A COMPARISON OF HYPER-REACTIVITY AND ACTIVITY IN RATS WITH LESIONS OF THE SEPTAL AREA AND THE OLFACTORY LOBES

by

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ABSTRACT OF THESIS

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The purpose of this experiment was to compare the hyper-reactivity exhibited by animals with septal lesions with the emotional behavior reported to occur in animals with lesions of the olfactory lobes. This comparison was made in order to determine whether or not disruption of olfactory function could be responsible for part or all of the emotional behavior exhibited by animals with septal lesions.

One group of animals was given septal lesions and then rated on a five point scale of emotional behavior. Another group was given lesions to the olfactory lobes and rated on the same scale of emotionality. Animals were then measured on the amount of activity in exploration of an activity drum.

After the activity measures, the animals were lesioned again. In the second surgery animals with septal lesions were given olfactory lesions and animals with olfactory lesions given septal lesions. The animals were again rated on the five point scale of emotionality.

Septal and olfactory animals exhibited a significant increase in emotional behavior in the two day session following the first surgery. However, the emotional behavior of olfactory animals was not of the same magnitude or duration as that of the septal animals.

After the second surgery those animals that received septal lesions again exhibited a significant increase in emotional behavior equal to that observed in septal animals during the first rating session. Those animals that had previously received lesions of the septum and were given olfactory lesions at the time of second surgery did not show a significant increase but remained at a level below that of the control

animals. These results suggest that what has been commonly termed the septal syndrome is not a results of interference with olfactory function.

Activity measures indicate that there are no significant differences between septal, olfactory, and control animals.

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A Thesis

Presented to

the Faculty of the Graduate School

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Director of Thesis

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I. INTRODUCTION

Since the early 1930's the study of the physiological basis of emotional behavior has centered in the limbic system. A great deal of evidence has accumulated which indicates that, perhaps, several structures within the limbic system are involved in the production of emotional behavior. This evidence has been primarily descriptive and there has been no satisfactory interpretation of the components of emotional behavior. As a result, little is known about the specific structures involved in the production of this syndrome. Because of the nature of the behavior, which appears to be a constellation of disorganized reactions (i.e., emotional behavior), experimentalists have encountered much difficulty in segregating these various responses into quantitative components. The data at best constitutes only an improvised system of subjectively rating the magnitude of the observed behavior of animals which have been subjected to lesioning within the limbic system.

In 1953, Brady and Nauta attempted to objectively evaluate the emotional behavior resulting from lesions of the septum. This attempt was based on a subjective rating

of the following responses:

> (a) resistance to capture in the home cage, (b) resistance to handling, (c) muscular tension reaction to capture and handling, (d) squealing and vocalization reaction to capture and handling, (e) aggressive reaction to presentation of forceps in close proximity to the snout, (f) aggressive reaction to prodding with forceps. (Brady & Nauta, 1953)

Their animals were rated both preoperatively and postoperatively on the above scale using a 0-4 point rating scale. The results of the experiment indicated the presence of dramatic changes in behavior as a result of lesions in the septal area. The most pronounced changes observed by Brady and Nauta were an increase in (1) startle reaction to auditory stimuli, (2) freezing reaction to innocuous objects, (3) attacking reaction to approaching objects, (4) attacking reaction to handling by experimenters, (5) urination and defecation during handling sessions, and (6) vocalization and escape behavior during handling.

An earlier experiment (Spiegel, 1930) reported behavior in septal cats similar to that observed by Brady and Nauta in rats with septal lesions. W. J. S. Krieg (1938) reported an increase in emotional or rage behavior as a result of an experiment in which he subjected rats to lesions of the septal area.

Since the Brady and Nauta study, various experiment-

alists have engaged in studies designed to furnish empirical data concerning the results of septal lesioning in animals. The purpose of these studies has been to build a body of data which will, in time, alleviate the difficulty that has been encountered in attempting to segregate the various systems which constitute emotional behavior.

The overt and somewhat obvious behavioral changes have been referred to by various investigators as the rage syndrome, hyperemotionality, hyper-irritability, hyper-activity, and hyper-reactivity. Hyper-reactivity appears to be the term most descriptive since the behavior occurs only in response to the presence of a stimulus. The difference in the degree of reacting to various stimuli preoperatively and postoperatively is the phenomena to be considered under the heading of hyper-reactivity in the present study.

Brady and Nauta (1953) found an attenuation of the behavioral hyper-reactivity over time. When handled and rated daily, the animals showed a steady decrease in hyper-reactivity which reached preoperative levels on about the ninth or tenth postoperative day. When given only limited handling, hyper-reactivity was still evident to some extent at 30-45 days postoperatively, but usually disappeared by the sixteenth day.

Although hyper-reactivity to various stimuli is probably the most pronounced and obvious behavior change in animals given septal lesions, it should be pointed out that not all septal animals exhibit this behavior (Nielson, et. el., 1965; Clody & Carlton, 1969).

Even though the hyper-reactivity to various stimuli is of a transient nature in animals with septal lesions, there have been several more lasting, long term behavioral changes reported. These long term changes include modification in avoidance behavior (McCleary, 1961), in operant responding (Schwartzbaum, Kellicut, Spieth, & Thompson, 1964), position habit reversal (Zucker & McCleary, 1964), spontaneous activity (Gotsick, 1969), differential activity related to the stimulus situation (Douglas & Raphelson, 1966), avoidance responses (Ursin, Linck, & McCleary, 1969), and increased water intake (Blass & Hanson, 1970). These long term changes support the idea that lesions of the septum produce an increase in reactivity to stimulation or a decrease in response inhibition. These long term changes are also exhibited in animals that do not show the post-operative rage behavior (Clody & Carlton, 1969). There has been a general acceptance, on the basis of these findings, that there is a dissociation between the septal syndrome and other behavioral effects of septal lesions

(McCleary, 1966).

