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NOTES

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Effect of visual pattern restriction in early life on brain enzyme in the rat[1]

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The present study was conducted to ascertain whether the visual patterning or the intensity of environmental light in early life is the critical factor in inducing reported behavioral and physiological changes in adult animals (cf. Singh et al, 1967). After weaning, littermate female rats were raised in either total darkness, facing a black-and-white striped or a flat-white enclosure for 70 days. Results show that these visual conditions produce differential body weight gains and melatonin activity in the pineal gland. On the basis of these findings, it appears that previously reported physiological changes were not due to the intensity of environmental light.

In an earlier study, Singh et al (1967) reported that rats raised in a visually complex environment gain more body weight and show greater brain acetylcholinesterase (AChE) activity than those rats raised in a less complex visual environment. Specifically, the visual input of those rats raised in a visually complex environment was restricted to a black-and-white pattern, while the rats raised in a less complex visual environment faced only a flat white surface. The obtained differences between these groups were interpreted by the authors as an indication of the role played by visual patterning in inducing physiological changes. However, there are a few studies that have shown that the reduction of environmental light causes increased melatonin synthesizing enzyme [hydroxyindole-O-methyltransferase (HIOMT)] activity in the pineal gland, which in turn seems to affect the functioning of the endocrinological system (Wurtman, Axelrod, & Chu, 1963; Wurtman, Axelrod, & Phillips, 1963). Now, the amount of light reflected by a black-and-white striped field, compared to a flat-white field, is less; though not highly probable, it is possible that the increased AChE activity and greater body weights of rats raised in a black-and-white striped field (complex visual environment) may be due to the reduction of environmental light rather than the visual patterning.

If the reduction of environmental light is indeed the critical variable, then one should find greater HIOMT activity in the pineal gland of rats raised in black-and-white striped environment compared to those raised in flat-white environment. To test this notion, rats were raised in black-and-white striped and flat-white visual environments. A group raised in total darkness was also added, since previous studies have shown that rats raised in total darkness have heavier pineal glands and greater HIOMT activity than rats raised in illumination (Wurtman et al, 1963).

SUBJECTS AND EARLY EXPERIENCE

Sixty-six littermate female albino rats (obtained from Holtzman Company), weaned at 20 days of age and matched for body weight, were assigned randomly to a dark (D), visual pattern (VP), or a restricted visual pattern (RVP) group. The visual environment of the VP group consisted of a board painted with ¾-in.-thick alternating black and white stripes, while the visual field of the RVP group was restricted to a flat-white painted board. All Ss were individually housed in stainless steel cages with wire mesh fronts; the visual pattern boards were hung 12 in. in front of the cage racks. The overhead fluorescent illumination diffused light evenly over all cages, and lights were on throughout the experiment. The D group animals were raised in total darkness until 90 days of age. Ss in all conditions were on ad lib food and water and were never touched, nor were their cages removed throughout the experimental period (70 days), except when the animals were weighed and rated for emotionality at 55 days of age.

PROCEDURE

All Ss were weighed and rated for emotionality on the King scale (1958) at 55 days of age. The King emotionality scale basically consists of lightly tapping the animal on the back, capturing, and handling; scores are assigned for vocalization, jumping, urination, and defecation. After emotionality rating, all Ss continued in their respective experimental conditions until 90 days of age, when all Ss were weighed and tested for emotionality for a second time. Starting at 91 days of age, all Ss were tested for 11 days for sensory conditioning. The procedure and findings of this test are reported elsewhere (Singh, Johnston, & Maki, 1969). At the age of 103 days, all Ss were decapitated, and the pituitary, adrenal, and pineal glands of each S were removed and weighed. The brain of each S was removed, weighed, and divided into four samples (anterior cortex, posterior cortex, anterior subcortex, posterior subcortex) and frozen for biochemical analysis. All brain samples and pineal glands were coded so the analyst was unaware of the treatment conditions to which the samples belonged. The AChE activity of brain samples was determined by the rate of hydrolysis of acetylcholine perchlorate (Ach), employing the procedure as reported by Rosenzweig, Krech, & Bennett (1958). The AChE findings will be reported elsewhere as a

