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Visual Discrimination Performance in Rats Following Nucleus Posterior Thalami and Di-Mesencephalic Juncture Damage.

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FOLLOWING NUCLEUS POSTERIOR THALAMI AND
DI-MESENCEPHALIC JUNCTURE DAMAGE.

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VISUAL DISCRIMINATION PERFORMANCE IN RATS
FOLLOWING NUCLEUS POSTERIOR THALAMI AND
DI-MESENCEPHALIC JUNCTURE DAMAGE

A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

in

The Department of Psychology

by
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ABSTRACT

Following training on both a size discrimination and a pattern discrimination problem, adult albino rats were given either 1-stage or 2-stage nucleus posterior lesions, 1-stage lesions to the di-mesencephalic juncture, or no lesions. Postoperative testing revealed that (a) brain-damaged Ss performed more poorly than normal controls in relearning the two visual habits, (b) 2-stage nucleus posterior lesioned Ss were not significantly different from 1-stage nucleus posterior lesioned animals, and (c) brain-damaged Ss did not differ significantly from normals with respect to performance on a size threshold task. This pattern of results suggests that neither diaschitic effects nor loss of visual acuity can adequately account for visual discrimination retention deficits induced by nucleus posterior lesions. The data also provide further evidence for the existence of a pathway through the di-mesencephalic juncture which is functionally significant in visual discrimination performance.

INTRODUCTION

Within the last decade, several articles have appeared in the neuropsychological literature which suggest that the region of the pretecto-diencephalon, and in particular the nucleus posterior thalami (NPT), is critical for retention of visual discrimination problems in the albino rat (Horel, 1968; McNew and Thompson, 1966; Thompson, 1963; Thompson, Lesse, and Rich, 1963; Thompson, Lukaszewska, Schweigerdt, and McNew, 1967; Thompson and Massopust, 1960; Thompson and Rich, 1961; Thompson and Rich, 1963; Thompson, Rich, and Langer, 1964). Earlier studies by Ghiselli and Brown (1938), Lashley (1935), Layman (1936), and Papez and Freeman (1930) also suggested the importance of the pretectal diencephalon for mediation of visual discrimination performance. One interpretation of the retention deficits following NPT damage was made by Thompson (1965) who suggested that the NPT functions as a sensory relay station between the visual cortex and the ventral midbrain in a "centrencephalic-type" visual memory system.

If the NPT serves as a sensory relay station in a pathway extending from visual cortex to ventral midbrain, then lesions of this structure might be expected to produce not only amnesia for previously learned problems but sensory deficits as well. Although there is little evidence for occipitofugal fibers entering the NPT directly (Goodman and Horel, 1966; Knook, 1966, p. 331), Horel (1968) reported that the ventral nucleus of the lateral geniculate body both receives occipitofugal fibers and projects to the NPT. Thus, while an anatomical basis

exists for a loss in visual acuity following damage to the NPT, there has been no systematic attempt to relate amnesic effects of NPT lesions with corresponding sensory defects.

Another possible explanation for the loss of retention following NPT lesions is that such lesions may have diaschitic effects. This interpretation is based upon the fact that diverse ascending and descending fiber systems course through or originate in the pretectodiencephalon (Knook, 1966, pp. 311-347; Krieg, 1947; Papez and Freeman, 1930). Thus, interruption of these fiber tracts coincident with NPT lesions might produce disfunctioning of cortical and/or brainstem mechanisms unrelated to the channeling of visual input from the occipital cortex to the ventral midbrain. The possibility of a diaschitic effect remains as long as NPT lesions are made in 1-stage operations (simultaneous, bilateral). Since there is an indication that 2-stage lesions (successive, bilateral) produce less disruptive (diaschitic) effects on behavior than 1-stage lesions (Adametz, 1959; Ades and Raab, 1949; Stewart and Ades, 1951), a study comparing the effects of 1-stage versus 2-stage lesions of the NPT on retention would provide a reasonable test of the diaschitic hypothesis.

