THE RELATION OF EXPERIENCE TO THE DEVELOPMENT OF HUNGER.

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INTRODUCTION

This investigation is concerned with the relation of some aspects of experience to the development of hunger. It has long been taken for granted that hunger is an innate[1] drive. Anderson (2) and others have suggested that the role of experience is to modify the inherent organization. The present study will examine a different hypothesis, namely, that even the initial organization of the hunger drive is dependent, not only on physiological maturation, but also on experience or learning. It is suggested that the first effect of a lack of food does not lead to an organized motivation, but to disintegration of some neural processes. "Hunger" implies a later stage of organization that involves learning. A consideration of recent theories on the nature of the organization of hunger will serve to clarify this problem.

Theoretical background. Morgan (8) conceives of a "drive" as a central motive state (CMS), an integrative process that organizes certain afferent impulses and leads to purposive behaviour. In the case of hunger specifically, the problem of the nature of the organization of this CMS is partially avoided by referring to "hunger defined as a craving (unlearned) for food" (8, p. 446). What are the implications of this assumption? An innate set of connections

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1. Innate or inherent is used in the sense of matured at birth.

must exist in the central nervous system between the internal stimuli resulting from food lack and the organization of motor behaviour leading to eating. Nutritional deprivation, by activating the CMS, functions to prime the animal to seek for, and respond to, definite stimuli exciting the receptors of the mouth. This process would be analogous to the response to certain patterns of sexual posture.

Young (14, 15) has not clearly stated his position with respect to the nature of the organization of general hunger, although he has shown that the need-stimulus theory is inadequate (14). At one time Young says that "all food-seeking drives are learned", then follows with "Internal hunger, of course, does exist" (15, p. 104). Although this concept of internal hunger is not fully elaborated, the example used implies that general food lack necessarily activates the tendency to seek food. Further evidence for a dichotomy between general and specific hunger appears in Young's suggestion of "a broader definition of learning which includes the acquisition of motives (specific food-seeking drives and food expectancies)" (14, P. 311). This statement seems to exclude general hunger as learned.

Hebb (4) has made explicit assumptions that more sharply limit those systems that are to be viewed as innate. First, the sucking reflex is considered to be matured at birth. Secondly, it is assumed that hunger contractions occur with food deprivation, and that stimuli from the lips, taste receptors, and alimentary tract lead to a cessation of these contractions by virtue of inherent neural connections. Thirdly, it is suggested that, under conditions of lowered concentration of blood nutrients, some of the experientially organized neural systems are characterized by a dysfuntion that may manifest itself as an emotional disturbance. What are the consequences of this position? Lack of either general or specific nutrients might produce a pathological syndrome with physiological and psychological signs, but as Young points out, "Deficiency symptoms are not drives" (14, p. 316). Upon first deprivation, then, an animal might be "disturbed", but he would not be hungry, when hunger is defined as the tendency to seek and eat food. Hebb does, however, suggest a mechanism whereby chance eating experiences occurring during the period of random excitation function to develop a neural "phase sequence" analogous to Morgan's CMS. It is the arousal of this neural system, developed through experience, that is characteristic of the _hungry_ animal.

Morgan's formulation is most representative of prevailing theory. That is, most workers take for granted that the CMS is intrinsically organized so that the physiological consequences of food deprivation are adequate to activate it to efficient functioning. Hebb, on the other hand, assumes that the neural organization of hunger is learned, or developed by experience. Young seems to represent a position between those of Hebb and Morgan. One must conclude, then, that the nature of the organization of hunger is not clear.

Definition of "hunger". The distinction has often been made between "hunger" and "appetite". "Hunger" is commonly used to refer to the existence of a nutritional need; "appetite" refers to a tendency to eat that does not necessarily meet a biological requirement.

The differentiation, then, is not based on differences in behaviour, but on a judgment on the part of the observer of the biological value of the activity. The psychological question, on the other hand, concerns the mechanism that determines the eating regardless of whether its operation has desirable effects or not. The present investigation is concerned with the neural system responsible for eating; hence no dichotomy will be made between hunger and appetite. Hunger is defined here simply as the tendency to eat.

Review of the evidence. A review of the literature reveals that none of the published experiments on hunger has been so designed as to offer a valid test of the premise that hunger is intrinsically organized. There is, then, no direct evidence to substantiate the assumption that internal stimuli resulting from food lack automatically arouse the tendency to eat. It would appear that this belief has been based on observations made, not in experimentally controlled situations, but from casual experience. For example, nutritional lack does appear to arouse hunger in most adult humans and other organisms under ordinary circumstances. Also, infants requiring nourishment show signs of discomfort that disappear upon feeding, although this behaviour does not necessarily justify the usual inference of a desire for food. These common facts, interpreted to fit the theory that deprivation automatically initiates the tendency to eat, may have obscured observations that are less consistent with it.