The data also indicate that the septum may be acting as a quieting system as expressed by Brady and Nauta (1953), and that ablation of this system permits certain activities to occur unchecked or perhaps in a purely reflexive form (Isaacson, 1964). The inhibitory or mediating function of the septum is further shown by the inability of a septal animal to perform a passive avoidance task while outperforming normal animals on an active avoidance task (Hamilton, et. el., 1970).

Since the septum is connected to many substructures both cortical and subcortical, the exact function is very difficult to ascertain. An effective approach in determining the function of the septum may be to ablate a structure related to the septum and record any inhibition or enhancement of the resulting behavior. Finally the septum would be lesioned in the same animal and behavioral anomalies between the two conditions recorded. By this method of observing either enhancement or inhibition, we may be able to infer the function of the septum (Grossman, 1967).

Recently, Douglas, Isaacson, and Moss (1969) have reported what they termed hyperemotionality in animals with olfactory lesions. This hyperemotionality was rated

as being "indistinguishable from septal lesioned rats during the height of their rage". Measures taken during this experiment included a measure of cage exploration activity. The results indicated no difference between the experimental and control animals. This study indicates that perhaps the emotional behavior observed in the animals with olfactory lesions is related to that observed in the previously mentioned studies, since the olfactory lobes send projections into the septal area as well as other areas within the limbic system.

The purpose of this experiment was to compare septal and olfactory animals on emotional behavior, spontaneous activity in cage exploration, and water consumption over an extended period of time. For purposes of comparison, one group of animals was prepared with bilateral olfactory lesions, another group with bilateral septal lesions, and another group as operated controls.

II. METHOD

Twenty-one female rats of the Wistar strain, reared in the animal colony at Morehead State University, were used as Ss. At the time of the first surgery the animals were 60-70 days of age and weighed 180-250 gm. The animals were housed in individual home cages for 30 days prior to the first surgery, with food and water available ad lib. throughout the experiment. Room temperature was controlled at a constant 73 (±2) degrees Fahrenheit. The light cycle was controlled by a timing apparatus and two 100 watt light bulbs. The light cycle was kept constant throughout the experiment with the dark period beginning at 4:00 P. M. (EST) and ending at 4:00 A.M. (EST). Noise level was measured at various times throughout the experiment and remained at 58 db in the cage room, as measured by a General Radio sound level meter (Model 1551-C). This sound level was a result of the continuous operation of the central heating and cooling unit in the building.

All surgery was performed under ether anesthesia. The lesions were produced using a standard 12 volt battery

connected to a microswitch and potentiometer to regulate the amount and duration of electrical current. Current was passed between a stereotaxically placed stainless steel electrode, insulated except for 0.5 mm at the tip, and a wound electrode to complete the circuit. A Krieg-Johnson-Stoelting (Model 51200) stereotaxic instrument was used for electode placement. All animals were placed in the stereotaxic unit and an incision made down the midline of the scalp to expose the skull. In animals receiving septal lesions, Group S-O, a dental drill was used to expose a section of cortex approximately 3 - 4 mm square. The electrode was introduced into the brain a total of eight times, four times on each side of the midsaggital sinus. All electrode placements were approximately 1.0 mm lateral to the midline, at an angle of 5 degrees, to prevent puncture of the saggital sinus upon entry. Two penetration depths, 4.5 mm and 5.0 mm below dura were used at each of two penetration coordinates, one at 1.0 mm anterior to bregma and the other 1.3 mm anterior to bregma. Lesions were produced by passing 1.5 ma. of D.C. current through the electrode tip for 15 seconds at each electrode placement.

Animals receiving olfactory lesions, Group O-S, were placed in the stereotaxic unit, the scalp incision made,

and a 4 - 5 mm section of skull removed with the dental drill approximately 7 mm anterior to bregma to expose the olfactory lobes. Lesions in this area were made by suction using a blunted 20 ga. hypodermic needle attached to a 10 cc hypodermic syringe to provide suction. Several passes were made bilaterally and the extracted material examined each time for the presence of brain tissue.

Control animals, Group C, were placed in the stereotaxic instrument, an incision made down the midline of the scalp to expose the skull, and the skull cleaned of all tissue. No portion of the skull was removed, hence, no electrode placements were made in the control animals.

Following surgery all animals were given an intramuscular injection of 50,000 units of procaine penicillin and placed in their home cages.

The above surgical procedures were repeated again just prior to the second rating period. Those animals that had received olfactory lesions in the first surgery, Group O-S, were given septal lesions in the second surgery. Those animals given septal lesions in the first surgery, Group S-O, were given olfactory lesions in the second surgery. Control animals were placed in the stereotaxic unit and an incision made during second surgery just as described for them during the first surgery.

After each surgical session, all animals were returned to their home cages for a 24 hour recovery period before ratings of hyper-reactivity were begun.

Ratings of hyper-reactivity were made on five responses tested during the handling periods: (1) reaction to being touched by a stick, .25" in diameter, introduced into the home cage; (2) vocalization during handling sessions; (3) escape behavior during handling; (4) bolus production during handling; and (5) urination during handling. The first three responses were rated on a 6 point scale. A rating of 0 was given if the behavior was not present during the handling session and a rating of 5 was given for the presence of the behavior in extremes. A score of 1 was added if the animal urinated during handling and the actual bolus count constituted the score added for defecation. All animals were handled and rated for 5 days prior to each surgery, and the mean of the last 2 days was taken as the baseline of normal reactivity for each group. Ratings were made throughout the entire rating period by two Es, each rating the animals on alternate days. The mean of the 2 days was taken as constituting a rating period. Neither E had knowledge of the ratings of the other until the ratings over the entire session had been completed. All handling

was done with Es wearing thick leather lineman's gloves. The ratings were made at the same time each day.