Table 1
Median Body Weights for Dark (D), Restricted Visual Pattern (RVP), and Visual Pattern (VP) Groups for Four Weighing Periods

Rearing Condition	Body Weights (g)	Age in Days 20	55	90	103
Dark	Median	52	162	213	235
	Range	45-57	126-187	179-247	215-264
RVP	Median	51	165	214	231
	Range	45-56	150-182	195-240	214-258
VP	Median	53	171	221	237
	Range	45-58	157-202	198-255	208-266

part of a more detailed paper. HIOMT activity in the pineal gland was determined by measuring the formation of melatonin methyl-^{14}C produced from S-adenosylmethionine-methyl-^{14}C and N-acetylserotonin, employing the procedure as reported by Axelrod et al (1961).

RESULTS

Experimental groups did not differ on emotionality rating either after 35 days or after 70 days in rearing conditions. However, significant differences in body weight were obtained for different groups, as evident in Table 1, which shows body weight for all experimental groups for four weighing periods. The body-weight gain of the VP group was significantly higher (Mann-Whitney U test; two-tailed $p < .05$) than the RVP and dark-reared group at 55 days and 90 days of age. At 103 days of age, though the VP group weighed more than the dark and RVP group, the differences were not statistically significant. The body-weight gains of the RVP and dark groups were not significantly different for any of the weighing periods. The finding of greater body weight of the VP group than of the RVP group is consistent with our previous finding (Singh et al, 1967).

No significant differences for pituitary and adrenal gland weights were evident among groups. Therefore, Table 2 presents only pineal gland weights and pineal HIOMT activity for each group. The pineal gland weights were obtained as a function of the body weight of the animal using the following formula: [pineal weight (mg)]/[body weight (g)] X 100.

As evident from the table, the group raised in the dark has the heaviest pineal glands (dark vs VP, $p < .01$; dark vs RVP, $p < .01$, based on Mann-Whitney U test) and shows the highest HIOMT activity (dark vs VP, $p < .01$; dark vs RVP, $p < .01$, based on Mann-Whitney U test) compared to the VP and/or RVP groups. However,

Table 2
Pineal Gland Weights and Pineal HIOMT* Activity for Each Group

Rearing Condition	Pineal	
	Weight	HIOMT*
Md	.570	1774
Dark Range	.43-.70	1659-2263
Md	.450	1144
RVP Range	.32-.57	849-1658
Md	.495	1213
VP Range	.30-.66	752-1634

** HIOMT values are expressed in terms of the count/minute of melatonin methyl-^{14} C/pineal gland.*

the pineal weight and HIOMT activity for the VP and RVP groups did not differ significantly. The findings of heavier pineal gland and higher HIOMT activity in the rats raised in total darkness are consistent with previous findings (Wurtman et al, 1963).

DISCUSSION

Results show that the VP group gain more body weight than the RVP or dark group. The lack of differences between VP and RVP groups for pineal weight and HIOMT activity are very important; on the basis of these measures, it can be concluded that both VP and RVP groups are exposed to a similar amount of environmental light; therefore, this factor cannot explain the body-weight differences observed between these groups. It appears that exposure to visual pattern, rather than reduction of environmental light, is the crucial factor in inducing changes in adult animals. The importance of visual patterning can further be deduced by comparing the rearing conditions of dark and RVP groups. Inspection of rearing conditions reveals that the only factor common to both dark and RVP groups is the absence of visual patterning; thus, the lack of body-weight differences is more likely due to the absence of visual patterning than to the amount of environmental light.

In conclusion, it appears that visual pattern restriction or enrichment (perhaps brightness contrast) in early life is a critical factor in producing physiological and biochemical changes in the adult animals.

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NOTES

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