For example, a few writers have described, but not interpreted, a phenomenon that suggests that an animal must learn to seek food when first deprived. Hunt et al.(5) note in their procedure that during the first few days of deprivation of the infant group, it was necessary to leave the mash in the cage for a few hours rather than the 10 minute period originally planned, since at first the animals showed no great inclination to eat. After repeated experience in the situation, the animals began to eat as soon as the food was presented. Meehl et al.(7), in discussing the behaviour of rats finding reinforcement in a maze after their second period of deprivation, say that "the hungry animals did not always eat continuously" (p. 380) even though this was the first 30 seconds during which they had access to food after a 20-hour lack. Unfortunately, the authors do not describe the behaviour on subsequent days, but it may be assumed that eating responses increased. Walker (12), also using a maze, reports that "in the first day or two of trials under hunger motivation, this required that the animals be left in the goal box for some time as they showed little disposition to eat. As training proceeded, they ate progressively more readily" (p. 43).

The best evidence to support the assumption that hunger is experientially developed can be found in a preliminary study by Hebb (4). The strength of the tendency to eat was observed in one group of naive, adult rats deprived for 24 hours and tested in a closed field apparatus to which the animals had been habituated, and in another group tested in the home cages after 48 hours deprivation. The data obtained under both conditions suggested that when first deprived the animals had to learn to seek food. However, the groups used were small and displayed a wide range of variability. Also, it may be that a strong degree of hunger was not aroused on the first test day because of emotional disturbance in the apparatus despite habituation, and the long deprivation period in the cage-tested group which, empirically, may decrease hunger. The experiment, therefore, should be repeated if any weight is to be given to the conclusion.

Statement of problem. The experiment to be reported in this paper was a test of Hebb's conclusion that hunger is learned by repeating his experiment with an improved procedure. The specific problem was to determine whether an innate organization exists by which the perception of edible substances will lead to more eating by a food-deprived animal than by one with a continuous supply of food. Even though food is always available in the cage, it cannot be assumed that no "learning" to eat occurs. The animal must repeatedly fail to eat at the exact moment when his physiological need of food appears, and thus would repeatedly experience the conditions that would make for learning to eat. It might, however, be expected that this learning would be minimal. The question to be asked, then, is whether the strength of the tendency to eat aroused in the animal deprived of food for the first time would be proportional to his past learning or his present physiological deficit. Elaborating this statement will show the experimental implications.

If past experience is as important as physiological need in determining hunger, on the first test day the animals would not eat enough to compensate for their deficit, and, under certain conditions, would behave like control animals. Then, through experience in eating when deprived, the animals would learn to associate food-eating with the cessation of the discomforts specific to nutritional lack, and would eat more on successive days of testing. In conventional learning terminology, they would show a selective learning of the correct response.

If nutritional need is innately operative in determining the degree of motivation, the animals would eat enough to compensate for their deficit on the first day. Further, no increase in eating would be expected upon consecutive testing, if the deprivation period remains constant each time. Finally, the deprived animals would always behave differently from those without nutritional need.

These generalizations apply to any randomly selected group tested with a given food. If it assumed that experience is important in the organization of hunger, familiar food stimuli would be expected to facilitate the functioning of the CMS relative to the effect of a new food. This hypothesis was investigated by comparing groups tested with a food encountered for the first time, as well as a familiar food. Also, different age groups were used to provide a comparison of the eating behaviour at various age levels.

PROCEDURE

A dish of moist food was presented to the experimental group which had not had food available for 24 hours, and a record made of the time spent eating and the amount eaten. A control group, with food present in the cages since birth, was similarly tested in order to provide an empirical baseline against which to evaluate the specific effects of deprivation upon eating behaviour.

The investigation was done with five litters of rats whose food experience, from birth onwards, was controlled by the experimenter.

All rats were weaned at 21 days and placed with their litter mates in a cage with a plentiful supply of Purina Fox Chow pellets and water. In addition, the animals were fed small pieces of fresh vegetables (potatoes, cabbage, and carrots) about twice a week. Four litters spent at least the first seven weeks of life in small cages, with sexes separated at 40 days of age, while the fifth litter was placed in a colony cage at five weeks. All animals had lived in a colony cage before 10 weeks of age.

The five litters were divided as equally as possible into the four groups to be described. Males and females were distributed approximately equally throughout the groups except for the oldest group, which had proportionately more males than the others. Each experimental group except the oldest was matched with a control group which had never been deprived of food. Animals serving as controls at one stage of the experiment were later used as experimental, that is, food-deprived animals. Testing under deprivation conditions represented the first period in the animals' experience during which they did not have a continuous supply of pellets in the cage. The animals were in four groups, as follows:

(1) Tested at 24 days of age with moist Purina mash. The experimental group consisted of three males and seven females, the control group of two males and seven females.

