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INDIVIDUAL DIFFERENCES IN THE EFFECTS OF EARLY EXPERIENCE ON AFTER BEHAVIOR.

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TWO SERIES OF STUDIES WHOSE SUBJECTS WERE EITHER HOODED AND ALBINO RATS OR YOUNG CHILDREN INVESTIGATED THE INFLUENCE OF EARLY EXPERIENCES ON LATER BEHAVIOR. IN THE FIRST, BOTH SUBSPECIES OF RATS WERE EXPOSED TO EITHER ENRICHED OR RESTRICTED ENVIRONMENTS TO ASSESS THEIR PROBLEM-SOLVING ABILITIES UNDER VARIOUS LEARNING CONDITIONS. THE RESULTS SUGGESTED THAT EARLY ENRICHED EXPERIENCES WILL HELP DEVELOP THE USEFUL CHARACTERISTICS THAT THE ORGANISM ORDINARILY EMPLOYS. WHEN THIS DEVELOPMENT IS INHIBITED, HIERARCHICALLY LOWER CHARACTERISTICS WILL EMERGE MORE PROMINENTLY. THE RESULTS REINFORCED THE IDEA OF GENETIC LIMITATION BUT SUGGESTED THAT THERE IS A WIDE VARIATION OF DEVELOPMENT IN THE ORGANISM WHICH DEPENDS ON ITS EARLY LIFE EXPERIENCES. IN ONE OF THE REINFORCEMENT STUDIES ON YOUNG CHILDREN, IN WHICH A "SUPER- PLAYPEN" ROOM WITH NINE SETS OF MANIPULANDA WAS USED, THE PERFORMANCE OF MIDDLE-CLASS 4-YEAR-OLDS WAS COMPARED TO THAT OF LOWER-CLASS NEGROES. BOTH GROUPS LEARNED THE DISCRIMINATIONS BUT THE MIDDLE-CLASS STUDENTS LEARNED FASTER AND MORE STABLY ALTHOUGH BY THE END OF THE EXPERIMENT THE LOWER CLASS GROUP HAD CAUGHT UP IN RATE AND LEVEL OF CORRECTNESS. THE STUDIES INDICATED THAT DIFFERENCES IN EXPERIMENTAL SUBJECTS ARE AS IMPORTANT IN HUMANS AS THEY ARE IN LOWER ANIMALS IN INVESTIGATIONS OF THE POSSIBLE PROFIT THAT CAN BE OBTAINED FROM EARLY EXPOSURE. STUDIES OF THE LONG-TERM EFFECTS OF ENRICHMENT INTERVENTION WERE RECOMMENDED. THIS PAPER WAS PRESENTED AT THE ANNUAL INVITATIONAL CONFERENCE ON URBAN EDUCATION (4TH, YESHIVA UNIVERSITY, APRIL 26, 1965). (NH)

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INDIVIDUAL DIFFERENCES IN THE EFFECTS OF EARLY EXPERIENCE ON LATER BEHAVIOR

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I wish, here, to make a progress report, as I have in the past, on two series of studies which have occupied our attention for several years. The studies are concerned broadly with the influence of early experience upon later behavior and, more recently, with an analysis of the nature of reinforcement. While our early efforts examined the process aspects of the phenomena, that is, the general statements which we can make about such behavior, we have lately become quite impressed with the apparent relationship which exists between subject characteristics and ability to profit from a program of early exposure and the manner in which such advantage may be reflected in specific behavior.

The latest studies of the first series use rats as subjects and have examined the effects of variation of specific type of exposure, time and amount of such exposure, and sub-species of rat. I will make a general report of these observations shortly. The second series of studies, though now of five years standing, is still quite preliminary. The observations are concerned with the behavior of young children in an elaborate playpen environment which delivers a good deal of sensory reinforcement for appropriate responding. I will describe this experimental setting and report on the results of two studies.