After the first rating session of 6 days, the animals were placed in two Lehigh Valley Electronics activity drums (Model 1497) and activity measures taken for 30 min. for each animal over a 7 day period. One aspect of activity that was measured was the total activity for each of the three groups throughout the 7 day period. Another measure of activity involved the amount occurring at different time periods. Each animal was run within each of four time periods beginning 2 hours after the onset of the dark period. Period 1 was from 6:00 - 7:30 P.M., period 2 was from 7:30 - 9:00 P.M., period 3 was from 9:00 - 10:30 P.M., and period 4 was from 10:30 - 12:00 P.M.. The third aspect of activity measured was the distribution of activity within each 30 min. session. This activity count was taken every 5 minutes throughout the 30 min. test period on days 1, 4, and 7 of activity measurement. During the activity measures the animals were left in the home cages in the darkened animal room and exposed to light for only 2.5 - 3 minutes during the transfer from the cage room to the activity drum. The activity drums were placed side by side on two tables 25 inches from the floor in a dark experimental cubicle

approximately 8' X 8' in size. White noise from a Grason-Stadler (Model 901-B) noise generator was fed into the cubicle through a KLH (Model 22) speaker placed on the floor beneath the activity drums. The noise level inside the activity drums, with covers in place, was maintained at 72 db as measured by a General Radio (Model 1551-C) sound level meter. In order to check and control for any possible effects of the white noise on activity over the seven day period, one extra activity measuring day was added and run without the white noise. During this session the noise level inside the activity drums was measured and found to be 58 db or the same as was measured in the animal room.

Throughout the first part of the experiment, before the second surgery, each animal was weighed and water intake measurements taken every 5 days after the first surgery for a total of eight measurements over a 40 day period. The procedure was as follows: On the day before water intake was to be measured, each water bottle was filled, weighed, and placed on the cages. Twenty-four hours later the bottles were removed and weighed again to determine the amount of water consumed and each animal was weighed. The water consumption was expressed as a proportion of body weight to water weight consumed. The

results of this proportion yield grams of body weight for each gram of water consumed and controls for differences in body weights between the various Ss.

At the end of this 40 day period the animals were again handled and rated for 5 days. After this initial rating the animals were lesioned again as described previously.

Histological examination of the size of the lesions was performed at the end of the experiment by perfusion of all experimental animals with a 10% Formalin solution and removing the brains. Independent ratings of the extent of brain damage were made by two Es. The extent of olfactory damage was determined by comparing an unaltered olfactory lobe of a control animal to the lesioned olfactory lobes and an estimate of percent destruction made.

III. RESULTS

Histological Examination

Of the animals given septal lesions in the first surgical session, six out of the seven were rated as having lesions of sufficient size to be included in Group S-O. These lesions in general covered most of the septal area, some extending dorsally far enough to destroy part of the corpus callosum and, in two cases, small portions of the cingulate cortex.

The group of animals receiving olfactory lesions during the first surgery (Group O-S) exhibited from 35% to 80% destruction with the mean extent of olfactory destruction being 61%. No animals were discarded from this group because of olfactory lesion size.

Of the septal group receiving olfactory lesions (Group S-O) only two of the original six were accepted in the final rating period. Three of the animals died as a result of massive subdural hematoma within 24 hours after the olfactory surgery. The other animal was rejected because of insufficient lesion size. For group S-O the mean olfactory lesion size was placed at 27%

destruction. (The data for individual subjects is presented in Table 1 of the appendix.) The septal lesions of those animals receiving olfactory lesions at the time of first surgery and septal lesions at the time of second surgery (Group O-S) were all rated acceptable by the Es.

Hyper-reactivity

Figure 1 illustrates the mean ratings of reactivity to handling. Within the first postoperative session the ratings for septal and olfactory animals increased to a great extent. Ratings for the control animals remained about the same for session 1 as was recorded for the preoperative session, P_1. A Kruskal-Wallis one-way analysis of variance (Siegel, 1956) by ranks was performed on the data from all sessions with the following results: In session P_1, the rating session prior to the first surgery, no significant differences occurred between groups ($H=4.78$, $.10 > p > .05$). Within session 1, which is the first postoperative session, a significant difference between groups was evident ($H=9.56$, $p < .01$). A comparison of ratings given during the second session yielded significant differences ($H=5.82$, $p < .05$). A comparison of ratings given during the third session yielded no significant differences ($H=0.17$, $p > .05$).

For rating session P_2, the rating just prior to the

second surgery, the differences between groups were again not significant (H=4.94, .10>p>.05). An analysis of differences between groups during session 4 achieved significance (H=11.15, p<.01). Session 5 produced results that were again significant (H=12.32, p<.01). An analysis of sessions 6 and 7 showed no statistical difference within either of the sessions (H=3.27 & H=4.94, p>.05). (The rating data for individual Ss throughout the 9 sessions is presented in Table 2 of the appendix and the results of the statistical analysis are listed in Table 8 of the appendix.)

In order to determine specific group differences within each rating session a Mann-Whitney U test (Bruning & Kintz, 1968) was performed on all sessions which achieved significance as indicated by the Kruskal-Wallis one-way analysis of variance. Application of the Mann-Whitney U test yielded the following results for sessions 1, 2, 4, and 5 for a two-tailed test: The ratings during session 1 between Group O-S and Group C were significantly different (p<.004). The U test also indicated a difference between Group S-O and Group C (p<.022), but no significant difference between Group S-O and Group O-S (p>.05). During rating session 2, Group S-O and Group C were the two groups yielding differences in ratings at a level of

p = .052. A comparison of Group O-S with Group C and Group S-O with Group O-S indicated no significant differences. After the second surgery a broad range of differences were again observed. Group O-S ratings were observed to increase dramatically over ratings of the other two groups. In session 4 a comparison of the control group with Group O-S indicated that the experimental group had significantly higher ratings than the control group (p=.00). A comparison of the control group with Group S-O indicated no significant difference. In session 5 a comparison of the control group with Group O-S indicated that the experimental group had significantly higher ratings than the control group (p=.00). A comparison of Group S-O with the control group indicated that Group S-O attained ratings significantly lower than the control group (p=.052), however, due to the small number of Ss in Group S-O the results are not conclusive. Thus, through rating sessions 4 and 5, Group O-S remained at a level of hyper-reactivity much higher than Group S-O or the control group.