Although the anatomical connection between the NPT and the ventral midbrain is well established (Knook, 1966, p. 331; Krieg, 1947; Papez and Freeman, 1930), the functional significance of this pathway remains obscure. The anatomical studies cited are in general agreement concerning the trajectory of the descending fibers through the diencephalic zone. Knook, for example, described the path taken by

degenerating fibers from the NPT as follows: a ". . . heavy degenerated bundle arches somewhat ventromedially to the dorsal surface of the medial lemniscus . . . [and] partly traverses the nucleus ruber to which an astonishing large number of degenerated fibres are distributed . . ." (p. 331). If this tract is essential for the performance of visually-guided behavior as suggested by an earlier study (Thompson, et al., 1964), then lesions of the di-mesencephalic juncture (DMJ) through which this tract penetrates would be expected to abolish previously learned visual discrimination habits.

In the current study, rats previously overtrained on two separate visual discrimination problems received either 1-stage or 2-stage bilateral NPT lesions, 1-stage bilateral DMJ lesions, or served as nonoperated controls. After a suitable recovery period, all Ss were tested for retention of the originally learned problems, and almost all of the animals were subsequently trained on a size discrimination threshold test.

METHOD

Subjects

The Ss were 34 adult male albino rats of the Wistar strain. Following discrimination training, 20 animals, 10 per group, received either 1-stage or 2-stage lesions to the region of the NPT (Groups NPT-1 and NPT-2, respectively), 7 Ss received bilateral 1-stage lesions to the DMJ (Group DMJ) and 7 Ss served as normal controls (Group C).

Surgery and histology

All surgical procedures were performed under deep chloral hydrate anesthesia. The rat atlas of Massopust (1961) was used to determine the coordinates to be employed in damaging the NPT and DMJ. A Baltimore stereotaxic instrument was used, and the lesions were made by passing DC (2.0-2.5 ma. for NPT lesions, 1.8 ma. for DMJ lesions) for 10 sec. through an electrode with 1 mm. of the tip uninsulated.

After the completion of the postoperative test, each S was sacrificed with an overdose of Nembutal, the brain removed and allowed to harden for 48 hr. in a 10% formalin solution. Subsequently, the brain was sectioned frontally at 90 μ with a freezing microtome. Every third section through the damaged area was photographed at 10X with the use of a Leitz enlarger.

An estimate of the extent and locus of lesions to the NPT was made by using a method similar to that described by McNew and Thompson (1966). Brain sections through the lesioned area were placed on slides

and traced after enlargement onto worksheets derived from Gurdjian's (1927) description of the NPT. From these worksheets estimates were made of the percent damage to the NPT, structures dorsal to the NPT, and ventral areas. A check (test-retest) made to determine the reliability of the obtained rankings resulted in Spearman Rho coefficients (Siegel, 1956, p. 202) of .98, .99, and .98, respectively. Animals with at least 25% bilateral damage to the NPT were assigned to Group NPT.

Apparatus

The apparatus was a 2-choice discrimination chamber similar to the one described by Thompson and Bryant (1955). It consisted of three clearly defined compartments: a start box, a choice chamber, and a wooden-floored goal box. Both the start box and the choice chamber had grid floors through which an electric current could be passed. The exit from the choice chamber was through two windows (5 1/2 in. square) which led into the goal box. These windows were normally covered by the discrimination cards, one of which could not be pushed aside. A 3 in. section of the grid in front of each window could be charged independently from the rest of the grid floor. All parts of the grid floor were connected to a variable powerstat.

Procedure

Preliminary training. On the first day, each animal had its vibrissae shaved, its ears clipped for identification, and was placed in the goal box for approximately 15 min. During this time, each S

was picked up by E and carried to the opposite end of the apparatus at least once. On the second day, each S was taught to push aside cards in order to gain access to the goal box. This training was accomplished in the following manner: S was placed in the start box and the plexiglas door separating the start box and choice chamber raised; S was given 5 sec. to enter the choice chamber after which entry was forced by mild foot-shock; once in the choice chamber, S was allowed approximately 30 sec. to enter the goal box before further foot-shocks were administered.

For the first three trials of preliminary training, the training cards (medium gray) positioned at each window only partially blocked the entrance to the goal box. As training proceeded, the cards were gradually placed in a flush position. Preliminary training was terminated when S readily pushed aside the card in order to gain access to the goal box. A 60 sec. intertrial interval was employed throughout preliminary training, discrimination training, and post-operative retraining.

