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OLFACTORY DISCRIMINATION IN
LOBOTOMIZED PATIENTS

by

Joseph R. Caldwell, S.J.

A Thesis Submitted to the Faculty of the Graduate School
of Loyola University in Partial Fulfillment of
the Requirements for the Degree of
Master of Arts

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1958

LIFE

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CHAPTER 1

Introduction

The purpose of this thesis was to investigate possible defects in the olfactory memory of lobotomized patients. Recent reports have indicated that there is a deficit in olfactory memory after damage to the orbital area of the brain. This deficit has proved lasting in the case of animals. In this study, we have been interested in testing for that same deficit in humans several years after they had the lobotomy operation.

Historical Review

The literature specifically related to the loss of olfactory memory after brain lesions is very limited. However, there are studies showing memory defects in other sense modalities after brain injury, which will be included in our review.

Arnold (1) suggests that sense memory is not a unitary function located in a cortical "center" but rather a combination of visual, auditory, somesthetic, gustatory, olfactory and motor memories, mediated by the association areas bordering on these sensory regions. To recognize something by sight, touch, sound, taste etc., means that we must recall having seen, touched, heard tasted this particular thing before, and must recall having found

it beneficial or harmful, good or bad for us.

There is considerable evidence for this view. In human beings the various types of agnosia and aphasia allow the conclusion that the parastriate and peristriate areas (Brodmann 18 and 19) are necessary for visual memory (recognition and visualization of objects) while a more extensive area in the occipital cortex is necessary for the recognition of letters, words and figures. The posterior part of the middle and inferior temporal gyrus (area 21, 37,) is necessary for the recall of word-sounds and the parietal association area for the recognition of objects by touch, (2).

In recent years a series of experiments by Pribram and associates at Yale have provided evidence for a similar localization of sense memory in animals. Pribram and Barry (3) have shown that monkeys lost a learned visual discrimination habit after ablation of the inferior edge of the temporal lobe and were unable to relearn it. When the parieto-occipital cortex was destroyed, monkeys lost tactile and weight discrimination habits but were able to relearn to some extent; the deficit seemed to depend on the size of the lesion. The monkeys with inferotemporal ablations showed no defect in somesthetic discrimination.

Weiskrantz and Mishkin (4) found some indication that auditory discrimination is lost after ablation of the anteromedial temporal cortex.

Bagshaw and Pribram, (5) finally found that the anteromedial supratemporal cortex bordering on the somesthetic area is necessary for conditioned taste discrimination. Since Ruch, Patton

Amassian (6) have shown that the taste area is within the somesthetic area for the tongue, at the lateral base of the postcentral gyrus, it seems that the supratemporal cortex is the gustatory association area.

Olfactory Discrimination

It should be noted first of all, that decrement in olfactory discrimination is generally not reported after accidental lesions, because olfactory sensations, like those of taste, are not usually used for recognition of things. Hence the loss of olfactory memory is not noticed. The patient can still distinguish between pleasant and unpleasant odors, and he is seldom called upon to identify odors. Therefore, little has been done in this area. Our report here will include what has been done first on animals and then on humans.

a) Animals

A report by Pechtel and Associates (7) suggested that the orbital area is important for smell. They found that destruction of the dorsomedial thalamic nuclei projecting to the orbital area abolished olfactory discrimination in cats. Moreover, the cats could not learn to distinguish between different smells in 6 to 11 months of retraining. It was also noted that the thalamic lesions impaired discrimination as such, rather than olfactory sensations. When, for example, the animals had once taken meat, fish or milk contaminated with a small quantity of oil of wintergreen

or mephenesin powder, both unacceptable to the normal cat, they would afterwards reject all food to which any odorous substance had been added, even though they had readily taken such contaminated food before the operation. As Arnold points out: "This surely means that animals could still distinguish between pleasant and unpleasant smells, even though they could not remember that an unpleasant smell might sometimes be attached to palatable food". (8).

b) Humans

Wenzel, B., (Columbia Greystone Study, 1952) found that patients after various types of brain operations were unable to distinguish smells, though before the operation they were able to identify the smells correctly.

