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ABSTRACT

Two experiments are reported in which cardiac habituation and dishabituation to pure tone stimuli were studied in well and malnourished Guatemalan infants. In both studies the magnitude of the orienting response was found to be attenuated or completely absent in infants suffering from nutritional insult. The findings were taken as evidence of a basic learning deficit that might account for the often reported poor performance of malnourished children on standard psychological tests. (Author/DP)

THE EFFECT OF MALNUTRITION ON AUTONOMIC REACTIVITY TO AN AUDITORY SIGNAL: SOME PRELIMINARY FINDINGS[1]

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Abstract

Two experiments are reported in which cardiac habituation and dishabituation to pure tone stimuli were studied in well and malnourished Guatemalan infants. In both studies the magnitude of the orienting response was found to be attenuated or completely absent in infants suffering from nutritional insult. The findings were taken as evidence of a basic learning deficit that might account for the often reported poor performance of malnourished children on standard psychological tests.

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Barry Lester

Studies relating nutritional status to mental development generally have been conducted with preschool and school-age children. Few attempts have been made to assess the effects of malnutrition on behavior within the first two years of life. Moreover, those studies which have focused on infancy have been concerned with reporting gross differences in behavior particularly as measured by standard infant scales (Chase and Martin, 1970; Cravioto and Robles, 1965; Monckeberg, 1968; Stoch and Smythe, 1968). While infant developmental scales are useful as descriptors of overall psycho-motor functioning, unfortunately, they do not specify the underlying psychological processes that may be affected by malnutrition.

On the other hand, specific psychological deficits are one characteristic feature of the clinical syndrome of malnutrition. The infant suffering from nutritional insult is universally found to be unresponsive to stimulus changes in the environment. The exploratory behavior, curiosity, and activity so typical of the normal infant is dramatically reduced or absent among malnourished infants. For example, so marked is this condition of apathy that one of the hallmarks of recovery from malnutrition is the reappearence of the smile.

The purpose of the present research was to provide an experimental test of the hypothesis that the infant's ability to respond appropriately to impinging environmental stimulation is affected by nutritional insult. Two studies are reported in which orientation and habituation to an auditory stimulus are compared in infants of varying nutritional status.

The first experiment was a pilot study to determine the utility of the habituation paradigm for assessing differences due to malnutrition. The subjects for the study were sixteen male infants with a mean age of 13 1/2 months. Subjects were drawn from State run institutions in Guatemala City, Guatemala, where they were supposedly rehabilitated from malnutrition. In fact, eight of the infants were suffering from second or third degree malnutrition whereas the remaining infants were better nourished, suffering from first degree malnutrition.

These grades of malnutrition are based on the weight for age norms established by Gomez (1956) from a sample in Mexico City. Weight is considered to be the key anthropometric measure, particularly at younger ages, as weight loss is one of the first signs of malnutrition. According to the Gomez (1956) scale, first degree malnutrition refers to body weight between 76% to 90% of the established norm for the child's age. For second and third degree malnutrition body weight is below 76% and 61% of the average weight for age, respectively. Table 1 shows the means for weight, height, head circumference, and age for these two groups of infants, one of which is relatively well nourished while the other is clearly malnourished.

The infants were seated in a sound attenuated chamber and presented with forty trials of a pure tone stimulus. The forty trials consisted of twenty trials of a 750 Hz tone followed by ten trials of a 400 Hz tone and ten more trials of the 750 Hz tone. The tones were presented at 90 db for five seconds with a randomized inter-trial interval. The dependent variable was heart rate calculated as a change score in cardiac activity from prestimulus to stimulus onset periods.

Insert Table 1 about here

Figure 1 shows the mean heart rate deceleration to the three tone sequences for the well and malnourished infants. A t test revealed that the mean heart rate deceleration to stimulus onset, or trial 1, was larger in the well nourished than in the malnourished infants [$t(14) = 3.67$, $p < .01$]. Likewise, the well nourished infants showed larger heart rate decelerations than the malnourished infants to the two dishabituation stimuli on trial 21, [$t(14) = 1.76$, $p < .05$], and on trial 31, [$t(14) = 1.77$, $p < .05$].