Spontaneous Activity

The spontaneous activity of all groups was measured for 30 min. each day over a 7 day period. (Individual data for each subject is listed in Table 3 of the appendix.)

An analysis of variance, two-factor mixed design, indicated no significant differences between groups (F=1.30, df=2/17, $p>.05$) on total activity over the 7 day period.

All animals were run at varying time intervals during the measurement period in order to correct for any time of day effect. This design presented an opportunity to look for any effects of time of day on any of the groups. (Individual data for each S is presented in Table 4 of the appendix.) An analysis of the data indicated no significant differences in the time of day animals were run (F=2.17, df=6/51, $p>.05$).

Within three sessions, days 1, 4, and 7, activity measures were taken every 5 minutes in an effort to detect any differences between groups in the amount of activity engaged in from the start of the session to the end. (Individual scores are presented in Table 5 of the appendix.) No significant differences were evident between groups (F=2.01, df=2/17, $p>.05$). An analysis of the scores of groups over trials interaction again resulted in no significant differences (F=1.32, df=5/85, $p>.05$). The decrease in activity over the 30 min. period observed for all groups was significant (F=8.67, df=5/85, $p<.01$). (The results of these measurements are shown in Figure 2.)

Water Consumption and Body Weight

Water consumption and body weight data were recorded every 5 days for a period of 40 days after the first surgery. (Individual 24 hour water intake measures for each S are listed in Table 6 of the appendix.) An analysis of the results indicated that there were no significant differences between groups ($F=1.35$, $df=2/17$, $p>.05$). A comparison of water intake over days and group by days interaction revealed no significant differences.

Body weight and weight gain data were taken in order to detect any gross differences between the effects of the two lesions on the maturational or metabolic processes. All weight data was taken on the same day as water measures with the exception of day 15. On this day the same weight as for day 10 was used for all groups. (Individual weights are listed in Table 7 of the appendix.) Application of an analysis of variance revealed that there were no significant differences between groups in the amount of weight gained ($F=0.02$, $df=2/17$, $p>.05$).

FIGURE 1

MEAN RATINGS FOR ALL GROUPS

All periods represent the mean of two days rating. P_1 represents ratings in normal condition prior to surgery. P_2 represents ratings prior to the second surgery.