(2) Tested at 45 days of age with moist Purina mash. The experimental group consisted of three males and six females, the control group of one male and four females.

(3) Tested at 45 days of age for six days with white bread soaked in milk, then tested for another six days with moist Purina mash. The experimental group consisted of two males and seven females, the controls of two males and three females.

(4)Tested at 85 days of age with moist Purina mash. The experimental group consisted of five males and four females.

Testing was done in the individual home cages to which the animals were habituated for 48-72 hours before testing was begun. The rats were weighed daily before each test.

During the testing period, all animals were observed for the first seven minutes after the presentation of food, and the time spent in eating during each of these minutes was recorded. The food was weighed after 7, 30, and 60 minutes, and then removed. For the first six days, the experimental animals tested with mash were food-deprived for 23 hours before each test, while the control animals had the usual supply of pellets in the cage. After the sixth session, pellets were replaced in the cages of the experimental groups, and the testing was continued in the same way for the next three days. A similar procedure was followed for the group tested with bread and milk, except that the deprivation period continued for nine days.

RESULTS

This section will first present an analysis of the eating behaviour of the deprived and non-deprived groups on successive days of testing. Differences in motivational organization as a function of (a) maturational level, and (b) familiarity with food, will then be briefly considered.

Behaviour of experimental group on first test day. Table 1 summarizes the time spent eating by the various groups of experimental and control animals during the first minute after food was placed in the cage. The most significant point to be noted is that the deprived

TABLE 1

Seconds eating during first minute of first day of testing.

Group		Experimental			Control		
age	tested with	M	Md	Range	M	Md	Range
24 days	mash	42	47	0 -59	39	42	0 -55
45 days	mash	56	59	43-60	52	58	32-60
45 days	bread	44	57	0 -60	57	55	47-60
85 days	mash	60	60				

animals did not, as a group, rush to the food, nor did they eat consistently during the first minute. Although some ate for the complete 60 seconds, others did not eat at all. Many animals pecked at the food for a few seconds, then turned away, and returned again for a nibble or two. This behaviour occurred despite the fact that none of the animals showed any sign of externally aroused emotion, nor could they have helped but smell the moist food placed a few inches away.

Most of the animals ate fairly consistently during the next few minutes, but their interest in food seemed to decrease around the fourth minute. For example, note the drop in the eating curve of the first day for the group tested with mash at 45 days of age (fig. 1). The drop was characteristic of all groups except the deprived animals tested at 24 days, and even this exception may be an artifact of the procedure.[2]

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2. Some of the animals of this young group were extremely weak from lack of food and, once eating consistently, tended to sit rather limply on the food dish. At times it was impossible to decide whether or not the animals were actually chewing, in which case they were counted as eating in order not to bias the results in favour of the general hypothesis. Because of this procedure, the animals may have been recorded as eating for a longer period than they actually were, and the drop in the eating curve observed in all other groups, including the controls of this young group, may have been thus obscured.

On the first test day, then, satiation, defined as voluntary cessation of eating, occurred before the nutritional needs of the animal could have been met. Muscle fatigue could not account for the cessation since (a) the animals had been reared on a diet of hard pellets and were tested with soft mash, and (b) the drop practically disappeared on the next day in the experimental groups.

Further, although the animals had access to food for almost one hour after this initial observation period, the total amount eaten did not compensate for the nutritional deficit since the animals lost weight from the first to the second day. Approximately one-half of the total amount eaten was consumed in the first seven minutes (Table 3), which is inconsistent with the idea that fatigue was the reason for their not eating enough in the total period. Thus it appears that a 24-hour food deprivation in itself does not necessarily prime the animal (a) to seek food, nor (b) to consume an adequate amount.

Comparison of experimental and control groups on first test day. A consideration of the behaviour of the control groups tends to clarify further the nature of the motivation aroused during this initial test period. Using the strength of the tendency to eat during the first minute as a basis for comparison, it can be seen from Table 1 that it was impossible to differentiate in any group those animals that had been deprived of food and those that had not. Secondly, the eating behaviour during the whole seven minute period was similar in experimental and control groups. For example, in the case of the group tested with mash at 45 days, satiation occurred about the fifth minute on the first day for both experimental and control animals (fig. 1). Also, the total time spent eating and the amount eaten during these first seven