Discrimination training. Twenty-four hours after preliminary training, each S was given 8 trials per day on the size discrimination problem. Pushing aside the unlocked large-disk card (4 in. diameter white disk centered on black background) was counted as a correct response, while receipt of foot-shock in front of the locked small-disk card (7/8 in. diameter white disk centered on black background) was scored as an error. The correction method was used throughout the study. Appearance of the positive card in the left or right window

varied according to a strict double-alternation pattern except during overtraining at which time a combination of single-alternation and double-alternation was employed. The procedure adopted in preliminary training with respect to placing S in the start box, opening the entrance to the choice chamber, and forcing a choice of exits was continued throughout the preoperative and postoperative testing periods. The criterion of learning on the size discrimination problem was at least 15 out of 16 correct responses on 2 consecutive days. When this performance level was attained, each S received an additional 50 trials of overtraining at a rate of 10 trials per day for 5 successive days.

Following overtraining on the size discrimination problem, all SS were required to learn a horizontal-vertical (1/2 in. striations for alternating black and white stripes) discrimination problem. The animals were trained to approach the card with horizontal stripes and to avoid the card with vertical stripes. Again the criterion for mastery was 15 out of 16 correct responses, and 50 overtraining trials were given.

Postoperative retention test. Surgery was carried out within two days following completion of discrimination training. Informal observational records were kept from the day after the operation until the day retention testing began. These records consisted of the following observations: weight data, quality and quantity of locomotor activity, use of vibrissae, excitability to handling and hand-claps, pupil size, and general physical appearance.

Retention testing began approximately 28 days following the first operation (14 days after the second lesion in Group NPT-2) in Groups NPT-1, NPT-2, and C and from 14-21 days in Group DMJ. Each S was required to relearn the two discrimination problems in the order in which they were originally mastered. The procedure employed in relearning was identical to that used in original learning.

A modification in the retention testing procedure was made for Ss that failed to reach the criterion after committing 2 1/2 times the number of errors made in original learning. Training on the size discrimination was interrupted, and the animals were placed on a simple brightness discrimination (white card, positive; black card, negative). When a criterion of 14 correct in two days or 8 correct responses in one day had been reached, the black card was replaced by the small-disk card and the animals trained to the less stringent criterion. Training on the original size discrimination was reinstated after the white card vs. small-disk card problem had been mastered.

Animals exhibiting difficulty relearning the pattern discrimination problem were terminated on the task after making 2 1/2 times the errors made in original learning. Training on the size discrimination to a criterion of 7 correct in 8 trials was given prior to testing on the size threshold task.

Size threshold test. Following relearning (but not overtraining) of the horizontal-vertical discrimination, the majority of Ss were tested on a size discrimination threshold task. This task consisted of the positive 4 in. disk card paired successively with

negative stimulus cards having disk-diameters of 1 in., 2 in., 2 1/2 in., and 3 in. The criterion for successful completion of each task was designated as 7 correct responses in 8 trials. Testing was terminated when S completed the four threshold discriminations or when 15 errors were made on any problem.

Statistical analyses. Percentage of error savings was the measure of retention. The savings score was based on errors made by an animal prior to achieving a significant run of perfect (Grant, 1947) or near-perfect (Runnells, Thompson, and Runnells, 1968) trials. This "significant run" savings score was used in addition to the traditional "errors-to-criterion" savings score.

The majority of the statistical analyses were computed for both the "significant run" savings score (SRSS) and the "criterion run" savings score (CRSS), and the .05 level of significance (one-tail) was accepted for all tests. In order to evaluate individual retention scores, a loss of retention was defined as a savings score (SRSS, CRSS) at least 3 SDs below the mean score obtained by Ss in Group C.

In order to statistically evaluate performance on the size discrimination threshold series, each S received a rank based on both the number of tasks completed and the total number of errors made on the series. Thus the animal completing the fewest tasks received the primary rank. Subjects completing the same number of tasks were further ranked according to total errors with the lowest rank accorded the animal committing the most errors.

RESULTS

Preoperative Performance

The size discrimination problem used in the current study was considerably more difficult to learn than was the pattern discrimination problem. A nonparametric test (Mann and Whitney, 1947) comparing the number of errors made on each problem prior to the criterion run resulted in a significant difference. However, there was no difference between the two problems in terms of percentage of correct responses made during overtraining (mean performance 95.2% for both problems).

In order to determine whether or not the four groups of animals (Groups C, NPT-1, NPT-2, DMJ) differed with respect to original learning ability, nonparametric analyses of variance (Kruskal and Wallis, 1952) comparing errors to criterion for each problem were computed. The obtained H's were not significant. Preoperative learning performance for each group is summarized in Table 1.