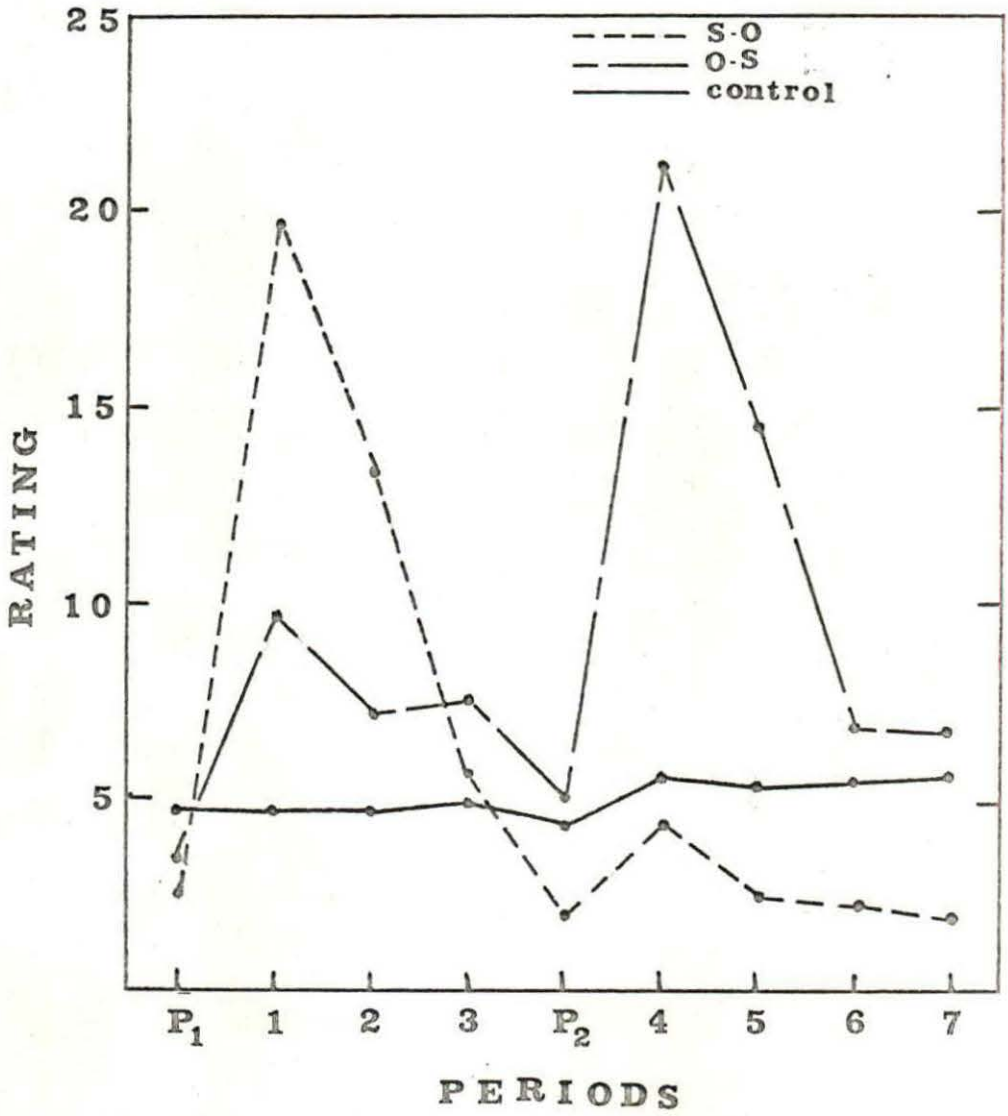
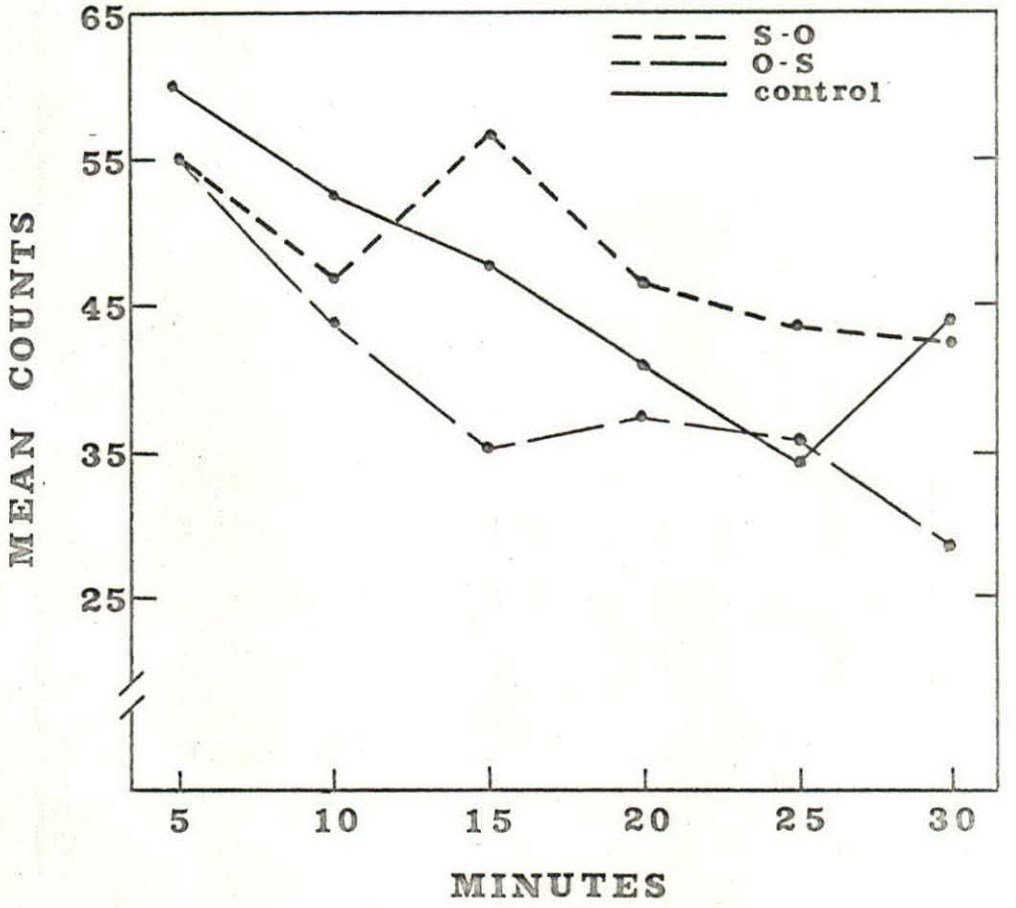

S-O
O-S
control
25
20
15
10
5
RATING
P1
1
2
3
P2
4
5
6
7
PERIODS

FIGURE 2

MEAN ACTIVITY OF ALL GROUPS
OVER THE 30 MINUTE PERIOD


S-O
O-S
control
65
55
45
35
25
MEAN COUNTS
5
10
15
20
25
30
MINUTES

IV. DISCUSSION

The results of this study indicate that the effects of septal and olfactory lesions are quantitatively different. The effects of olfactory lesions were not of equal duration or magnitude to those of septal lesions. These results are in conflict with those found previously by Douglas, et. al. (1969), and tend to expand the possibility that there is a relative contribution from the olfactory mechanism to the heightened emotional activity of septal animals. The possibility that disruption of the olfactory process may be a primary factor in the production of hyper-reactivity found in septal lesioned animals is not supported by the present study. Animals which had previously shown hyper-reactivity to handling as a result of olfactory lesions displayed the usual septal syndrome when given septal lesions. Should disruption of the olfactory mechanism be one of the primary factors in the production of septal hyper-reactivity, then one could have expected a proportionate decrease in the emotional behavior when the olfactory function is destroyed before the septal area is lesioned.

No change was observed in Group O-S.

The possibility that the septal area may act as a balance system for several mechanisms in the limbic area, as proposed by Gotsick (1969), or in a mediating role, as proposed by Clody and Carlton (1969), is supported to some extent by this study. If the behavior which results from septal lesioning can be viewed as an attempt, by the subject, to cope with its environment by reacting to significant stimuli without the balancing or mediating function, then the hyper-reactivity of septal animals can be more easily understood. An assumption could be made that the septum acts as a mediating and balancing mechanism which serves to integrate the activity of several limbic structures and, as a result, provides a systematic functioning of all these mechanisms to the most important stimuli present, either in the internal or external environment. Unlike the control animals, those with septal lesions appear unable to provide discriminating responses to various types of external stimuli. A slight touch on the back with an instrument has been observed to cause a septal animal to bound violently around the home cage. Apparently, the slight stimulus is enough to provoke a full jumping response. From this point, the stimulus created by the S's striking the sides of the cage

appears from observation to be enough in itself to perpetuate the activity until responses dissipate as a result of exhaustion. Similar reactions to other types of stimuli such as light and sound have been reported by others (Douglas & Raphilson, 1966; Gotsick, 1969).