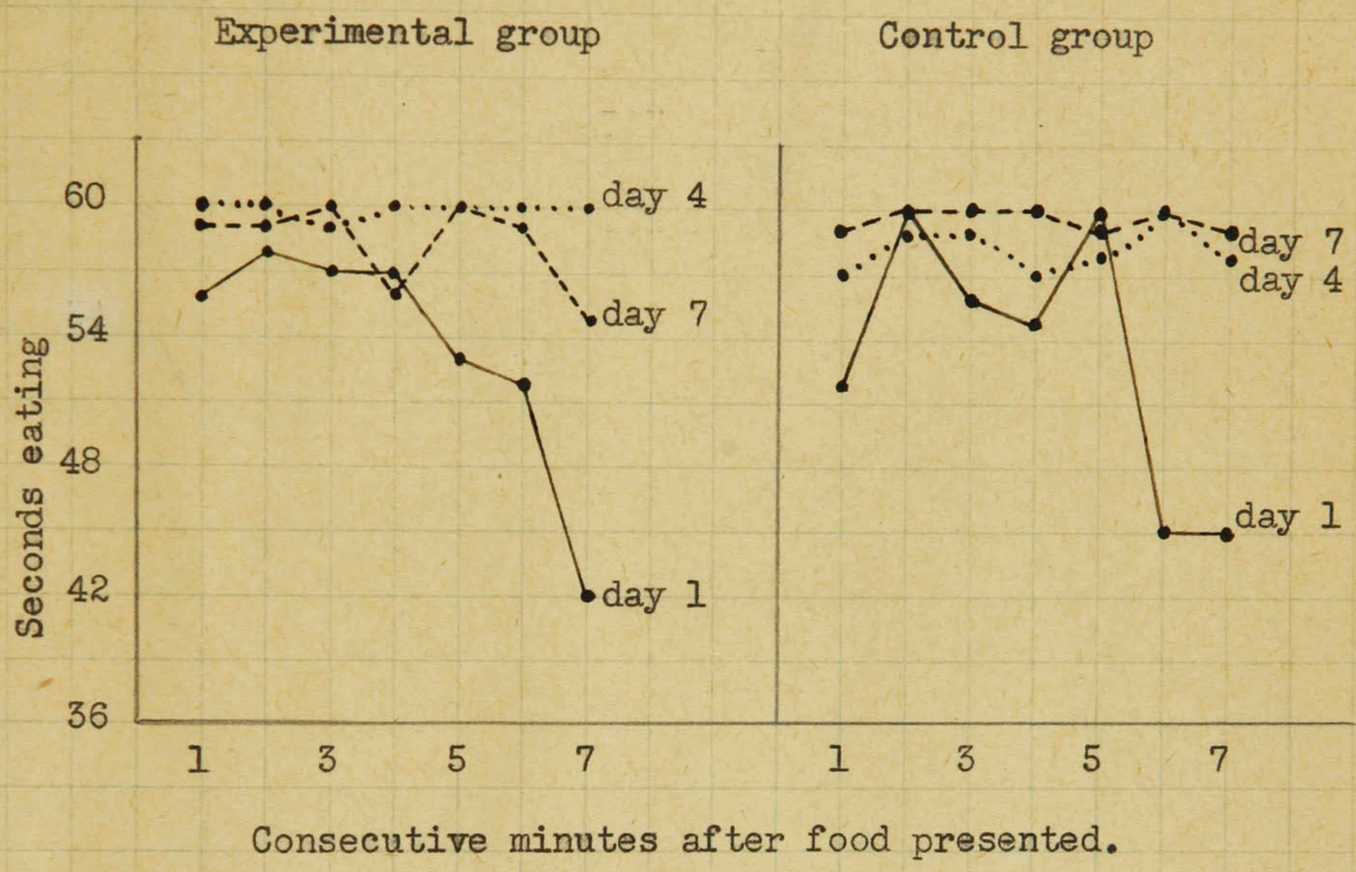

FIGURE 1. Eating curves for successive test days of group tested with mash at 45 days of age.

The control group had a supply of food available at all times. The experimental group experienced daily, 23-hour deprivations on days one to six, with food returned 24 hours before testing on day seven.

minutes were equal in deprived and non-deprived animals (Tables 2 and 3).

It was previously suggested that by the time of testing, each animal may have already developed a motivation to eat, but presumably for only short periods of time since food had always been available. In the familiar cage environment this motivation, organized by common past experience, seemed to have been activated in both deprived and non-deprived groups. The degree of hunger aroused on the first test day, then, appeared to be a function of the past need and experience of the animal rather than the present physiological need.

One difference, however, did appear on this first day. The experimental groups ate greater amounts than the controls after the initial seven minute period (Table 3). It may be that deprivation functioned to lower the threshold for re-arousal of the CMS, or that the increased eating is an expression of a rapid learning.