In a private communication from the author of the study, it was learned that 22 patients were tested representing four different surgical procedures, none of which were classical Prefrontal lobotomy. The breakdown of these various types of operations were as follows:

- 11 patients. . . .Venolysis or Ven^o Ligation
- 2 patients. . . .Thalamotomy a la Spiegel (i.e. electrocoagulation of both dorsomedial nuclei).
- 2 patients. . . .Thermocoagulation (presumably of prefrontal area).
- 7 patients. . . .Transorbital Lobotomy.

Since these operations, as described above, either destroyed the orbital area or prevented its activation by subcortical

impulses, it seems reasonable to assume that in man, as in animals, the orbital area is essential for olfactory discrimination, i.e. olfactory memory.

It should be noted here that the Greystone Study on humans, though similar to the one done in this thesis, is not exactly the same. The finding indicated above was a qualitative result, incidental to the main purpose of their study. This study was designed to verify that qualitative result and hence differs from the Greystone in the following way:

The purpose of the Greystone was to measure olfactory sensitivity by determining the thresholds for odor identification before and after various brain operations. The purpose of this study was to investigate the possible lack of olfactory discrimination in lobotomized patients, several years after the lobotomy. In a sense then, this thesis attempts to verify experimentally the incidental, qualitative finding which was contained among the results of the Greystone Study.

It should also be noted that in this study, only patients with classical pre-frontal lobotomies were used in the experimental group. Although the results stated in the Greystone Study were merely qualitative, (9), still they are of great importance, because, as Arnold points out:

"They show that a sense modality may be unimpaired, yet the person may not be able to recognize the object sensed, because the connection between sense area and association area is broken." (10)

CHAPTER II

PROCEDURE

I. Description of the Population.

The population in this study is divided into three groups:

A) the normal group; B) the experimental group; C) and the control group. The normal group was used in order to test the apparatus and to get an idea of the kind of responses a normal group would give to the selected odors. The experimental group was used to test for a deficit in olfactory discrimination among lobotomized patients, (the purpose of this thesis). The control group was used in order to ascertain whether or not the fact that the lobotomized patients are psychotic could explain any deficit that might be found in the experimental group. Each of these groups are described fully as follows:

A. The Normal Group

This group consisted of fifteen college students, males and females who were taking a summer school course in chemistry. They were asked to volunteer for a psychological experiment, the nature of which was not explained to them until they arrived for testing. This group was considered "normal" for three reasons: 1) They were capable of perceiving common odors. In order to assure this factor, two special precautions were taken. The students left the building in which they were attending lectures and came over to

another building on the campus. This gave them an opportunity to breathe fresh air, thus helping to eliminate odors they may have perceived in the chemistry building. Secondly, those students who had colds or temporary nasal conditions inimical to our purpose were rejected.

2) These students were not psychotic, to distinguish them from the control group. 3) These students were not lobotomized, to distinguish them from both the control and experimental groups.

B. The Experimental Group.

This group consisted of fifteen patients at Chicago State Mental Hospital. Each of these patients had undergone a standard pre-frontal lobotomy operation and were resident patients, some five years after the lobotomy was performed. They were classified, generally, as "psychotic" and initially selected for our study by the psychologists who worked with them on the wards of the hospital. The criterion used for selection was twofold: 1) The ability of the patient to perceive common odors; 2) The ability of the patient to cooperate with the experiment, and to report their sensations.

From a list of twenty-five patients submitted by the psychologists, fifteen were selected by the experimenter after a first interview. The other ten were rejected as being unable to cooperate with the instructions. These fifteen were all women. There were only two men on the initial list and these had to be rejected as completely unsuited for the experiment. Since our major criterion

was the lobotomy itself, the type and degree of psychotic disturbance was ignored, except when it interfered with the patient's ability to cooperate as we have indicated. If they could perceive odors and if they could cooperate with the instructions, we considered them apt subjects for our purpose.

C. The Control Group

This consisted of fifteen mental patients at Chicago State Mental Hospital. All of them were women, and all of them had been selected by a psychologist who worked with them on the ward. Our criterion for this group was three-fold: 1) They were capable of perceiving common odors, (none of them had colds or other normal nasal obstructions); 2) They were not lobotomized; 3) Though classified as "psychotic", they were considered capable of cooperating with the instructions and reporting their reactions.