The results of the activity measurement confirm what has previously been found in activity measurements on both septal and olfactory animals, i.e., under normal conditions activity is not significantly different from that of normal animals (Douglas, Isaacson, & Moss, 1969; Kenyon & Krieckhaus, 1965).

The results of water intake data do not agree with data taken previously by Blass and Hanson (1970) which conclude that septal animals consumed more water than normal Ss. Their results were taken from the amount consumed after a period of water deprivation and further suggest an over-reaction in consummatory behavior. The results of the present study indicate that under normal ad lib. water and food conditions, the septal animals do not consume more water than normal animals. This again appears to support the idea that there is a lack of integration of proper responses in the septal animal under conditions of increased stimulation.

The increased reactivity of septal and olfactory

lesioned animals, and the attenuation of this hyper-reactivity over a period of time suggest a possible formation of new modes of responses which replace those lost as a result of the lesions. The heightened escape activity, vocalization, biting, freezing, urination, and defecation common to animals with limbic lesions suggest that there is a simultaneous and uncoordinated operation of most of the body systems in attempting to adapt to a new stimulus situation. What we term emotional behavior may be the result of the activity of two or more mechanisms operating in conflicting adaptive responses. Difficulty would be encountered in any attempt to identify lost modes of response since the hyper-reactivity of septal and olfactory lesioned animals tends to camouflage any lack of a behavior mode. Further research along this line need be undertaken in order to determine the relative contributions of the structures of the limbic system to the overt behavior of an animal.

V. SUMMARY

The purpose of this experiment was to compare the hyper-reactivity exhibited by animals with septal lesions with the emotional behavior reported to occur in animals with lesions of the olfactory lobes. This comparison was made in order to determine whether or not disruption of olfactory function could be responsible for part or all of the emotional behavior exhibited by animals with septal lesions.

One group of animals was given septal lesions and then rated on a five point scale of emotional behavior. Another group was given lesions to the olfactory lobes and rated on the same scale of emotionality. Animals were then measured on the amount of activity in exploration of an activity drum.

After the activity measures, the animals were lesioned again. In the second surgery animals with septal lesions were given olfactory lesions and animals with olfactory lesions given septal lesions. The animals were again rated on the five point scale of emotionality.

Septal and olfactory animals exhibited a significant

increase in emotional behavior in the two day session following the first surgery. However, the emotional behavior of olfactory animals was not of the same magnitude or duration as that of the septal animals.

After the second surgery those animals that received septal lesions again exhibited a significant increase in emotional behavior equal to that observed in septal animals during the first rating session. Those animals that had previously received lesions of the septum and were given olfactory lesions at the time of second surgery did not show a significant increase but remained at a level below that of the control animals. These results suggest that what has been commonly termed the septal syndrome is not a result of interference with olfactory function.

Activity measures indicate that there are no significant differences between septal, olfactory, and control animals.

REFERENCES

Blass, E. M., & Hanson, D. G. Primary hyperdipsia in the rat following septal lesions. Journal of Comparative and Physiological Psychology, 1970, 70, 87-93.

Brady, J. V., & Nauta, W. J. H. Subcortical mechanisms in emotional behavior: Affective changes following septal forebrain lesions in the albino rat. Journal of Comparative and Physiological Psychology, 1953, 46, 339-346.

Bruning, J. L., & Kintz, B. L. Computational handbook of statistics. Glenview, Illinois: Scott Forsman Co., 1968.

Clody, D. E., & Carlton, P. L. Behavioral effects of lesions of the medial septum of rats. Journal of Comparative and Physiological Psychology, 1969, 67, 344-351.

Douglas, R. J., Isaacson, R. L., & Moss, R. L. Olfactory lesions, emotionality and activity. Physiology and Behavior, 1969, 4, 379-381.

Douglas, R. J., & Raphelson, A. C. Septal lesions and activity. Journal of Comparative and Physiological Psychology, 1966, 62, 465-467.

Gotsick, J. E. Factors affecting spontaneous activity in rats with limbic system lesions. Physiology and Behavior, 1969, 4, 587-593.

Grossman, S. P. A textbook of physiological psychology. New York: John Wiley & Sons, Inc., 1967.

Hamilton, L. E., Kelsey, J. E., & Grossman, S. P. Variations in behavioral inhibition following different septal lesions in rats. Journal of Comparative and Physiological Psychology, 1970, 70, 79-86.

Isaacson, R. L. Basic readings in neurophychology. New York: Harper & Row, 1964.

Kenyon, J., & Krieckhaus, E. E. Enhanced avoidance behavior following septal lesions in the rat as a function of lesion size and spontaneous activity. Journal of Comparative and Physiological Psychology, 1965, 59, 466-468.

Krieg, W. J. S. Personal communication to W. E. Le Gros Clark, in The Hypothalamus. London: Oliver & Boyd, 1938. Cited by J. V. Brady & W. J. H. Nauta, Subcortical mechanisms in emotional behavior: Affective changes following septal forebrain lesions in the albino rat. Journal of Comparative and Physiological Psychology, 1953, 46, 339-346.

McCleary, R. A. Response specificity in the behavioral effects of limbic system lesions in the cat. Journal of Comparative and Physiological Psychology, 1961, 54, 605-613.

McCleary, R. A. Response-modulating functions of the limbic system: Initiation and suppression. In E. Stellar and J. M. Sprague (Eds.), Progress In Physiological Psychology. New York: Academic Press, 1966.

Nielson, H. C., McIver, A. H., & Boswell, R. S. Effect of septal lesions on learning, emotionality, activity, and exploratory behavior in rats. Experimental Neurology, 1965, 11, 147-157.

Schwartzbaum, J. S., Kellicutt, M. H., Spieth, T. M., & Thompson, J. B. Effect of septal lesions in rats on response inhibition associated with food-reinforced behavior. Journal of Comparative and Physiological Psychology, 1964, 58, 217-224.

