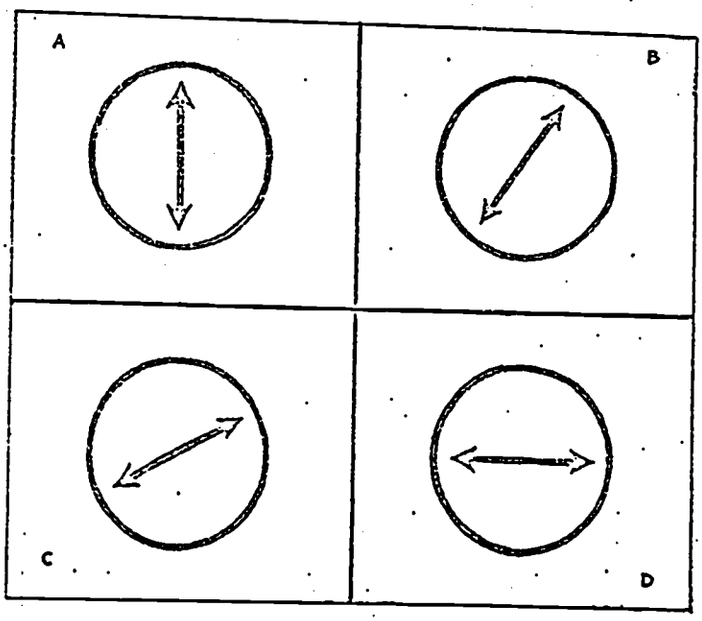



Figure 3.

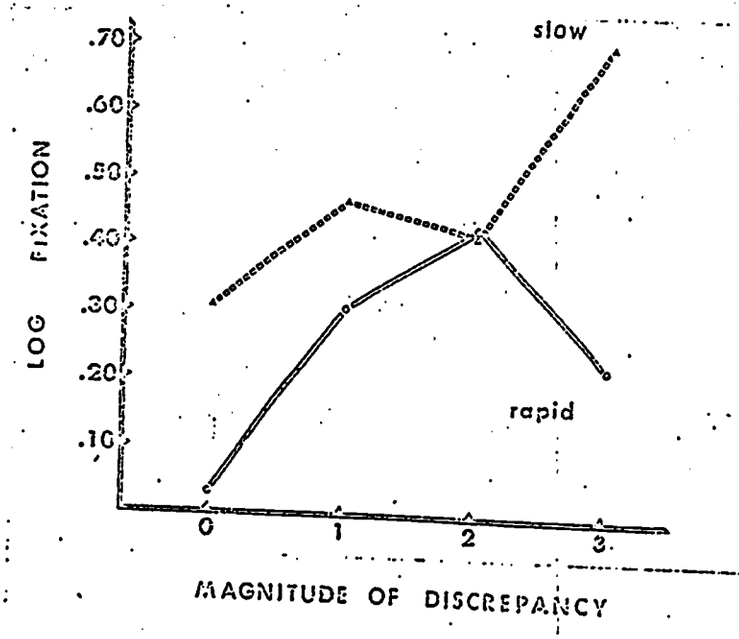
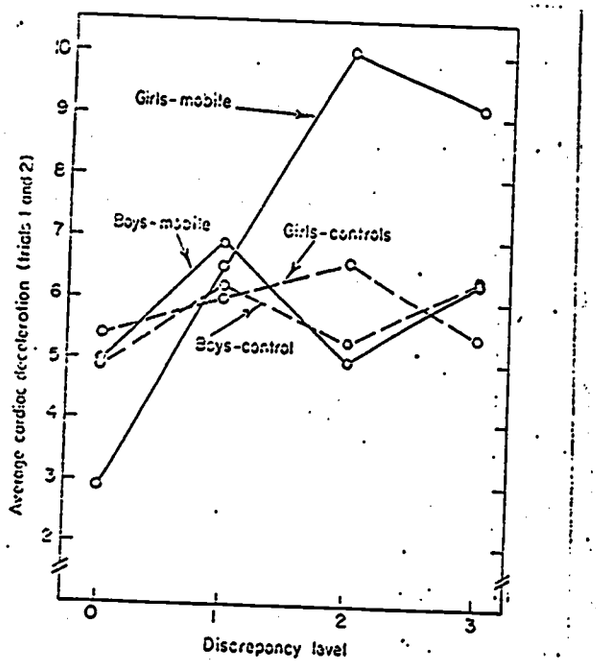



Figure 4.

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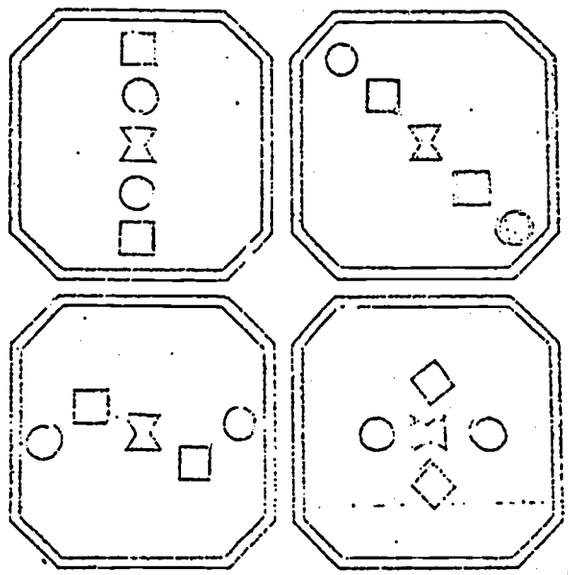

Figure 6.

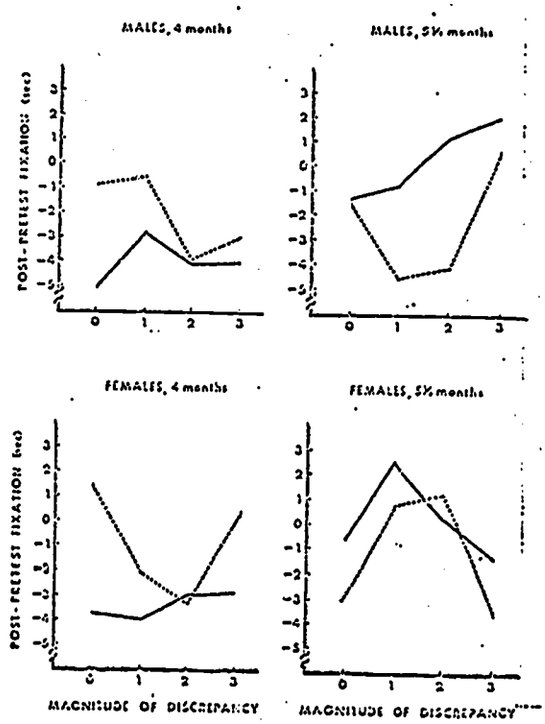




Figure 7