As indicated briefly above, a control group was needed, to test the hypothesis that a deficit in olfactory memory was due to the fact that the patients had been lobotomized, and not that they were psychotics. The classification, "psychotic", was taken in a loose sense in order to approximate the random classification of the experimental group. The majority of the patients were selected from the same ward as the patients in the experimental group. This could not be controlled completely because the patients were often moved from one ward to another. Since the experiment proved threatening to this group, as contrasted with the other two, we eliminated the interview, and began with the experiment itself, as in the

case of the normals.

II. Experimental Procedure and Technique.

A. The Apparatus

This consisted of a form of the Elsberg Olfactometer for blast injection (Elsberg and Levy, '35). A form of this apparatus was used, since it proved to be an apt instrument for measuring olfactory threshold. Although it was not our purpose to measure thresholds, as was pointed out in the discussion of the Greystone Study, still some form of the Olfactometer was thought advisable because the sensitivity might differ in the two nostrils. According to the authors, perception and identification of odors depend upon several factors, as follows:

"1. A sufficient mass of odor must come into contact with the olfactory receptors before an odor can be appreciated.

2. In order to produce an adequate stimulus, the odor must impinge upon the olfactory membrane with a certain degree of force.

3. The identification of many odors depends not only upon sufficient volume and force, but also upon an effect upon the sensory receptors of the trigeminal nerve. There are relatively few pure olfactory stimulants. Apparently some odors affect only the olfactory cells; many also stimulate the trigeminal nerve so that in addition to the odor, there is a stinging, burning, cool or hot sensation. In some odors, such as ammonia, the trigeminal effect is prominent. The identification of an odor depends upon memory and association and many odors are recognized from the combination of the olfactory and trigeminal components." (11)

The blast injection method, used in this study, is based upon the principle of the injection of different volumes of odor into

one or both nasal passages during a period of momentary cessation of breathing, the force of the injection taking the place of the ordinary inspiration movement.

This method has the advantage that the force of the injection is equal for all subjects.

The material used in the apparatus includes the following:

1. Six bottles with a capacity of 500 cc's.
2. Six odorous substances which are placed at the bottom of the bottles, leaving the rest of the area filled with the odor itself. The odors selected are described below.
3. Six nosepieces, one for each bottle. One branch of each nosepiece is closed with a rubber stopper allowing us to test each nostril separately. Each nosepiece is connected to the outlet tube by means of pure gum rubber tube which is compressed by a spring pinchcock.
4. Six "Vim" glass syringes of a capacity of 10 cc's each. Since in this experiment we were not interested in measuring olfactory thresholds, a 10 cc. syringe was considered sufficient since it provided the volume needed for an adequate blast of each odor.
5. Each bottle was enclosed at the neck with a rubber stopper with two perforations. Through these go the inlet and outlet tubes for the passage of air.

The inlet tube passes into the bottle and its length is such that it ends just above the surface of the solid or fluid substance which is giving off the odor. The outlet tube runs through the other perforation in the stopper which projects to just beyond the under surface of the stopper. The inlet tube, bent at right angles just beyond the surface of the stopper, is connected by a piece of rubber tubing which is itself connected to the nozzle of

a syringe making an airtight connection. The outlet tube is so arranged, that pressure upon the pinchcock will release the odor from the bottle. Onto the tip of this outlet tube are attached the nosepieces. Each nosepiece has attached to its end a piece of rubber tubing of appropriate size so that an airtight connection can be made between the nosepiece and the tip of the outlet tube.

Regarding the selection of odors, this was based on later studies done by Elsberg and associates. Their criterion for the selection of odors was that the odors should be familiar and easily identifiable, and that one of the substances should be a pure olfactory stimulant and one should have a trigeminal effect.

That the selected odors should be familiar is rather obvious. Ability to identify and name odors is based upon experience and is the result of memory and association. Sometimes an individual may be unable to name a specific familiar odor, but the majority are able to identify common odors rather quickly.

Concerning the trigeminal effect of an odor the authors point out that the ease with which an odor can be identified may depend in part upon the trigeminal sensation which is associated with the olfactory effect of the odor. The odor of ammonia, for example, is recognized by the olfactory sensation and by the characteristic irritation of the nasal passages. It may well be that the trigeminal is of as much or of more significance for the recognition of this odor than the olfactory sensation itself. Therefore, at least some of the odors used for olfactory testing should have a trigeminal as

well as an olfactory effect.