Effects of repetition. Having examined the behaviour on the first test day, let us consider the effects of repetition of the procedure. With repeated experience, the animals in all groups ate more consistently, and more avidly, that is, more per unit time. The changes specifically manifested by the group tested with mash at 45 days are reported in detail, but the pattern is representative of the behaviour of the other groups.

Although the measured eating time quickly reached the maximum value in the experimental group (Table 2), evidence for the strengthening effect of added experience appears in the continued increase in the total amount eaten (Table 3), and the rate of eating (Table 2). Even

TABLE 2

Time and rate of eating during seven minute period on consecutive test days by group tested at 45 days of age with mash.

The control group had pellets in the cages throughout the whole nine day test period. The experimental group experienced daily, 23-hour deprivations for the first six days, then had pellets in the cage for the last three days.

Day	1	2	3	4	5	6	7	8	9
Group	Seconds spent eating								
Experimental	376	402	415	416	419	419	412	416	416
Control	374	352	409	411	412	413	415	421	418
	Milligrams eaten per minute								
Experimental	13	15	17	19	21	24	14	19	17
Control	13	14	14	17	22	17	22	21	24

TABLE 3

Grams eaten during one hour period on consecutive test days by the group tested at 45 days of age with mash.

The conditions of testing were the same as in Table 2.

Day	1	2	3	4	5	6	7	8	9
Group	Grams eaten during first seven minutes.								
Experimental	4.9	6.0	7.3	7.9	9.0	9.7	6.4	8.3	6.8
Control	4.6	4.5	5.3	6.4	8.7	7.0	8.9	8.5	10.0
	Grams eaten during total sixty minutes.								
Experimental	10.5	13.2	15.0	17.0	17.5	20.8	12.3	14.9	13.8
Control	7.0	8.4	9.5	11.5	14.3	12.7	16.5	15.1	17.4

at the end of the six day deprivation period, most of the animals had still not learned to eat enough to meet their physiological requirements. This was shown by the continued (a) rise in rate and amount of eating, and the (b) fall in weight from day to day. While practice in the situation did develop a more sustained or stronger motivation in all animals, the deprived animals reached a higher level of consumption more quickly than the controls (Tables 2 and 3).

The control group markedly increased the rate and amount of eating with added experience (Tables 2 and 3), and also gained weight consistently during the nine day test period.[3] This latter fact suggests that the extra caloric intake provided by the testing did not decrease proportionately the degree of hunger habitually aroused in the home cage. These results further attest to the importance of factors other than nutritional need in determining the degree of hunger, and specifically emphasize the role of practice in a particular situation.

Post-deprivation period. The first day after the return of food to the experimental animals, their desire for food diminished (for example, Tables 2 and 3). During the next two days, however, these animals tended to show an increase in total eating time, rate of eating, and amount eaten. It might be noted that even the least amount of time

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3. It might be said that since the only control groups used consisted of 24 and 45 day old animals, the gain was a function of normal growth processes. A similar weight gain was, however, observed in adult animals used in work not reported here.

spent eating during this post-deprivation period was equal to or greater than the eating time when first tested under conditions of deprivation.

On the assumption that the hunger drive is learned, it was previously suggested that the time spent eating on the first test day was an expression of the kind of CMS ("central motive state": Morgan) organized by ordinary cage experience prior to the experiment. With practice in the test situation, the animals increased their eating time, that is, the CMS was changed by the deprivation experience. In the post-deprivation period, the arousal of this changed organization of hunger resulted in more sustained eating behaviour relative to the first test day. The observations made in the post-deprivation period, then, are consistent with the point of view that hunger is organized by experience.

On the other hand, it might be said that even after the pellets were returned, the animals still needed more food from a nutritional point of view since they were underweight. The physiological need may have served to maintain the high level of eating. This type of explanation, however, would not account for the animals' increased consumption on successive test days; a "nutritional need" theory would predict decreased eating as the animals' biological requirements diminished. Finally, the fact that the control group actually ate more at this time than the experimental group suggests that the biological deficiency need not be the main determinant of the sustained eating, but rather that the amount of practice in eating mash under constant conditions may be the more important factor in this situation.

Different age groups. Additional evidence for the importance of past experience in the organization of hunger appears in the differences

TABLE 4

Comparison of eating time of different age groups.

Mean seconds eating during the first seven minutes after food was presented, and the significance of the differences.

	Control group				Experimental group	
Age group	Day 1	t	Day 6	t	Day 7(post-deprivation)	t
24 days	321 ± 21	2.0	360 ± 16	3.0	321 ± 17	5.0
45 days	374 ± 17		413 ± 6		412 ± 5	

observed between the various age groups. Let us consider the behaviour of the animals tested with mash at 24 and 45 days old under conditions of nutritional satiation. Similar differences were observed in the deprived animals, but the possible inequality of physiological need in animals of different ages after 23 hours deprivation would unnecessarily complicate the discussion.