The rat studies involve exposing the animal to an enriched environment (free-environment) or to a sparse environment (restricted) for various periods during development. The free-environmental experience has been described sufficiently well in the literature; briefly, here, it consists of a large box, as compared with the ordinary living cage, and the box contains many "playthings" - simple metal and wooden objects which the subjects may run over, through, around, and so on. The rats are placed in small groups in this free-environmental box for a period of time varying from one to several weeks and removed to regular colony experiences for the remainder of the development period. They are tested, usually when they are about 120 days of age, for "emotionality" - typically using the open field test, and scored in terms of activity, field penetration, defecation and urination - and for intellectual responding - using the Hebb-Williams maze.

We have emplcyed two sub-species of rat in these studies - the hooded rat which has a pigmented eye and therefore good vision, for a rat, and the albino rat with the non-pigmented eye and therefore not very good vision, especially for distant viewing.

Free-environmental exposure times have included in one study, which employed albino rats, every three-week period from birth until 109 days of age (that is, 0 to 21 days, 22 to 43 days, 44 to 65 days, etc.,); in another study using albino rats: one, two, or three weeks after weaning as compared with three weeks at maturity or no exposure at all; and in a third study, in which hooded rats were used: one, two, or three weeks after the eyes are open (15 days) or at weaning (21 days) as compared with three weeks at maturity or no experience at all.

Since we are careful to provide all animals in such studies with equivalent handling experiences, it is usual that we find no "emotionality" differences at maturity among animals in a study. Such is the case here. We do find, however, that the albino animals are somewhat more "emotional" than the hooded, a finding which, I believe, is not in disagreement with the literature. On the Hebb-Williams maze, however, there are clear differences among the groups. Those exposed to the free-

environment before maturity are clearly better adult problem solvers than those exposed at maturity or not at all. Even those animals receiving only a week's exposure at 15 or 21 days of age display better adult intellect than those receiving three weeks exposure at 90 days of age. Those receiving the free-environmental experience as adults are not significantly better problem-solvers than those not receiving the experience at all.

These effects apply to both the albino and hooded animal; that is, for both types of rat early free-environmental exposure is associated with superior adult problem solving. On the other hand, there are clear differences between the hooded and albino rats. The hooded animal appears to be a superior performer on the Hebb-Williams maze to the albino animal, whenever specific groups with comparable past experiences are compared. Interestingly, the restricted (no free-environmental exposure) hooded rat makes about as many Hebb-Williams errors as the enriched (early free-environmental exposure) albino rat, that is, if both are reared in the light; of course, the restricted albino rat makes still more errors, so the superiority of the hooded is maintained throughout. This is not so if all animals are reared with restricted light experience, as you will shortly hear. It is also not so if the animals are maze-run in the dark, as you will also hear.

After we run the rats on the Hebb-Williams maze problems, we usually run them on a series of problems in the same maze, but one in which we change the visual distance or near cues, the olfactory cues, and so on. We attempt in this way to discover the kinds of cues which, if changed, will be most disruptive to problem solving. We assume that such cues are likely involved in successful maze performance under typical running conditions. In the studies I have already mentioned, we have found that early enriched exposure is associated with the use of different kinds of environmental cues in successful maze running. The hooded animals are more disrupted by a change in the visual distance cues, while the albinos are more disrupted by a change of visual near cues. It seems, then, that the hooded animals with early enriched experience make greater use of visual distance cues in

the superior maze performance while albinos with early enriched experience make greater use of visual near cues in their superior adult maze running. These results may not stagger your imagination. Since you know that the hooded animal has far better visual equipment than the albino, it is reasonable, indeed, that he will more tend to employ the stable visual distance cues to aid his maze performance while the albino will tend to use more the near visual cues or some other kind of near cue. In brief, then, each type of organism will profit from the early enriched exposure according to the capabilities which he has to begin with. Our own thinking is in this direction, but the picture is not quite so simple.