According to the criteria stated above, we selected for our study the six following odors:

1. Citral (Oil of Lemon)
2. Coffee (Freshly Ground)
3. Oil of Turpentine
4. Oil of Almonds
5. Oil of Roses
6. Ammonia (Trigeminal effect)

This selection corresponds with that which Elsberg and associates found suitable for clinical test of olfactory function by the blast injection method. They recommended Coffee, Citral, Oil of Turpentine and Benzaldehyde. Since it was our purpose to test olfactory memory we selected more than three odors in order to have a fair sample of different odors.

B. Procedure for the Normal Group

After determining the ability of the subject to perceive odors the nature of the experiment was explained to them and he was given a demonstration of the procedure. With the help of an assistant the experimenter showed the subject how to insert the nosepiece into his nostrils so as to direct the current upward toward the olfactory membrane. He was instructed to hold his breath while the experimenter injected air into the bottle and then released the blast by pressure upon the pinchcock. As explained before, this blast takes the place of the inspiration movement. The subject was

then asked, "What was that?" or "What did that smell like?" When the subject was clear on the instructions we proceeded to the experiment itself.

The order of presentation of the odorous substances for each nostril was always the same. A more familiar substance, Oil of Lemon, came first, and the most irritating, Ammonia, was given last. Sufficient time was given between presentations in order to control possible perseveration.

A controlled amount of air was injected into the bottle by means of the syringe. The volume was based upon as many cc.'s as called for by the olfactory coefficient of each odor. The coefficient differs for each odor, and expresses the number of cubic centimeters required for identification of the odor.

The subject's responses to the presentation for each nostril were recorded by an assistant. Every effort was made to keep the subject from sniffing up through the nosepiece, but we were not always successful in getting this point across.

After all six odors had been presented as described, the same six odors were again presented. This time, however, the procedure was much simpler. Each subject was presented with a standard size chemistry bottle containing the same odorous substances and in the same sequence. He was told to smell the open bottle held under his nose, and answer the same questions, "What was that?", or "What did that smell like?". His answers were recorded as before. It was felt that such a procedure gave adequate opportunity for each

subject to try and identify the odors. Also is provided an important check on the first answers given with use of the Olfactometer. Finally, it helped to eliminate possible errors due to the subjects inability to comply strictly with the instructions connected with the use of the Olfactometer.

C. Procedure for the Experimental Group

The same procedure was used for this group as for the "normals" except for the following changes:

1. In the first interview, the patient was given a "trial run", as part of the demonstration of experimental procedure. The odor, oil of almond, was used since the normal group practically never recognized it, and it was considered good for our purpose. Only a very few cc.'s of air were injected, thereby not permitting a blast sufficient for normal recognition. It was felt that the subject's response to this "demonstration" would in itself be an indicator of possible deficit in olfactory memory. Also it provided the experimenter with an opportunity to discover whether or not the subject was sufficiently able to follow the instructions.
2. Besides the questions already indicated, it was sometimes necessary to add, "What does that remind you of?", or "Did you ever smell anything like that before?". This seemed to encourage a response which might not otherwise be given.

D. Procedure for the Control Group

The same procedure was used for this group as for the other two groups, except for the following changes:

1. As already indicated (pg. 10) the first interview was eliminated for this group, since any kind of psychological testing appeared more threatening for this group than for the other two. So we began with the experiment itself, after briefing the patient on the instructions.

2. A rather drastic change had to be introduced after the first few trials with the Olfactometer. It will be recalled that this group was made up of non-lobotomized psychotics. They were selected on the basis of their ability to follow instructions and give adequate responses. However, even though they could do this, they seemed to be afraid of the apparatus itself that it was decided not to use the Olfactometer and settle for the small bottles which presented no problem for these people.

The first two patients, for example, were startled by portions of the apparatus, especially the syringes and nosepieces. One of them would push the nosepiece away from her. The other, upon seeing the six bottles before her on the table, began to leave the room. A third one, when asked to identify the odor, began to cry and then became quite violent, saying she was "fed up with these. . . . tests!". Because of these reactions, it was decided to try only the small open bottles containing the same odors. Accordingly the Olfactometer was put away, and the bottles presented in the usual sequence. The same patients, who balked at the Olfactometer, responded readily to the open bottles and their interesting answers were recorded.