TABLE 1

PREOPERATIVE LEARNING PERFORMANCE OF GROUPS C, NPT-1, NPT-2, DMJ

Group	N	Size Discrimination			Form Discrimination		
		Mean errors to SR	Mean errors to CR	% correct in overtraining	Mean errors to SR	Mean errors to CR	% correct in overtraining
C	7	23.6	30.1	97.1	12.3	14.1	93.7
NPT-1	10	19.5	21.9	95.0	12.0	16.3	95.2
NPT-2	10	18.0	20.5	96.6	15.2	16.8	96.2
DMJ	7	24.1	27.4	92.0	15.6	19.3	95.7

Postoperative Performance

Retention of Size and Pattern Problems

1-stage vs. 2-stage NPT lesions. A nonparametric analysis of variance test (K-W) comparing the retention scores of Groups C, NPT-1, NPT-2, and DMJ resulted in significant H's for retention of the size discrimination (SRSS, CRSS) and for retention of the form discrimination (CRSS). Since the K-W test comparing the four groups on SRSS retention of the form discrimination resulted in an H approaching statistical significance ($H=7.5$, $p<.10$), U tests were computed for all possible comparisons and are summarized in Table 2.

With respect to retention of the size discrimination, both NPT groups performed significantly poorer than Group C. In addition, Group NPT-2 was significantly worse than Group C with respect to retention of the form discrimination. No significant differences were found when retention scores were compared for Groups NPT-1 and NPT-2. Figure 1 shows the lesions of two NPT Ss having retention deficits on both problems.

An uncomplicated comparison of the performance of NPT-1 and NPT-2 Ss would obviously require that each group have approximately equal amounts of damage to the NPT. In order to meet this requirement, two Ss were discarded from each group leaving 8 matched pairs (mean percent damage to the NPT 51.8% and 53.3%, respectively). Figure 2 shows the lesions of two Ss (left column, Group NPT-1; right column, Group NPT-2) matched in terms of the amount of damage to the NPT.

TABLE 2
MEAN RETENTION SCORES FOR GROUPS C, NPT-1, NPT-2, DMJ

Group	N	Size Discrimination				Form Discrimination			
		Mean % SRSS	Range	Mean % CRSS	Range	Mean % SRSS	Range	Mean % CRSS	Range
C	7	97.4	91-100	96.9	87-100	99.3	95-100	98.6	90-100
NPT-1	10	65.5 ^a	-33-100	50.9 ^a	-130-100	89.9	9-100	80.6	8-100
NPT-2	10	55.4 ^a	-94-100	33.1 ^a	-130-100	78.3 ^a	-36-100	58.2 ^a	-38-100
DMJ	7	41.1 ^a	-31-94	-7.0 ^{a,b}	-248-89	85.9 ^a	50-100	17.0 ^{a,b}	-150 ⁺ -95

^aSignificant group differences: NPT-1 > C, NPT-2 > C, DMJ > C.

^bSignificant group differences: DMJ > NPT-1.

Fig. 1. Unstained sections from two NPT ss having retention loss on both problems. (Left column --NPT-1-56, 43% bilateral NPT damage: size discrimination = 41%, 21%; form discrimination = 90%, 86%. Right column --NPT-2-19, 32% bilateral NPT damage: size discrimination = 52%, 66%; form discrimination = -36%, -25%.)

Fig. 2. Unstained sections from two Ss having approximately equivalent damage to NPT. (Left column --NPT-1-45, 61% bilateral damage to NPT: size discrimination = 100%, 93%; form discrimination = 100%, 100%. Right column --NPT-2-44, 64% bilateral damage to NPT: size discrimination = 100%, 100%; form discrimination = 100%, 100%.)

Mean retention scores for the two groups were as follows: Group NPT-1 size discrimination = 67.3, 49.9, pattern discrimination = 87.4, 83.3; Group NPT-2 size discrimination = 70.1, 46.9, pattern discrimination = 73.9, 51.4. A nonparametric test comparing two related samples (Wilcoxon, 1945) was used to determine the significance of differences in retention of the size and form discrimination problems. The T's were not significant at the .05 level although differences between the groups with respect to retention of the pattern discrimination approached statistical significance.