To study further the nature of free-environmental experience, we examined the adult problem-solving ability of the hooded rat provided with visual distance cue experience in early life as compared with such animals not allowed this experience. We accomplished this by rearing the animals in boxes with open mesh sides or in closed boxes which were lighted inside. In each case we had enriched and restricted groups. When we tested them as adults, we found no "emotionality" differences among groups, but did find on the Hebb-Williams maze that the two enriched groups were superior to the two restricted groups, and there were no differences between the two enriched groups and none between the two restricted groups. Recall that one of each of these was raised in an open mesh environment and the other in a closed environment. How can this be? Did we not already find out that visual distance cues contribute importantly to maze performance? Are both enriched groups using to good advantage the same cues in their maze performance? No! Disrupted cue analysis reveals that the animals reared in the free open environment use visual cues in general more than those animals reared in the closed environment, and especially visual distance cues. Closed animals use more near visual cues and olfactory cues. Thus, both open and closed reared free-environmental hooded rats are superior to their restricted counterparts, but, apparently, for different reasons. They seem to have profited from the rearing, but on the basis of the successful utility of different cues.

The last rat study which I will report here is one whose data have just been collected earlier this month. It is a thesis study being accomplished by Robert LaVallee at the University of Vermont. This was a more systematic attempt to assess the relationship between subject characteristics and the influence of early experience than those which had been accomplished previously. Hooded and albino rats were used as subjects. Half of each group was reared in the free-environmental setting and the other half in the restricted environment of small laboratory cages. Half of each of these groups were put in a sealed room in which good lighting was left on 24 hours a day; the other half were put in a sealed room in which good lighting was put on for one hour a day. Essentially this latter group was reared in the dark with sufficient light, however, so that there would be no retinal or thalamic degeneration. When all were mature animals they were tested for "emotionality" and displayed no significant differences among the various group comparisons. All had been handled a good deal during rearing. The Hebb-Williams testing was done initially in a sealed room which was well lighted, much like the rearing environment. On these maze problems the hooded animals over-all sub-groups are not significantly superior to the albinos - the first time that we have found this. There is, however, a significant interaction between type of animal and light vs. dark rearing. Essentially, if reared under the darker conditions, hooded animals score about the same as albinos reared in the same environment. If reared under light conditions, hooded animals are significantly better than albino animals reared in light. Hooded animals reared in the light are superior to hoodeds reared in the dark. For albinos, it makes no difference; those reared in the dark are the same as those reared in the light. What these results amount to, then, is that restriction leads to a poor problem solver in the albino animal and this is not influenced further by the amount of light stimulation provided him, within the limits of this study. The same is true for free-environmental experience for the albino. The hooded animal is generally better, however, than the albino. If he is given free-environmental experience in light or in dark or if he is simply provided a good

deal of light experience during development, even in a restricted environment, he turns out well at maturity on the maze problems. If he is reared in the restricted environment with little light stimulation he turns out to be a poor problem solver later on; or, in other terms, one can <u>almost</u> make a hooded-type problem solver out of the albino animal if the albino is provided a good deal of enriched early experience, although not necessarily including visual experience. On the other hand, one can produce a hooded animal with typical albino problem-solving characteristics only by a combination of the restricted environment and little light experience during early life.

The story goes on. After these animals had been tested in the Hebb-Williams maze under normal light conditions, they were subjected to further testing in the same maze but in a completely dark room. The animal wore a collar treated with phosphorescent material and the grid floor of the maze was similarly treated. The experimenter could make out the pattern of maze running and count errors reliably after he had become completely dark adapted. Now, how will the animals fare? If our hunch is correct, the hooded animals will be more adversely influenced than the albinos by the change in light conditions which precludes the use of visual distance cues to aid solution of the maze problems.