The experiment for the two groups, experimental and control, were conducted in the same room off of one of the wards at the Chicago State Mental Hospital. The room was relatively free of other odors, and sufficiently removed from the medical examination room and the ward itself, since both of these places would contain odors with which the patient was quite familiar. Available space for our use was at a minimum and we had to be content with a room in which such variables as temperature could not be systematically

controlled. The staff and attendants at the hospital were very cooperative and helpful within the limits of time and space available to them.

CHAPTER III

RESULTS

The results of this study are reported for each of the three groups. Before turning to the tables, it will be recalled that six odors were used in this experiment, as follows:

- No. 1Oil of Lemon
- No. 2Oil of Almond
- No. 3Coffee Grounds
- No. 4Turpentine
- No. 5Oil of Roses
- No. 6Ammonia

An answer that was considered correct is given a plus (+) sign in the tables; a negative or incorrect answer is given a minus (-) sign. It was not required that the subject identify the odor exactly. In fact, an effort was made to give the benefit of the doubt to a positive answer. For example, in odor No. 1, Oil of Lemon, such answers as "like citrus fruit"; "fruit juice"; "lime" were all given plus signs even though the strictly correct answer was lemon. An example of a negative answer for this odor was, "something sweet", "very familiar". These answers were given by the normal group and were used as a criterion for scoring the

answers on the other two groups. We anticipated that the Psychotics would have some difficulty in identification of odors. Therefore, we were as lenient as possible in scoring an answer as positive. Only those which did not indicate discrimination were scored negatively.

IDENTIFICATION OF ODORS BY NORMAL GROUP

Odors	With Olfactometer												Open Bottle Only						
	Left Nostril						Right Nostril						Open Bottle Only						
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	
Subjects 1	+	-	+	-	+	-	+	-	+	+	+	+	+	-	+	+	+	+	
2	+	-	-	+	+	+	+	-	-	+	+	+	+	-	+	+	+	+	
3	-	-	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	
4	-	-	+	+	+	-	+	-	+	+	+	-	+	-	+	+	+	+	
5	+	-	+	+	-	-	+	-	+	+	-	+	+	-	+	+	+	+	
6	+	-	+	-	+	-	+	-	+	+	+	+	+	-	+	+	+	+	
7	+	-	+	-	+	+	+	-	+	-	+	+	+	-	+	-	+	-	
8	-	-	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+	+	
9	+	-	+	+	-	+	+	-	+	+	-	+	+	-	+	+	-	+	
10	+	-	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+	+	
11	-	-	-	+	-	-	-	-	-	+	-	-	-	-	+	+	+	+	
12	+	-	+	+	+	-	+	-	+	+	+	+	+	-	+	+	+	+	
13	-	-	+	+	-	+	+	-	+	+	+	+	+	-	+	+	+	+	
14	-	-	+	+	-	-	-	-	+	+	+	-	+	-	+	+	+	+	
15	+	-	+	-	-	+	+	-	+	+	-	+	+	-	+	+	-	+	
Total +		9	0	13	11	9	8	13	0	13	14	11	12	14	1	15	14	13	15
Total -		6	15	2	4	6	7	2	15	2	1	4	3	1	14	0	1	2	0
Total Correct (+) = 185 69%												Odor 1 Oil of Lemon							
Total Incorrect (-) = 85 31%												Odor 2 Oil of Almond							
Total Trials = 270												Odor 3 Coffee Grounds							
												Odor 4 Turpentine							
												Odor 5 Oil of Roses							
												Odor 6 Ammonia							

TABLE II

IDENTIFICATION OF ODORS BY LOBOTOMIZED PSYCHOTICS

Odors	With Olfactometer												Open Bottle Only					
	Left Nostril						Right Nostril						1	2	3	4	5	6
Subject 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+	-
4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
5	+	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-
6	+	-	+	+	-	-	+	-	+	+	-	-	+	-	+	+	-	-
7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
9	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+
10	-	-	-	-	+	-	-	-	-	+	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	+	+	-	-	-	-	-	+	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	+	-	-	+	-	-	+	-	-	-	-	-	+	-	-	-	-	-
+ Total	4	0	1	1	3	2	3	0	1	2	0	1	3	1	2	3	2	1
- Total	11	15	14	14	12	15	12	15	14	13	15	14	12	14	13	12	13	14
Total Correct	= 30												11%					
Total Incorrect	= 240												89%					
Total Trials	= 270																	
												Odor No. 1 Oil of Lemon						
												No. 2 Oil of Almonds						
												No. 3 Coffee Grounds						
												No. 4 Turpentine						
												No. 5 Oil of Roses						
												No. 6 Ammonia						