DMJ lesions. Retention of both the size and the form discrimination problems was significantly poorer for Group DMJ than for Group C. No differences in retention were found between Groups DMJ and NPT-2. Group DMJ did not differ significantly from Group NPT-1 with respect to the SRSS measure but had significantly more difficulty attaining the criterion of learning on both problems. Comparisons for Group DMJ are summarized in Table 2.

Overtraining Accuracy

The mean overtraining scores for Groups C, NPT-1, NPT-2, and DMJ were 97.4, 95.4, 91.6, and 93.1, respectively. Only Group NPT-2 was found to differ significantly from Group C when nonparametric comparisons were made. For Group NPT-2, overtraining performance was not highly correlated with an overall measure of retention ($Rho=.04$).

Size discrimination threshold performance

The K-W test comparing performance on the threshold task for

the four groups did not result in a significant difference. Table 3 summarizes performance by the four groups on the threshold task.

TABLE 3
NUMBER OF Ss IN EACH GROUP ATTAINING CRITERION
ON SIZE DISCRIMINATION THRESHOLD TASKS

Group	N	Circle diameters of negative stimulus cards				Mean rank
		1 3/4 in.	2 in.	2 1/2 in.	3 in.	
C	6	6	6	6	5	17.9
NPT-1	7	7	7	6	3	10.1
NPT-2	6	6	6	6	5	15.0
DMJ	7	6	6	5	4	11.9

In order to determine the extent to which postoperative performance on the discrimination problems was correlated with size threshold ability, Spearman Rho correlation coefficients were computed (Table 4). None were significant.

TABLE 4
SPEARMAN RHO CORRELATION COEFFICIENTS BETWEEN RETENTION
SCORES AND SIZE THRESHOLD PERFORMANCE
COMPUTED ON THE OPERATE Ss

Measure		Size discrimination retention		Form discrimination retention	
		SRSS	CRSS	SRSS	CRSS
Size threshold discrimination	NPT-1	.14	.12	.36	.29
	NPT-2	.37	.26	.53	.43
	DMJ	-.36	.22	.37	.07

Lesion locus and performance

Spearman Rho correlations between amount of damage to a given area of the posterior thalamus and retention of the discrimination problems were computed on the combined NPT groups in order to determine a critical area for retention loss. All correlations between both the NPT and the area immediately dorsal to it (pretectal nucleus, lateral posterior thalamic nucleus) and retention were found to be negative. On the other hand, damage to an area including the ventral portion of the NPT and the medial portion of the nucleus ventralis was found to be positively and significantly (size discrimination, SRSS; form discrimination, CRSS) correlated with retention. Table 5 summarizes the correlations computed.

TABLE 5

SPEARMAN RHO CORRELATION COEFFICIENTS BETWEEN RETENTION
SCORES AND % DAMAGE TO THALAMIC AREAS FOR
Ss IN COMBINED NPT GROUPS

Lesioned area	Size discrimination retention		Form discrimination retention	
	SRSS	CRSS	SRSS	CRSS
NPT	-.44*	-.42*	-.28	-.31
Dorsal to NPT	-.41*	-.23	-.35	-.49*
Ventral to NPT	.46*	.34	.26	.44*

* Significant at .05 level

Figure 3 depicts five sections through the rat brain beginning with a section through the anterior portion of the NPT and ending with a section showing the rostral portion of the red nucleus. On the right half of each section, the path taken by descending fibers from the NPT [adapted from Knook (1966, p. 331), Krieg (1947), and Papez and Freeman (1930)] is shown. This pathway descends through the posterior thalamus and DMJ, maintaining a position immediately dorsal to the medial lemniscus and lateral to the fasciculus retroflexus, and disappears at the level of the red nucleus. A composite drawing of lesions producing losses on both problems is shown for comparison on the left side of Figure 3.

Of the 7 Ss receiving bilateral damage to the DMJ, 4 displayed loss of retention for both retention measures on both problems. In addition, one other S exhibited loss of retention of the size discrimination problem and had difficulty reaching criterion on the form discrimination task. The only S (DMJ-70) having normal retention of both problems received a dorsal DMJ lesion destroying much of the pretectal area and the medial part of the superior colliculus. The lesion of DMJ-70 and the lesion of a S exhibiting a loss of retention of both problems are illustrated in Figure 4.