Our hunch turned out to be quite acceptable, even though this was not at all a case of serendipity. In absolute error terms, each sub-group of albinos performed better than the comparable sub-group of hoodeds. A more interesting analysis is provided, however, by comparing the error score derived from running in the light to that reflecting running in the dark. For the albino groups, three of the four sub-groups decreased their error scores by from 25% to 30%. The fourth dropped only 11%; this was the group reared in the free-environment in the light. In short, the albino group most likely influenced during rearing by visual experience is most affected by change in light conditions during maze running. As for the hooded rats, a sorry lot, two sub-groups decreased their error scores by a small amount, 4% and 8%, and two demonstrated actual increases of error score, 4% in each case. You have guessed by now! The groups reared in the dark decrease while those

reared in the light increase.

The results of this study and previous ones suggest to us that early enriched experience interacts with subject characteristics to determine whether the environment will have a beneficial effect, and, if so, the manner in which this will be accomplished. Hooded rats are typically better adult problem solvers than albinos of comparable experience. In past studies where animals were reared under light conditions, this generalization could have been made group by group. We have now added the limitation to this generalization: if hoodeds are reared under restricted and dark conditions they will be as poor as the restricted albino - not worse, mind you, but as poor. Both types of animal appear to benefit from enriched early experience, but, apparently, for different reasons; one because of the greater development of the use of visual distance cues, and the other, the use of near cues. Light experience does not seem to be especially crucial for the albino animal, while it appears quite important for the hooded. If the hooded animal doesn't have much light experience, then you have to give him the free-environmental treatment if he is to be a good adult problem-solver. The albino animal requires the free-environmental treatment if he is to be a reasonably good adult problem-solver, regardless of amount of light experience. Hooded animals who are deprived of the early visual distance experience still profit from free-environmental exposure, but it must be because they are using to advantage other cues presumably sharpened by their early experience.

Specifically, then, these results encourage the speculation that enriched experience in early life will aid the development of those characteristics which are prominently useful and ordinarily employed by the rganism. If such characteristics do not develop because of a limiting environment, then other characteristics, lower in the organism's hierarchy, may develop to a higher degree than they ordinarily would, given a more typical developmental environment. Either of these patterns of development may then lead to superior adult problem solving ability. This possibility would depend, of course, on the nature of the adult tasks used to evaluate

the effects of the early experience. These notions would appear to have relevance for a general theory of development and particularly for speculations concerned with the determination of the most efficacious training methods for the inculcation of sophisticated behavior patterns in the young. Our results are consistent with the idea of genetic limitation, but suggest a wide variation of development within that limitation, such development being dependent upon the type and amount of experience, especially that during early life.

As an aside, I might mention here that our new series of early experience studies, beginning in the summer, will employ a modified exposure technique over that we have used. Instead of the animal "going to" the experience, we will bring the experience to the animal. We have felt for some time that our exposure technique, large boxes versus small cages, did not provide sufficient control. All animals, in the future, will be reared in a small box. Each of the four walls of the box will open out on a long tunnel. Through a program of stimuli we will provide for a little or a lot of visual experience, distance and near cues, and the like. We will have a much better idea than presently of the differences in experience of our various groups.

So much for the lower animal research. I wish now to briefly describe the second series of studies which have concerned us over the past several years. This program involves human subjects and began as an inquiry into the nature of reinforcement. Eight years ago we constructed a super-playpen for young children; it was an eight-foot-square plywood enclosure with different kinds of manipulanda available to the subjects which, if activated, resulted in lights and bells and other types of sensory feedback occurring. We placed youngsters singly in this environment for short periods for a few trials and observed their activity. To study the utility of the playpen as a learning situation, beyond that involved in learning to manipulate such things as levers, we provided a dummy set of manipulanda beside each of those that activated the sensory change. A brightness discrimination - black versus white panels - was associated with the manipulanda so that the child

could learn to receive the sensory payoff by operating the apparatus mounted only on a black panel. Children of both sexes and from 9 months to 5 years of age were observed under generally informal circumstances. Early results were promising, at least to the extent that such young children would remain in the playpen for periods of 15 minutes or so without fear, they were able to operate the manipulanda, and they appeared to be motivated to receive the sensory feedback. On the other hand, those subjects who were exposed to the playpen for several trials seemed to satiate on the limited sensory feedback possibilities, since they did not change from trial to trial. In short, they got bored. Moreover, this environment turned out not to be a good learning situation, since the black and white panels were fixed, thus allowing the subject to adopt position habits and avoid the brightness discrimination altogether. As one of our objectives was to study a variety of discriminations we were forced to modify the environment.