Explanation of Table I

As can be seen from Table I, out of 270 trials using both the Olfactometer (on right and left nostrils separately) and the open bottle presentation, 185 responses were marked correctly, 85 incorrectly. A correct response, in our study, meant that the subject was able to both recognize and identify the odorous substances as indicated in the discussion of the results. It will be recalled that six odors were used, as described in the Table, and fifteen normals made up our subjects.

Explanation of Table II

As indicated in this table, out of 270 trials using both the Olfactometer and the open bottle presentation, 30 responses were found correct, 240 incorrect. This group is the Experimental Group consisting of 15 lobotomized psychotics as described in Chapter II. The same six odorous substances were used, as indicated in the Table, and the same presentation was given to this group as to the normals.

Explanation of Table III

This Table represents the control group, or Non-Lobotomized Psychotics. Since the Olfactometer was not used with this group, the table refers to the open bottle presentations only. Out of a total of 90 trials, 65 were marked correct, 25 were marked incorrect. Again the same six odorous substances were used as in the other two groups and the same sequence of presentation was maintained.

Statistical Results

The statistical method selected was that of Chi Square in a two by two contingency table. Its use was to test the null hypothesis, i.e., that there are no significant differences between proportions for the two samples; that the differences are explainable in terms of chance variation arising from random sampling of a common population.

TABLE IV

Values of χ^2 for all presentations combined

Comparison	Control	Experimental
Normal	0.436	268.186
Control	- - -	110.266

With one degree of freedom, χ^2 must = 3.841 for significance at five per cent
 With one degree of freedom, χ^2 must = 5.412 for significance at two per cent
 With one degree of freedom, χ^2 must = 6.635 for significance at one per cent

Explanation of Table IV

When the normal group is compared with the control group the value of χ^2 is 0.436. This value is not significant, hence the null hypothesis may not be rejected. There is no basis, then, for assuming that the difference in success and failure between the two groups is due to anything other than sampling fluctuations. The control group of non-lobotomized psychotics and the normal group may, therefore, be considered as random samples from a common population.

This situation is dramatically reversed when the normal group is compared with the experimental and also when the control group is compared with the experimental. In these comparisons the values of χ^2 are 268.186 and 110.266 respectively, as seen in Table IV. Since a value of χ^2 equal to 6.634 is sufficient to reject the null hypothesis at the one per cent level of confidence, it is readily seen that these values of χ^2 are highly significant and that the null hypothesis may be rejected with a high degree of confidence. Hence, there is adequate evidence to make tenable the proposition that differences in ability to recognize odors between normal and experimental groups and between control and experimental groups are real differences and that the experimental sample cannot be considered a random sample from the same population from which were drawn the control and normal samples.

TABLE V

Values of χ^2 for Open Bottle Presentation Only

Comparison	Control	Experimental
Normal	0.450	80.357
Control	- - -	63.752

Explanation of Table V

As in the case of the figures in Table IV, the difference between the normal and control groups can be explained in terms of chance. When the normal is compared with the control, the value of χ^2 is 0.450. This value is not significant; hence, the null

hypothesis again may not be rejected.

However, when the normal is compared with the experimental and also when the control is compared with the experimental, the situation is again quite different. In these comparisons the values of χ^2 are 80.357 and 63.752. Again these values indicate a very high degree of significance and the null hypothesis is again rejected with a high degree of confidence. In this presentation, limited to the open bottle, a total of 90 trials was given to all three groups. This of course would account for the difference in the values of χ^2 between Tables IV and V. In Table IV the figures refer to all presentations, thereby, covering the use both of the Olfactometer and the open bottles. A total of 270 trials was given to the normal and experimental groups, while a total of 90 trials was given to the control group, since only the open bottles were used.

TABLE VI

Values of χ^2 for Left Nostril and Right Nostril Presentation

Method of Presentation

Comparison	Left Nostril		Right Nostril	
	Control	Experimental	Control	Experimental
Normal	*	37.823	*	73.309
Control	- - -	*	- - -	*

* The control group was not compared here since it was not given the left and right nostril test due to difficulties in using the Olfactometer as described in Chapter II.