Insert Figure 1 about here

Furthermore, whereas the well nourished infants showed clear recognition of the changes in tonal frequency, the malnourished infants appeared not to. Within group t tests between each dishabituation trial and the immediately preceding trial revealed that for the well nourished infants the mean heart rate deceleration was larger on trial 21 than on trial 20, [$t(17) = 2.16$, $p < .05$], and was larger on trial 31 than on trial 30, [$t(7) = 2.18$, $p < .05$]. For the malnourished infants, similar comparisons were not significant. Finally, mean differences in prestimulus heart rate between the two groups were not significant suggesting that these results were not an artifact of baseline differences in autonomic activity.

These preliminary findings suggested that the experimental technique of habituation was sensitive to the early effects of nutritional insult. Specifically, the orienting response appeared to be diminished in infants suffering from malnutrition. However, because of the possible confounding effects of institutionalization and the small sample size, a more comprehensive study was planned.

The subjects for the main study were forty, male, one-year-old infants from the lower socioeconomic class of Guatemala City. The infants were full-term, full birth weight, clinically normal, and suffered no major illnesses as of the time of testing. Their mothers reported no pregnancy or birth complications, nor were they sedated during the birth of the child. Half of the infants were suffering from second or third degree malnutrition according to the Gomez (1956) norms whereas the remaining twenty infants had an average or slightly below average weight for their age. The age and anthropometric characteristics of the sample are presented in Table 1.

The experimental procedure was identical to that reported in the first study with the following exceptions. First, twenty rather than forty trials were presented. Second, the design was balanced for the order of stimulus presentation. Thus, twenty subjects were randomly assigned to one order which consisted of ten trials of a 750 Hz tone followed by five trials of a 400 Hz tone and five trials of the 750 Hz tone. For the other half of the sample, this order was reversed. As an analysis of variance revealed no effects due to the order of stimulus presentation, the order conditions were collapsed resulting in twenty subjects per nutrition cell.

A third difference from the first experiment is that infants in the present study were tested while seated in their mother's laps. The mothers were prevented from hearing the tones by listening to prerecorded music through a set of head phones. Finally, all infants were tested while in an awake and alert state.

The results from this study are presented in Figure 2 which shows the mean heart rate deceleration to the three tone sequence for the well and malnourished infants. Note the order conditions are combined in the figure. For the well nourished infants analysis of variance

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Insert Figure 2 about here

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showed a response decrement in heart rate deceleration to each tone sequence, $F(9,153) = 8.78$, $p < .005$ for tone A; $F(4,68) = 12.55$, $p < .005$ for tone B; and $F(4,64) = 6.25$, $p < .005$ for the second sequence of tone A. In other words, each tone produced a large initial orienting response followed by rapid habituation. The analysis for the malnourished infants, on the other hand, revealed no significant trials effect for any of the tone sequences. The minimal heart rate decelerations for these infants remained constant throughout the entire experimental session.

Similarly, whereas the well nourished infants evidenced substantial increments in heart rate decelerations to the two dishabituation stimuli,the malnourished infants did not react to the changes in tonal frequency. Analysis of variance for the well nourished group showed that the magnitude of heart rate deceleration was larger on trial 11 than on trial 10, $F(1,18) = 27.88$, $p < .005$, and was larger on trial 16 than on trial 15, $F(1,16) = 32.38$, $p < .005$. For the malnourished group, the dishabituation stimuli did not result in increases in the magnitude of heart rate decelerations.