The second environment was considerably more complicated than the first. The original super-playpen was a plywood room within a "real" room. This proved to be disturbing to some children who knew that mother was just beyond a four-foot plywood wall. In addition, some of the mothers, sensing that their little Johnnies, and feeling, perhaps erroneously, that this game was some sort of intelligence test, encouraged their children over the wall - hardly a sharply controlled experimental situation. The revised colossal-playpen was a full room, 11 by 16 feet, with nine different gadget complexes mounted in colored wooden enclosures attached to the four walls. Each sensory payoff apparatus had two distinct sets of manipulanda; these, in turn, were electrically connected to relays and counters in an adjoining room which also contained a one-way window looking on to the playroom. Knife switches were provided so that either manipulandum for a gadget could be set to activate it. Four-inch wooden squares, easily changed, were attached above each manipulandum and formed the basis of the discrimination problem for the child. The sensory payoffs included:

a. different colored lights activated by pressing the correct levers.

b. a music box playing a tune ("How Dry I Am") when the correct lever was turned.

c. a hidden drum which could be sounded by pulling sharply on the correct of two cords.

d. an electric train on a 3-foot track mounted behind clear plastic; the train could be activated for 3-second intervals by pressing the right switch.

e. a unit containing white shielded lights and hand switches, but actually operated by foot treadles. This was an attempt to observe "superstitious" behavior in our subjects.

f. a sixth gadget was our counterpart of Aldous Huxley's "feelies." The child could reach his hand into one of two entry ports, feeling a thick piece of soft sponge rubber in the correct port and a smooth piece of plastic in the "incorrect" port.

g. a unit containing a number of interchangeable plastic-mounted pictures attached to a round disc which revolved with correct lever press allowing the view of a single picture through an aperture. The pictures were colored and of such objects as a teddy bear, a baby, an adult female, an adult male, etc.

h. two telephones connected to a third in the adjoining room. If the child spoke into the correct phone, the experimenter would speak to him for a few seconds and then hang up.

i. two window ports opening on to the adjoining room. If the child pulled the correct cord, the port would open allowing him a view of the experimenter (a young adult female).

You will recall that all of the manipulanda are

connected to counters giving us an exact picture of the frequency of interaction between child and gadget and the number of correct as well as incorrect responses. Sequence of the child's activity is provided by observation through the one-way window.

In one series of studies, we have placed children who were from a little less than one year to a little more than 5 years of age in the playpen for from 6 to 10 acquisition trials of 10 minutes each, with a brightness discrimination to be solved. The trials occur at the rate of three per week and the correct manipulanda and discrimination squares are varied on a random basis.

In one study whose results I have already partly reported we have compared two groups of 4-year-old children, both sexes equally represented. One group consisted of children of middle class parents and the other of children of working class parents. Negro children comprised this latter group. Their behavior patterns in the playpen situation are quite different. An important finding is that neither group seems to get satiated in this environment. At the end of the trials most subjects are quite willing to continue and appear to have enjoyed the experience. There are gadget differences between the two groups. The "feelies" are not as attractive to our subjects as Huxley would have had us believe; this is true for both groups. The telephones are manipulated much more frequently by the working class children, likely because they are more novel stimuli for them. Both groups display superstitious behavior and equally so. And so on.

Over all trials, the middle class subjects make about 50% more responses than the working class subjects. This is more than just a matter of more diffuse activity on the part of the middle class children, since they also make more <u>correct</u> responses than the working class children. Remember, this is on the basis of over-all responding. Both groups display evidence of learning the discrimination, but the middle class subjects show it earlier and more stably. The maximum amount of time for any child in the playpen is less than two hours, total, so the learning would appear to be reasonably efficient.