Explanation of Table VI

Again the values of χ^2 are highly significant, and the null hypothesis must again be rejected.

CHAPTER IV

Discussion of the Results

In the previous chapter we reported the results or findings of our study. It now remains to discuss those results in terms of our purpose and investigation. The statistical results are explained in the previous chapter and are rather obvious. They will only be used here in confirmation of the actual findings. Accordingly, we shall discuss the results for each of the three groups.

I. The Normal Group

As can be seen from Table I, (pg. 19), this group was given a total of 270 trials. From that number 185 gave adequate identification of the six different odors; 68 per cent, in other words, were correct. An analysis of this table shows the following interesting observations:

- A. In general, identification of the odors progressed with each presentation. For example, Odor No. 1, Oil of Lemon, was increasingly more recognized in the progression of presentations from left nostril to right nostril to open bottle. In terms of numbers, as can be seen in the total plus (+) column of the table, the Left Nostril is 9; the Right Nostril is 13; the Open Bottle is 14. This is also true of all the other odors, as can be readily seen from a glance at the total plus (+) column on Table I. Proportionately, the number of incorrect answers decreases with each new presentation of the odor as can be seen from the total minus (-) column of Table I.

- B. A second interesting observation of these results was the apparent inability of the subjects to recognize or identify Odor No. 2, Oil of Almonds. As can be seen from the table only one subject out of fifteen identified this odor correctly, and that was an open bottle presentation. The response of this subject was actually "Castor Oil", which was given a plus rating. One possible reason for this almost complete lack of identification might be found in the fact that these subjects were students and perhaps quite unfamiliar with cooking smells, such as Oil of Almonds. The possibility of rejecting this odor was discussed, but we decided to retain its use because of its test qualities for the experimental group, as was explained earlier (pg.15).
- C. A third and final observation is that the odor universally identified by this group in the open bottle presentation was Odor No. 6, Ammonia. This was expected, due to the large trigeminal effect of this odor. Almost all of the subjects displayed some discomfort reaction upon perception of this odor, despite the fact that they were chemistry students and somewhat familiar with it. This discomfort reaction proved quite significant with the experimental group, since it gave us an indication that the subject was able to perceive the odor, though he was unable to identify or remember it.

In general then, we can say that the Normal Group, in terms of the majority, were able to identify the odors presented, and consequently gave no significant indication of a deficit in olfactory memory.

II. The Experimental Group (Lobotomized Psychotics)

In contrast with the Normal Group findings, the results for the experimental group reveal the following observations:

- A. There is no increase of identification of any odor from presentation to presentation, as can be readily seen from Table II (pg.20)
- B. Only one subject out of fifteen identified Odor No. 2, Oil of Almonds, and her response, as in the Normal Group, was "Caster Oil". This "identification" took place only in the open bottle presentation, again as

in the Normal Group.

- C. As contrasted with the Normal Group, these subjects did not significantly identify Odor No. 6, Ammonia, in any presentation. As can be seen from Table II, there were only four "correct" identifications, two of these, in the left nostril presentation, responded with "a chemical" and "ether", which were given a plus rating. All of the subjects but one showed some reaction of discomfort to the ammonia when presented in the open bottle. Most of them showed no such reaction when ammonia was presented in the Olfactometer. This could be due to the difficulty many of the subjects had in following the instructions accurately.

In general then, out of 270 trials, 240 or 89 per cent could not identify the odors as presented. As explained on page 23, this result is highly significant at better than the one per cent level of confidence. Hence the differences in ability to recognize odors between the Normal and Experimental Groups are real differences and cannot be explained merely by chance.

Our contention was that this significant and real difference was ~~due to the fact that the subjects in the Experimental Group were~~ due to the lobotomy. However, the question obviously arose: Is this difference actually due to the lobotomy, or to the fact that these patients are psychotics? Hence it was necessary to perform the experiment on a control group consisting of non-lobotomized psychotics. As explained previously, page 15, it was necessary to change the procedure with this group due to their fear reactions to the apparatus as such. Hence only the open bottle procedure was used with this group cutting down the number of actual trials from 270 to 90.