Other behavioral observations

All operated animals, with the exception of NPT-2 Ss, exhibited aphagia and adipsia for several days postoperatively. Soft, palatable food (a mixture of ground rat pellets, sugar, powdered milk, and water)

Fig. 3. Five frontal levels derived from the Massopust (1961) atlas. (Right half of each section--pathways from NPT to RN adapted from Knook, vertical lines; Krieg, horizontal lines; and Papez & Freeman, diagonal lines. Left half of each section--composite damage to Ss having loss on both problems, crosshatched; S with normal retention of both problems, stippled. Abbreviations: CF=fornix column, CPT=posterior commissure, CSU=superior colliculus, FM=fasciculus retroflexus, GL=lateral geniculate nucleus, GM=medial geniculate nucleus, H=Habenula, L=lateral thalamic nucleus, LM=medial lemniscus, NPT=nucleus posterior thalami, NR=red nucleus, PP=cerebral peduncle, SG=stratum griseum, SN=substantia nigra, TO=optic tract, V=ventral thalamic nucleus, VDA=mammillothalamic tract.)

Fig. 4. Unstained sections from two DMJ Ss. (Left column--DMJ-70, size discrimination = 92%, 89%; form discrimination = 97%, 95%. Right column--DMJ-62, size discrimination = -31%, -35%; form discrimination = 93%, 67%.)

placed in the cage with the Ss usually induced feeding within the first postoperative week.

Several transient deficits were seen in all operated groups. The main ones were loss of vibrissae movement (either unilaterally or bilaterally), dilated pupils, circling, and head canting. In almost all cases, these defects were temporary and had disappeared by the time retention testing began.

During retention testing, almost all lesioned animals were indistinguishable from the normal controls in terms of orientation to stimulus cards, number of foot-shocks required to induce running, and emotional behavior in the apparatus. Almost all Ss with lesions in the DMJ area exhibited, at least temporarily, difficulty pushing open the positive stimulus card. In addition, DMJ-40 explored the choice chamber on almost every trial during retention testing despite repeated shocks for such behavior. The exploratory tendency of this S probably accounted for the difficulties it had in attaining the criterion of 15 correct responses in 16 trials.

DISCUSSION

The results of the present study support previous work (e.g., Horel, 1968; Thompson et al., 1967), in showing that pretectodiencephalic lesions significantly impair retention on visual discrimination problems. However, the observed deficits were neither striking nor positively correlated with the extent of damage to the NPT, a finding which is at variance with earlier reports (Breen, 1965; McNew and Thompson, 1966; Thompson and Rich, 1961; Thompson, et al., 1967). Instead, in partial agreement with Breen and McNew and Thompson, the amount of damage to the region immediately ventral to the NPT (medial part of the nucleus ventralis) was found to be significantly correlated with the magnitude of the retention deficit.

Differences in experimental procedures between the present study and previous experiments may, in part, account for the failure of this experiment to obtain positive correlations between extent of damage to the NPT and retention deficits. One difference stems from the fact that SS in previous studies did not receive overtraining on the visual discrimination problems prior to brain damage. In a study comparing overtrained and criterion trained SS, Lukaszewska and Thompson (1967) found that overtrained NPT animals exhibited significantly better retention of a pattern discrimination problem than criterion trained SS. Lukaszewska and Thompson concluded that overtraining on the pattern discrimination enables the problem to take on features of a simpler

problem and thus makes it more resistant to disruption by brain damage. In addition, probably because of the difficulty of the size discrimination problem used in the present study, Ss exhibited positive transfer upon initial exposure to the form discrimination and learned the latter problem much more rapidly than the former. Lack of a significant difference between Group NPT-1 and Group C with respect to SRSS retention of the pattern discrimination was possibly the result of the combination of overtraining and difficult size discrimination.

Another difference between the present study and previous studies can be traced to the fact that relatively small lesions were made in the current experiment. For example, the mean percent damage to the NPT in the present study was 53.3% as compared to a mean of 69.6% in Experiment 1 of the Thompson et al. (1967) report. The combination of overtraining and relatively small lesions may have militated against positive correlations by producing both a larger critical area within the pretectum and relatively minor amounts of damage to this critical area, respectively. The one locus of damage found to be positively correlated with loss of retention was in an area immediately ventral to the NPT. Inspection of Figure 3 reveals that this area is traversed by the descending pathway connecting the NPT with the red nucleus. In addition, Faull and Carman (1968) reported that prerubral radiations ascend to the medial portion of the ventral thalamic nucleus.