There are response level changes over trials. The working class children increase their response rate over trials as compared with the middle class children who maintain a relatively stable rate throughout. At the end of the series of trials the working class children display a rate of correct response equivalent to that of the middle class children. In short, they have "caught up" with the middle class group on this relatively easy discrimination problem.

We have carried these observations further in some very recent studies, in line with our interest in studying more difficult discrimination problems within the same experimental design. We employed a shape discrimination as our problem - the familiar triangle versus circle. Wooden squares with these figures painted on them were mounted over the manipulanda and the placement changed from trial to trial on a random basis. Triangle was positive for half the subjects and circle for the other half. Two groups of four-year-old subjects comparable to those described already were employed. Results were similar to those reported for the brightness discrimination problem. Middle class children respond more absolutely and more correctly on the early trials; at the end of ten trials, the working class children are responding at the same rate and level of correctness as the middle class children. Both groups display evidence of learning the discrimination, with the middle class children showing the learning earlier and more stably.

We have taken this inquiry one step further. We have essentially replicated the shape discrimination study with four-year-old children of middle and working class parents. Before we put each child into the shape discrimination problem, he was exposed to about six trials in the playpen with the brightness discrimination problem. Initial differences on the brightness discrimination problem were found, as before, in favor of the middle class children. And as before, differences disappeared by the end of testing. Now when these two groups are exposed to the shape discrimination problem we find no over-all differences between the groups with respect to rate of response or level of correct response.

This is true for the initial as well as the terminal trials. In brief, then, the short prior exposure on the easy problem had wiped out the differences in performance of the two groups on the more difficult discrimination. There are many possible reasons for this influence. I would prefer not to speculate about them until we have collected more data, which we are in process of doing.

The results of these studies will be available in publication in the near future. I report them here to suggest that subject differences seem to be as important in humans as they are in lower animals with respect to possible profit to be derived from early experience exposure. It is dangerous in general to compare directly the results of human studies with those using lower animals as subjects. This is certainly the case in the present studies. We know nothing of the long-term effects of such early exposure in the human. I believe that this is equally true for most studies attempting to influence selectively the behavior of the child, such as the recent concern with language acquisition in the young child. We can say, however, that young children can learn, and quickly, in the playpen situation and without the signs of trauma which, I understand, is sometimes associated with some early learning situations. We have not begun to study the effect of such exposures in the first year of life; we plan to continue the exposures over much longer periods of time. We have gone from the brightness task to a shape discrimination. We will go on to more difficult shape discriminations, including letters, numbers, words, and so on. We wish to discover what level of complexity of learning can be managed within the play situation. We hope that the increased complexity will counteract the tendency to satiation which could develop with a large number of trials in the playpen. We have begun to employ, in another series of studies, much simpler gadgetry - a portable sensory feed-back apparatus tied in to a multiple button keyboard. The problems are concept formation and we are presently testing preschool children.

In all of these human studies, we are beginning to examine the importance for effective learning in the

"play" situation of such subject variables as age, sex, socio-economic status, personality characteristics, and so on. We will attempt to follow up the possible long-term influences of such early exposures. We continue to be much interested in investigating at the human level the crucial-periods hypothesis with regard to programs of early experience.

In these studies, then, we have tried to point out the importance of subject characteristics, whether based genetically or experientially or, more likely, on both kinds of factors, in determining the benefits to be derived from a program of early exposure or in determining the manner in which subjects will profit from such experiences. We have suggested that the possibility of crucial periods existing for benefit to be gained from such exposures ought to be investigated further. Finally, we have proposed that we all be cautious in interpreting the results of early exposure studies, especially those employing human subjects. Without adequate long-term follow-up, with appropriate controls, we must be extremely hesitant in making generalizations regarding these influences.