Finally, analysis of variance were performed between the two groups for each tone sequence. As might be expected, the analysis for each tone sequence revealed a significant nutrition by trials interaction, $F(9,324) = 5.61$, $p < .005$ for tone A; $F(4,132) = 5.56$, $p < .005$ for tone B; and $F(4,132) = 4.78$, $p < .005$ for the second sequence of tone A. This interaction was due to the large heart rate deceleration to the first trial of each tone sequence in the well nourished group. In fact, between group differences were no longer significant when the first trial of each tone sequence was eliminated from the analysis.

Once again, there were no group differences in prestimulus heart rate. Furthermore, while it might be suspected that the malnourished infants reacted to the tones as a fear producing stimulus, this suspicion did not gain empirical support; there were no differences in heart rate accelerations to any of the tone sequences between the well and malnourished infants.

The results from this study reveal a clear nutritional effect on the infant's ability to respond to and process impinging novel stimulation. Infants suffering from malnutrition were found to evidence an attenuation or complete absence of the orienting response when presented with repeated trials of a novel stimulus as well as qualitative changes in that stimulus. These results support the clinical observations of Birch (1970) and others that stimulus receptivity is affected by nutritional insult and further suggest that this lack of receptivity is due to the absence or attenuation of the orienting response.

Recent studies by Zeiner and Schell (1971) and Ingram and Fitzgerald (1972) have reported a relation between magnitude of the orienting response and rate of acquisition of a conditional discrimination. If magnitude of the orienting response does, indeed, predict conditionability then absence or attenuation of the orienting response may be indicative of a learning deficit. This suggests that the kinds of deficits observed in the present study, if they persist into childhood, can account, at least partially, for the often reported poor performance of malnourished children on standard psychological tests (Birch and Gussow, 1970).

Obviously, whether or not these effects are reversible cannot be determined from the present study. Research with animals has shown that malnutrition can lead to structural damage to the central nervous system. Dobbing (1970) has proposed that in any species, brain development may be most vulnerable to damage if malnutrition occurs during the period of rapid brain growth. In terms of such an hypothesis, the human brain would be most sensitive to nutritional insult from the last trimester of pregnancy through the first few years of life. Studies with humans have, in fact, shown that the effect of nutritional insult on intellectual functioning is most severe when malnutrition is suffered early in life.

Thus, the timing of the onset of malnutrition may be a determinant of the reversibility of the effects of malnutrition. This implies that for developing countries, such as Guatemala, nutritional rehabilitation programs should pay particular attention to the period of infancy, especially where early weaning on protein deficient diets often leads to malnutrition within the first year of life.

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Table 1

Descriptive Data

Pilot Study

Groups	Age (mos.)	Weight (lbs.)	Height (cms.)	Head Circumference (cms.)
Well nourished	$\bar{X}$=13.75	$\bar{X}$=17.40	$\bar{X}$=71.85	$\bar{X}$=44.57
(N=8)	SD= 7.81	SD= 3.28	SD= 5.81	SD= 2.07
Malnourished	$\bar{X}$=13.25	$\bar{X}$=14.71	$\bar{X}$=68.42	$\bar{X}$=43.14
(N=8)	SD= 3.10	SD= 3.03	SD= 5.34	SD= 1.46

Main Study

Groups	Age (mos.)	Weight (lbs.)	Height (cms.)	Head Circumference (cms.)
Well nourished	$\bar{X}$=12.38	$\bar{X}$=20.76	$\bar{X}$=72.19	$\bar{X}$=45.48
(N=20)	SD= 1.30	SD= 1.92	SD= 2.87	SD= 1.34
Malnourished	$\bar{X}$=12.28	$\bar{X}$=15.44	$\bar{X}$=67.77	$\bar{X}$=43.87
(N=20)	SD= 1.34	SD= 1.42	SD= 2.89	SD= 1.35

Figure 1. Heart Rate Deceleration to Pure Tone Stimuli in Well and Malnourished Infants