The controls of the older group spent more time eating on the first day and reached a higher level by the sixth day; the experimental animals of this group decreased their eating time relatively less after the return of pellets (Table 4). Essentially, a stronger tendency to eat appeared to be characteristic of the older animals. Biological need could hardly be responsible for this greater hunger since food was equally and continuously available to both groups. It must be, then, that the hunger system itself is different in these age groups. If past experience is important in determining the organization of the CMS, perhaps as the older animal has "needed" more food through the processes of growth, he has learned to eat more than a younger animal. When the CMS was activated, this learning manifested itself in the more prolonged eating time relative to the younger group.

The difference observed between these age groups is consistent with a learning theory of hunger, but a difference in learning is not a necessary explanation. It might be said that maturation alone was responsible for changes in the CMS. While this may be so, the explanation is at best a vague one. Hunger theories do not indicate the direction that maturation effects may be expected to take, nor the mechanism of their operation. Maturation could as easily be called upon to "explain" decreased as well as increased eating by older animals.

The interpretation on the basis of differences in learning provides the only specific, although tentative, explanation that is consistent with the available data.

Effect of new food. The group tested at 45 days with bread and milk spent less time eating on the first day, did not reach as high a level after practice, and was more variable from day to day than the same age group tested with mash. Similar behaviour was, however, produced in another group fed the familiar mash but sweetened with saccharine. These observations raise the question of how a substance that is not absorbed (saccharine) can satiate, that is, function to lead to a cessation of eating. This problem was not fully investigated, and hence the results will be considered only in so far as they are relevant to an interpretation of the eating behaviour of the animals fed the new food, bread and milk. It may be that bread and milk is relatively sweeter than mash, and that the important factor in determining the lesser eating was not the lack of familiar food stimuli to facilitate the motivation, but the apparently greater satiating properties of a sweeter food. Thus the results obtained with the new food constitute equivocal evidence, neither confirming nor denying the hypothesis that lack of familiar food stimuli may hinder the ease and strength of arousal of the hunger drive.

DISCUSSION

Significance of results for theories of hunger. The results of these experiments are consistent with the conclusions of Hebb, Young, and others that hunger can be aroused in the absence of nutritional need. Not only is deficit not a necessary condition, but these experiments show that physiological need in itself is not even an adequate condition for the arousal of the tendency to eat. Since some of the deprived animals did not eat at all during the first minute after food was presented on the first test day, it must be assumed that hunger is not automatically aroused by stimuli due to food lack. Further, the interest in food manifested by the deprived group on the first day was not greater than that of the controls, but increased rapidly on successive days. It appears that the animal gradually learned to "want" food when perceiving the internal stimuli due to nutritional need. The priming property of the CMS expressed itself only after experience had developed the appropriate organization. It must be concluded, then, that the neural system of hunger is not innately adequate; the organization of hunger is essentially dependent on a learning process.

Since animals may exhibit specific as well as general hunger, a theory of hunger must integrate the results obtained under both conditions. The data on specific hungers is consistent with the hypothesis that the hunger is organized through experience. Young (14) shows that the tendency to seek a particular substance that the animal lacks appears only after adequate practice with the appropriate food; that is, learning must occur. Neither general nor specific nutritional need, then, necessarily produces hunger. Similarly, under conditions of physiological satiation, Young (14) shows that food preferences, and Beebe-Center <u>et al</u>. (3) that drink preferences, are a function of the animals' experience with the object. Young concludes that "habits of seeking particular foods appear to rest directly upon the effects of ingesting these foods" (14, p. 316). In view of the data reported in this paper, the statement might summarize the facts more accurately if the reference to "particular" foods were omitted.

At any given time of testing, however, the animal does not start at a hypothetical zero point of hunger; rather, the degree of hunger aroused is a function of the kind of learning acquired through past experience. First, since the degree of hunger aroused in the deprived and control groups was the same on the first test day, the eating behaviour was presumably determined by the learning acquired through the common past experience of these animals. Secondly, the difference observed in the present experiments between the younger and older animals may be due to the learning to eat more by the older animals. Thirdly, the deprived animals consistently increased their eating time with experience in the test situation, and in the post-deprivation period continued at this higher level relative to the first test day. In all cases, then, the point at which satiation occurred was related, not to the physiological deficit, but to the amount of eating that in the past had been experienced as satisfactory.