Siegel, S. Nonparametric statistics for the behavioral sciences. New York: McGraw-Hill Book Co., 1956.

Spiegel, E. A., Miller, H. R., & Oppenheimer, M. J. Forebrain and rage reactions. Journal of Neurophysiology, 1930, 3, 538-548. Cited by J. V. Brady & W. J. H. Nauta, Subcortical mechanisms in emotional behavior: Affective changes following septal forebrain lesions in the albino rat. Journal of Comparative and Physiological Psychology, 1953, 46, 339-346.

Ursin, H., Linck, P., & McCleary, R. A. Spatial differentiation of avoidance deficit following septal and cingulate lesions. Journal of Comparative and Physiological Psychology, 1969, 68, 74-79.

Zucker, I., & McCleary, R. A. Perseveration in septal cats. Psychonomic Science, 1964, 1, 387-388.

APPENDIX

TABLE 1

Evaluation and Rating of Lesions

Group S-O S#	Septum	Olfactory Destruction
1	Rejected*	----------
2	Accepted	Rejected*
3	Accepted	Rejected**
4	Accepted	25%
5	Accepted	Rejected**
6	Accepted	Rejected**
7	Accepted	30%
Group O-S S#		
1	Accepted	55%
2	Accepted	65%
3	Accepted	75%
4	Accepted	35%
5	Accepted	70%
6	Accepted	80%
7	Accepted	45%

* Rejected because of small lesion size.

** Expired following olfactory surgery.

TABLE 2

Individual Ratings Over Sessions

Group S#	P_1	1	2	3	Mean	SD	P_2	4	5	6	7	Mean	SD
S-O													
1	1	9	4	7	6.6	2.5							
2	3	4	9	7	6.6	2.5							
3	2	25	24	8	19.0	9.5	0	7	4	2	2	3.7	2.3
4	2	27	11	3	13.6	12.2							
5	2	15	4	5	8.0	6.1							
6	3	27	20	4	17.0	11.8	1	2	2	3	2	2.0	0.0
O-S													
1	2	11	6	8	8.3	2.5	13	17	17	8	7	12.2	5.5
2	5	14	10	12	12.0	2.0	8	20	19	17	16	18.0	1.8
3	1	10	12	10	10.6	1.1	2	21	19	8	13	15.2	5.9
4	4	6	3	4	4.3	1.5	4	23	9	1	3	9.0	9.9
5	2	10	8	3	7.0	3.6	2	24	10	2	4	10.0	9.9
6	5	11	8	8	9.0	1.7	5	18	11	7	6	9.5	6.5
7	1	5	7	8	6.6	1.5	2	26	15	10	4	13.7	9.3
C													
1	2	5	3	2	3.3	1.5	3	6	6	6	5	5.7	0.5
2	4	4	4	4	4.0	0.0	5	6	7	7	6	6.5	0.5
3	2	4	4	4	4.0	0.0	4	6	5	5	6	5.5	0.5
4	6	4	3	4	3.6	0.5	4	6	4	5	6	5.2	0.9
5	5	5	5	5	5.0	0.0	2	3	5	4	5	4.2	0.9
6	2	4	4	4	4.0	0.0	4	5	7	6	5	5.7	0.9
7	5	6	8	10	8.0	2.0	5	9	6	8	8	7.7	1.2

TABLE 3

Activity Scores Per Day/100

Group S#	Day 1	2	3	4	5	6	7	Mean	SD
S-O									
1	32.6	33.5	35.8	42.0	35.7	33.3	29.3	34.6	3.9
2	45.1	19.8	13.0	25.6	23.8	14.5	13.5	22.2	11.3
3	34.7	47.9	22.4	15.5	25.1	46.3	24.4	30.9	12.4
4	35.5	44.9	45.7	37.9	31.6	36.3	52.2	40.6	7.2
5	39.0	30.1	31.2	38.1	18.9	13.1	28.8	28.5	9.5
6	36.4	37.6	21.2	19.7	14.3	15.0	3.1	21.0	12.3
O-S									
1	23.7	14.3	12.4	13.1	7.7	8.4	10.1	12.8	5.4
2	28.1	14.6	22.4	17.6	16.0	9.9	4.0	16.1	7.9
3	37.6	34.8	31.5	27.6	18.5	18.8	18.1	26.7	8.3
4	21.3	22.4	16.6	19.5	21.5	20.1	19.2	20.1	1.9
5	35.5	31.3	32.9	29.3	31.4	32.5	31.4	32.0	1.9
6	31.0	38.0	32.2	28.3	11.1	28.4	29.0	28.3	8.3
7	32.6	29.5	27.3	21.6	22.3	20.0	19.2	24.6	5.2
C									
1	29.9	29.2	34.3	25.8	26.2	23.2	22.2	27.3	4.2
2	37.1	36.8	37.7	33.3	38.7	34.2	35.9	36.2	1.9
3	23.9	29.0	30.2	33.6	30.0	24.3	25.0	28.0	3.7
4	29.1	27.1	28.9	24.3	25.5	18.4	23.1	25.2	3.7
5	30.5	32.0	29.8	29.1	25.0	33.4	28.8	29.8	2.6
6	27.5	31.3	35.5	28.7	29.6	26.0	31.8	30.1	3.1
7	35.5	35.8	34.6	31.3	33.9	29.6	33.2	33.4	2.3