III. The Control Group (Non-Lobotomized Psychotics)

Keeping in mind the above mentioned change in the number of trials, the results as seen in Table III, Page 21, show that out of 90 trials 65 identified correctly, or 72 per cent. This is not significantly different from the performance of the Normal Group which was 80 per cent in the open bottle trials. For all presentation in the Normal Group the per cent was 68. As already indicated, identification of the odors was much more accurate with the open bottle presentation.

As indicated in the statistical results (pg.23), the difference between the Control and Experimental Group is again highly significant and cannot be explained in terms of mere chance. Hence it seems quite apparent that the Control Group of non-lobotomized psychotics are quite able to identify the odors, and that the deficit in olfactory memory is due not to the factor of mental illness, but due to the lobotomy itself.

Two other incidental observations are interesting in connection with the results for the Control Group.

A. As contrasted with the other two groups, the subjects in the Control Group were able to identify Odor No. 2, Oil of Almonds, in a very significant manner. Keeping in mind that this group had the open bottle presentation only, twelve out of fifteen were able to identify the odor. Their responses, however, were limited to "Caster Oil", "Olive Oil" and "Mineral Oil", all of which were given a plus rating. None of them gave the actual response of Oil of

Almonds.

B. As contrasted with the Normal Group, this group showed no significant increase in the recognition of Odor No. 6, Ammonia. This could be explained by the fact that chemistry students should recognize Ammonia more readily than others. The patients did, however, show the expected reaction of discomfort when presented with the Ammonia in the open bottle.

In the Experimental Group (lobotomized psychotics) subject No. 6 seems to have had some olfactory discrimination. As can be seen in Table II, Page 20, she identified an odor correctly nine times out of eighteen trials. This was a better record than any other subject in the Experimental Group, as can be readily seen from the table. This is probably explained by the fact that the dorsomedial nucleus projection to the orbital area was not completely severed.

According to Meyer and Beck (12) standard lobotomy severs the projection from the dorsomedial nucleus to the prefrontal area. But in any given case, it is not possible to say whether this connection has been interrupted completely.

CHAPTER V

SUMMARY AND CONCLUSION

This experiment was constructed to investigate the possible deficit in olfactory memory of lobotomized patients. Three groups were used:

1. A Normal Group, consisting of fifteen university students who were neither lobotomized nor psychotics.
2. An Experimental Group, consisting of fifteen metal patients who had undergone a standard pre-frontal lobotomy operation some five years ago.
3. A Control Group, consisting of fifteen psychotic patients resident in a mental hospital. These patients were not lobotomized. Their stay in the hospital approximated that of the patients in the Experimental Group.

Each of these groups were tested for possible deficit in olfactory memory. Six odors were used and were presented through an Olfactometer and six open bottles as explained in Chapter II of this thesis. The results of our experiment suggests the following conclusions:

1. There was no significant deficit in olfactory memory among the subjects of the Normal Group.
2. There was no significant deficit in olfactory memory among the subjects of the Control Group.
3. There was a highly significant deficit in olfactory memory among the subjects in the Experimental Group.

Since only the subjects in the Experimental Group had been

lobotomized, we suggest that the inability to identify common odors is due to the damage done to the orbital area of the brain by the lobotomy itself. We suggest further, that this inability to identify the odors is due to a deficit in olfactory memory, since sense identification depends on previous associations. If a person cannot be expected to remember the odor, he cannot be expected to identify it. This was quite evident among the patients in the Experimental Group. They would often say, "This is very familiar to me, but I can't seem to remember", or "I know what it is, but I can't tell you". Similar expressions were found among the subjects of the other two groups, but never to a significant extent.

In conclusion, we suggest that our study shows a deficit in olfactory memory among humans after damage to the orbital area of the brain in prefrontal lobotomy. As in the case of animals, this damage has proved lasting in human beings.

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APPROVAL SHEET

The thesis submitted by Joseph R. Caldwell, S.J. has been read and approved by three members of the Department of Psychology.

The final copies have been examined by the director of the thesis and the signature which appears below verifies the fact that any necessary changes have been incorporated, and that the thesis is now given final approval with reference to content, form, and mechanical accuracy.

The thesis is therefore accepted in partial fulfillment of the requirements for the degree of Master of Arts.

May 29, 1958
Date

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