Somewhat similar observations have been made by other workers. Hunt (5) has reported that a group deprived in infancy and then again when adult, ate more than an adult group deprived for the first time. The greater hunger of the first group may be partly due to the learning to eat more because of the past experience of deprivation. In summarizing the results of one of his experiments, Young says, "An experiment upon the hunger-thirst balance with different periods of total deprivation demonstrated that the percentage of choices of purina varied with the number and distribution of reinforcements with apparent disregard for the carefully planned periods of total deprivation" (14, p. 298). Again it appears that the degree of hunger aroused depends upon past learning rather than upon the length of the deprivation period.

The experiments of Young (14,15) and Anderson (1), and the results described in the present report, emphasize that a rather strong tendency to eat can be aroused under conditions of satiation. As Nelson (14) has shown, the palatability factor can be so effective in arousing hunger as to lead to excess consumption to the extent of producing pathological signs. On the human level there is a wealth of intuitive knowledge on techniques for stimulating the tendency to eat, but the mechanism of their effectiveness is not yet understood. Conversely, nutritional need may not be adequate to arouse hunger even in adults if low palatability or new foods are offered. For example, Young has pointed out (14) that during the war soldiers often threw their rations away; similar commonplace observations could be multiplied many times over. The general point to be noted is that these data must be integrated into, not excluded from, a theory of hunger.

Morgan's concept of hunger as a CMS ("central motive state") allows for the possibility that many stimuli can arouse the tendency to eat, but he does not specifically consider the role of non-deprivation stimuli. Anderson says, "It is assumed that a drive such as hunger is originally dependent for its arousal upon internal conditions of the organism, but, that, through continuous use of the drive in a relatively constant situation, the drive becomes aroused by an external situation in the absence of the original internal conditions, that is, becomes externalized" (2, p.223). This concept of a secondary elaboration of an innate system of hunger is, however, inconsistent with the observations indicating that hunger is organized by experience.

Young (14, 15) goes a step farther than Anderson by assuming that all specific food-seeking drives are learned, and hence the arousal of hunger by environmental cues can be explained by general learning principles.[4] Hebb (4), specifically stating that general or specific hunger is learned, has suggested that the external stimuli consistently associated with eating form an integral part of the developing system. These stimuli may then facilitate or initiate the arousal of the tendency to eat. Hebb and Young, by considering environmental stimuli as an essential component of specific drives, offer at least a partial explanation for the fact that eating occurs without physiological need. This theoretical approach further emphasizes the importance of past experience in the organization of hunger.

Implications for the psychology of motivation and learning. The experimental work reported in this paper is relevant not only to theories of hunger, but also to the psychology of motivation and learning. Some implications for these fields will be briefly indicated.

(1) Morgan (8) points out that one of the difficulties in motivational studies is the very ambiguity of the term "drive". A motive is generally inferred either (a) by virtue of the objective lack of a particular object, or (b) from the striving of the animal for the object.

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4. It is not directly relevant here to discuss Young's theory of the role of proprioceptive tension in setting up the neural pattern of hunger, since the assumption of learning in itself suggests that individual drives are differently organized.

That the psychological processes actually involved in these two situations need not be the same has been demonstrated by the experiments on hunger previously described. In terms of psychological mechanisms, then, inferences from objective lack may often be invalid or inaccurate. This point has long been stressed by phenomenologists and clinicians.

(2) If the degree of hunger is determined by the interaction of past experience and current stimulating conditions rather than merely by the degree of nutritional lack, than the design and interpretation of some of the experimental work on motivation and learning may well require change. For example, recent studies by Saltzman and Koch (10), Seward (11), O'Kelly and Heyer (9), and others have equated number of hours of food deprivation with degree of motivation.

Saltzman and Koch report a higher degree of behaviour strength than predicted when testing was done under presumably low intensities of hunger (1/2, 1, and 2 hours deprivation), but just prior to this testing the animals had developed a strong hunger motive due to daily 23 hour deprivations for an 11-day period. Similarly Seward, in a study of the relation between drive and habit strength, concludes that even very low drive strength (1hour deprivation) yields appreciable learning, although in this case, too, a strong drive had been developed by daily 22 hour deprivations before testing under one hour deprivation. O'Kelly and Heyer, in a study on the relation of motivation to retention, report that in the original learning there was no significant difference in the speed of running between animals deprived for 36 hours and animals deprived for 35 hours with two-thirds of their deficit filled one-half hour before testing. Here again the degree of motivation aroused was apparently proportional to the CMS organized by past experience rather than to the immediate tissue need. The fallacy of assuming that the degree of drive strength is proportional to the extent of deprivation is shown by the fact that, in the experiments reported in this paper, the degree of hunger in the post-deprivation period was higher than the initial testing under either satiation or deprivation conditions.