The fact that Groups NPT-1 and NPT-2 were comparable in retention fails to provide evidence in support of a diaschisis explanation for retention deficits following NPT lesions. With the exception of

more rapid recovery following 2-stage lesions (this was not reflected in differential mortality rates), there was little to distinguish 2-stage and 1-stage lesioned animals in the present study. This finding contrasts with those reported by Adametz (1959), Ades and Raab (1949), and Stewart and Ades (1951).

Although significant losses in retention were seen between each operated group and the controls, performance by the brain-damaged animals on the size discrimination threshold task was not significantly poorer than that of normal Ss. Since several brain-damaged Ss exhibited excellent retention of one or both discrimination tasks, a check was made to determine the extent to which performance on the discrimination tasks was correlated with threshold task performance. The results of the obtained correlations revealed that poor discrimination performance was not significantly correlated with inability to master the threshold tasks. Therefore, from the results of the present experiment, it may be concluded that loss of visual discrimination retention following damage to the posterior thalamus and/or the pathway connecting the NPT and the red nucleus is not primarily a function of loss of visual acuity.

The present study also provided evidence supporting the results of a previous study by Thompson et al. (1964) who found that knife cuts separating the posterior thalamus and red nucleus produced retention deficits for a brightness discrimination. Lesions in the DMJ region of the brainstem closely corresponding to the trajectory of the NPT efferent tract described by Knook (1966, p. 331), Krieg (1947), and

Papez and Freeman (1930), produced significant losses of retention on both problems.

Another possible explanation for retention losses following NPT damage is that of a defect in attention (Thompson et al., 1967). Animals with NPT lesions in the current study exhibited at least three defects which might lend support to an attentional loss hypothesis. First of all, NPT Ss (excluding animals with perfect retention) had difficulty attaining the high degree of performance necessary for the criterion run. This difficulty was reflected in a significant difference between errors to SR and errors to CR. Secondly, postoperative performance on overtraining was poorer for NPT-2 Ss than for controls. Thirdly, a few Ss with poor savings scores displayed a tendency to explore the choice chamber. However, an attentional defect is probably not sufficient to explain performance deficits following NPT lesions since several Ss performed poorly on the discrimination problems without exhibiting any of the above defects. Additionally, overtraining performance for Group NPT-2 was not highly correlated with retention performance.

It is highly probable that a unitary explanation for visual discrimination deficits following posterior thalamic lesions does not exist. Instead, some combination of mild attentional loss, loss of visual acuity, and increase in threshold for pain [Thompson et al. (1967) found that NPT Ss had difficulty making a correction response after an error was committed] might provide a more satisfactory explanation.

SUMMARY

Two possible explanations for amnesic effects following lesions in the posterior thalamus are diaschisis and loss of visual acuity. In addition to obtaining data relevant to the two explanations for NPT deficits, the present experiment examined the functional significance of an efferent pathway through the di-mesencephalic juncture (DMJ) connecting the NPT and the red nucleus. All Ss were trained and overtrained on a size discrimination problem and a pattern discrimination task, and most animals were tested on a size discrimination threshold task after retention testing.

To test for diaschitic effects, several animals were subjected to either 1-stage or 2-stage NPT lesions. After recovery, brain-damaged Ss were retrained and compared with similarly treated unoperated controls for retention of the problems. Group NPT-1 was significantly poorer than Group C with respect to retention of the size discrimination, and Group NPT-2 performed worse than the controls on both discrimination problems. Groups NPT-1 and NPT-2 did not differ significantly. The threshold task, a test of visual acuity, did not differentiate brain-damaged and control Ss.

Animals with DMJ lesions were found to be significantly poorer than normals with respect to retention of both visual discrimination problems. Performance on the size threshold task was not significantly different for DMJ lesioned Ss and controls.

It was concluded that neither diaschisis nor loss of visual acuity can adequately account for retention deficits after NPT lesions. The brainstem area through which an efferent fiber tract connecting the NPT and red nucleus passes was found to be critical for normal retention of visual discrimination problems.

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VITA

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EXAMINATION AND THESIS REPORT

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Major Field: Psychology

Title of Thesis: Visual Discrimination Performance in Rats Following
Nucleus Posterior Thalami and Di-Mesencephalic
Juncture Damage

Approved:

Major Professor and Chairman

Dean of the Graduate School

EXAMINING COMMITTEE:

Date of Examination:

16 June 1969