TABLE 4

Activity Scores/100 Over Time Periods

Group S#	Time Period 1	2	3	4	Mean	SD
S-O						
1	27.0	21.0	30.0	36.0	28.5	6.2
2	17.5	40.5	30.0	26.0	28.5	9.5
3	26.5	46.5	38.0	25.0	34.0	10.1
4	25.5	38.5	37.0	36.0	34.2	5.9
5	14.0	29.0	34.0	29.0	26.5	8.6
6	17.5	23.5	31.5	36.0	27.1	8.2
O-S						
1	24.0	6.5	14.5	20.0	16.2	7.6
2	15.0	32.5	18.5	26.0	23.0	7.8
3	31.0	28.5	28.0	30.0	29.4	1.4
4	19.0	24.5	34.5	31.5	27.4	6.9
5	31.0	28.5	29.5	21.5	27.6	4.2
6	28.0	16.5	17.5	17.0	19.7	5.5
7	19.0	14.0	12.0	23.0	17.0	4.9
C						
1	33.5	30.0	21.0	25.0	27.4	5.5
2	32.5	26.0	25.5	33.0	29.2	4.0
3	29.5	29.5	29.0	32.0	30.0	1.3
4	26.5	33.0	33.5	35.0	32.0	3.8
5	27.0	30.0	34.5	29.0	30.1	3.2
6	28.5	30.0	29.0	38.0	31.4	4.5
7	27.5	28.5	34.5	34.0	31.1	3.6

TABLE 5

Mean Activity Scores Over 5 Min. Periods

Group S#	Minutes 5	10	15	20	25	30	MEAN	SD
S-O								
1	68	52	61	61	30	71	46.8	8.2
2	53	45	59	35	45	44	41.3	10.1
3	46	38	58	43	30	33	69.2	2.6
4	65	70	69	73	70	68	52.8	7.8
5	62	46	63	45	51	50	32.8	9.9
6	48	35	33	37	23	21	57.2	14.8
O-S								
1	50	26	25	29	13	15	26.3	13.2
2	42	24	28	22	34	15	27.5	9.5
3	63	52	47	41	36	37	46.0	10.3
4	48	37	23	31	37	24	33.3	9.4
5	61	58	50	54	56	41	53.3	7.1
6	59	55	47	54	39	40	49.0	8.3
7	63	58	27	33	35	29	40.8	15.6
C								
1	47	45	50	7	73	37	43.2	21.4
2	62	66	56	24	0	44	42.0	25.5
3	57	49	36	61	31	41	45.8	11.8
4	67	45	39	45	39	20	42.5	15.1
5	67	57	51	51	33	35	49.0	13.0
6	62	50	46	50	9	76	48.8	22.4
7	62	60	52	51	51	57	55.5	4.8

TABLE 6

Water Consumption In Grams

Group S#	Day 5	10	15	20	25	30	35	40	MEAN	SD
S-O										
1	20	40	31	57	69	77	52	37	47.9	19.4
2	42	41	31	40	55	58	34	27	41.0	10.9
3	39	43	26	50	54	36	31	47	40.7	9.6
4	25	35	96	52	35	42	32	44	45.1	22.1
5	63	46	42	99	101	118	79	84	79.0	27.1
6	40	40	22	27	36	44	44	53	38.2	9.9
O-S										
1	40	46	24	45	52	22	30	25	35.5	11.6
2	40	30	17	20	28	25	23	31	26.7	7.2
3	30	36	17	30	35	22	20	30	27.5	7.0
4	32	39	28	34	27	22	74	25	35.1	16.6
5	30	42	14	34	48	37	37	33	34.4	9.9
6	49	50	25	45	38	46	41	42	42.0	8.0
7	30	29	14	30	34	19	23	26	25.6	6.6
C										
1	70	53	31	32	34	25	27	37	38.6	15.3
2	8	41	35	24	28	34	34	31	29.4	10.0
3	5	33	30	26	28	25	18	29	24.2	8.9
4	38	40	36	37	31	32	33	27	34.2	4.3
5	40	40	36	31	28	36	32	33	34.5	4.3
6	60	58	39	32	46	39	77	34	48.1	15.6
7	37	43	34	41	38	42	34	31	37.5	4.3

TABLE 7

Weight Gain Over 40 Day Period

Group S#	Day 5	10	*15	20	25	30	35	40	MEAN	SD
S-O										
1	235	248	---	239	260	278	294	305	263	26
2	200	229	---	227	235	262	260	262	238	22
3	215	218	---	210	248	260	267	252	236	23
4	235	233	---	220	240	267	268	284	247	22
5	227	250	---	252	267	285	290	285	263	22
6	250	255	---	238	269	283	294	299	268	22
O-S										
1	252	250	---	265	261	271	275	308	266	19
2	215	233	---	220	235	244	234	244	232	10
3	230	222	---	224	244	245	240	280	238	19
4	240	232	---	250	260	264	278	292	256	21
5	240	230	---	240	260	270	275	292	255	23
6	230	232	---	250	261	285	290	310	261	30
7	240	232	---	246	268	268	267	287	255	20
C										
1	180	222	---	240	255	270	273	290	244	35
2	238	225	---	232	247	266	272	285	249	23
3	200	210	---	212	221	232	230	249	220	16
4	230	230	---	247	255	264	273	295	253	24
5	240	232	---	241	262	269	276	278	254	20
6	220	245	---	258	277	295	316	303	270	33
7	270	259	---	273	284	310	311	316	285	24

* Weights for day 15 were taken to be the same as recorded for day 10 in calculating water consumption data.

TABLE 8

Statistical Results On Analysis of
Hyper-reactivity Data

Kruskal-Wallis ANOVA			Mann-Whitney U Test	
Rating Session	H	p	Comparison	p
P_1	4.78	$>.05$		
1	9.56	$<.01$	O-S vs C	$<.004$
			S-O vs C	$<.022$
			S-O vs O-S	$>.05$
2	5.82	$<.05$	S-O vs C	$=.052$
			O-S vs C	$>.05$
			S-O vs O-S	$>.05$
3	0.17	$>.05$		
P_2	4.94	$>.05$		
4	11.15	$<.01$	O-S vs C	$=.00$
			S-O vs C	$>.05$
5	12.32	$<.01$	O-S vs C	$=.00$
			S-O vs C	$=.052$
6	3.27	$>.05$		
7	4.94	$>.05$		