(3) The Spence versus Leeper controversy on cognition or reinforcement learning offers another example of motivational inferences that may be unjustified. On the basis of the present experiments, it might be suggested that animals must have experience in eating under deprivation conditions before the drives are reversed, if it is to be assumed that they are hungry in the sense of looking for food. Even this training, however, may not be adequate to ensure well-differentiated drives; perhaps actual practice in discriminating between hunger and thirst would be necessary. Leeper's procedure, in contrast to all the other experiments, provided such discrimination training. In fact, before that training, even Leeper's animals did not show that cognitions had been established. Some of the disagreement in this field, therefore, may have arisen because of taking for granted that "hunger" equals "nutritional lack".

(4) Finally, one application of the present work to experimental procedure in general may be mentioned. When using hunger as a drive in experimental work, the time necessary for preliminary training may be decreased by allowing the animals to develop a well-organized hunger motivation while still in the home cage. This could be done by daily

23-hour deprivations for from 6-10 days before beginning training. The writer, for example, observed that a few animals which had already learned to eat, ate fairly consistently and showed little emotional disturbance when placed in a new apparatus. This behaviour contrasted sharply with the lack of interest in food shown by control animals deprived for the first time, but habituated to the apparatus.

Conditions of testing. A minor problem raised in this experiment was the divergence of some of the results from those reported by Hebb (4). The animals used in the experiments described in this paper spent more time eating on the first test day, and learned more quickly than those originally reported (4). Some preliminary work with small groups was done to investigate some of the factors in the test situation that possibly operated to produce these differences.

It was found that early-weaned (21 days) animals displayed a more sustained hunger motivation than late-weaned (30 days) animals.[5] Also, a few animals were tested in an enclosed area of one yard square to which they had previously been habituated. It was observed that in this situation, relative to cage testing, the animals ate much less on the first test day, and learned more slowly to prolong this eating time on subsequent days. Finally, animals reared in a colony ate less at first, but rapidly increased with practice, than the animals reared in the experimental laboratory.

It may be tentatively concluded, then, that the age at weaning, the degree of restriction of the testing situation, and the environmental cues of the laboratory, may each play a role in determining the degree

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5. This finding is relevant to the psychanalytic theory that early-established drives exert a dominant influence on adult behaviour, but this general problem will not be elaborated upon here.

of hunger aroused in a given situation. These factors must be taken into account in future work on this problem. It might be noted that even this brief analysis served to re-emphasize the importance of past experience in organizing the present structure of the hunger system.

SUMMARY and CONCLUSIONS.

This experiment was designed to test the hypothesis that the hunger drive is not fully innate, but essentially dependent on a learning process.

Food was placed in the home cages of the experimental group of rats for only one hour per day, on six consecutive days. The time spent eating and the amount eaten during the first seven minutes after food was presented were recorded, together with the amount eaten during the total hour period. After the sixth session, a continuous supply of food was returned to the deprived animals, and the testing was continued for the next three days. The experimental animals were subdivided into four groups, three tested with moist mash at 24, 45, and 85 days of age, and one tested with bread and milk at 45 days of age. Each of these subgroups except the oldest was matched with a control group. The control groups always had food pellets available in the cages, but otherwise they were tested in the same way as the deprived groups.

It was observed that during the first minute of the first test day, most of the experimental animals did not eat consistently, and some did not eat at all. The time spent eating and the amount eaten during the whole seven minute period on the first day was the same in the deprived and non-deprived groups, although the total amount eaten during

during the hour period was higher for the deprived animals. On subsequent test days, the experimental animals consistently increased the time spent eating and the amount eaten, but steadily lost weight. Although they did not reach as high a level of consumption as the experimental groups, the control animals also increased the time eating and the amount eaten, and gained weight. When food was again freely available to them, the experimental animals decreased their eating time somewhat, but still ate more than on the first day of testing after 24 hours deprivation. The older animals, under either conditions of nutritional deprivation or satiation, consistently ate more than the younger animals. The group tested with bread and milk ate less than the group tested with mash, but it was not clear whether this was due to the flavour of the food or to a lesser degree of hunger.

The relevance of these results for theories of hunger, and for the psychology of motivation and learning, was discussed. The conclusions may be summarized as follows:

(1) Nutritional need is not necessarily an adequate condition for the arousal of hunger, defined as the tendency to seek for and eat food.

(2) When first deprived, it appears that an animal must <u>learn</u> to seek food, that is, hunger is not innately organized.

(3) Experience in eating under constant conditions may increase the amount eaten. With the same degree of practice, consistent periods of deprivation serve to develop a stronger hunger drive than that organized under conditions of satiation.

(4) The degree of hunger aroused at a given time is a function of the animal's past experience and the method of testing, and cannot be equated with the extent of deprivation.

(5) A high degree of hunger (as defined) can be aroused under conditions of nutritional satiation.

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