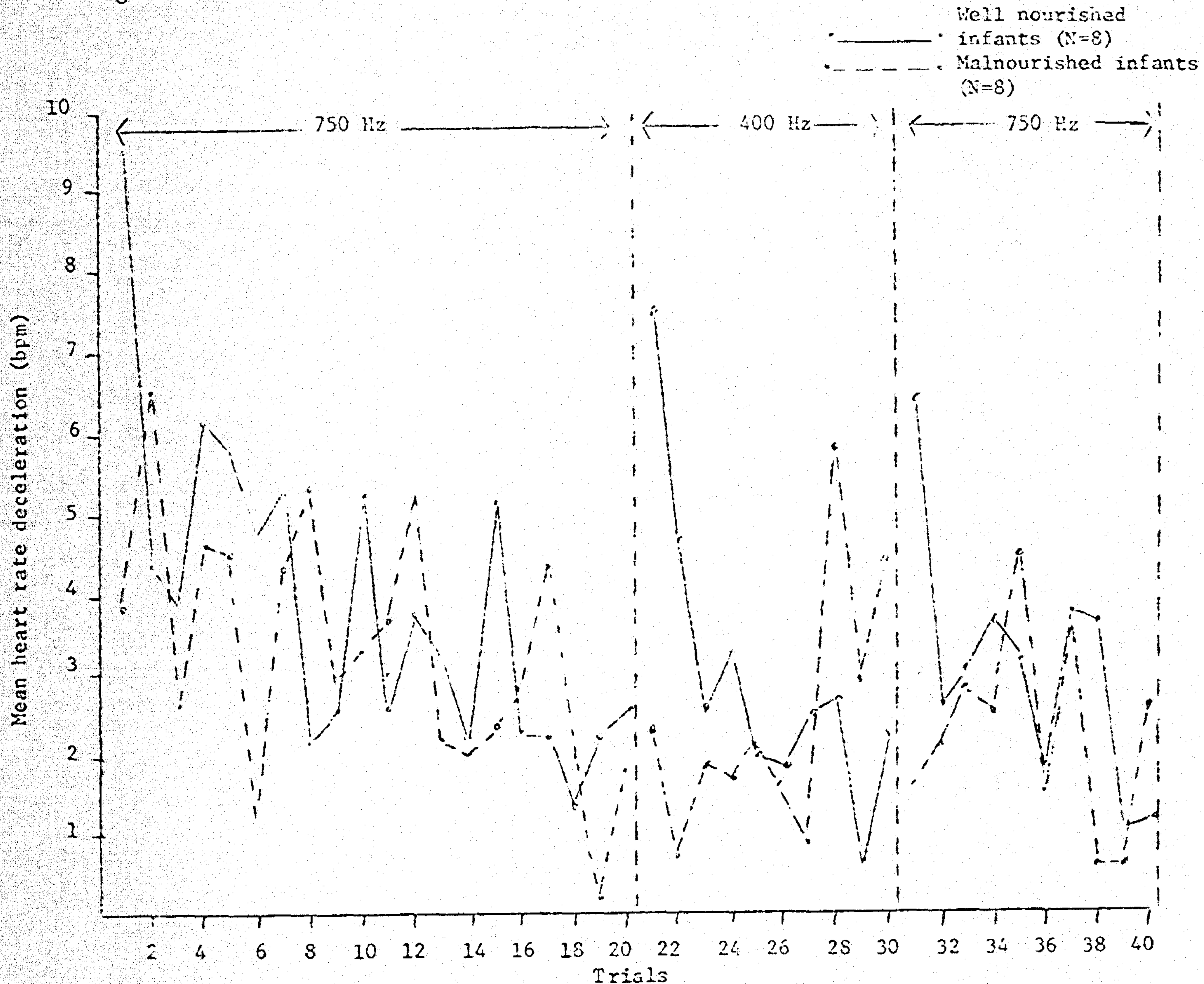

Figure 2. Heart Rate Deceleration to Pure Tone Stimuli in Well and Malnourished Infants