HOARDING

Hamsters do it, rats do it, and human beings do it. But why? Recent studies at Caltech suggest that physiological and genetic factors may be involved.

By JOHN S. STAMM

HOARDING, OR THE collection of more materials than can be anticipated to be needed, can be easily observed with many animals and with men in most cultures. We have all seen the squirrel busily engaged in collecting and burying food; the pack rat is famous for carrying and hoarding many objects; and the hamster is, of course, the prime example of a hoarder. As a matter of fact, in the German language the words for hamster and hoarding are synonymous, and this animal has been known to accumulate such vast amounts of grain that during times of famine in Europe his hoards have been raided to supply human food.

In our society, all of us are acquainted with hoarders —people who collect food, fuel, valuable objects, or often ridiculous ones, to a far greater degree than they can be expected to be used in the reasonable future. In many, but not all, primitive societies this "irrational" activity has also been observed.

Unfortunately, we do not know much about the conditions which bring about this activity, either in animals or humans. Naturalists and zoologists have little to say about hoarding activity, other than to mention it when it occurs. Similarly, psychologists and anthropologists know little about human hoarding—although they do have a number of theories about it.

Recent investigations at Caltech have been concerned with the biological basis of hoarding. In order to clarify some of the innate mechanisms which underlie hoarding behavior in rats, the physiological and genetic bases of hoarding were investigated. These studies yielded some interesting results about the control of hoarding activity by a specific area of the brain, and about genetic differences in hoarding. Before discussing these findings, however, it may be of interest to describe some of the experimental conditions which have been found to influence the hoarding performance.

I. EXPERIMENTAL CONDITIONS

1. *Apparatus.* The hoarding apparatus has been pretty well standardized. The common one is a "closed" alley —a runway 4 inches wide and about 3 feet long, enclosed by about 8-inch high boards. This connects at one end to the cage, which has a door that can give the rat access to the alley. At the far end is a bin in which the material to be hoarded (usually food pellets) is stored.

2. *Onset of Hoarding.* When a rat is allowed access to this apparatus, it will usually not begin hoarding right away. Even under the most favorable hoarding conditions, several days will elapse before the rat will leave the cage and commence to hoard.

There is always a hoarding schedule which permits the rat a certain period of time daily in the apparatus. This may be one-half hour daily, twice a day, 12 hours daily, or continuously. In all cases pellets are counted at regular intervals and then returned to the bin.

Even though animals may not exhibit hoarding behavior for many days after the experiment has begun, the amazing thing is that once a rat begins to hoard, it does so very abruptly. On the first day of hoarding, it collects many pellets—the number usually depending on how late in the trial it commenced to hoard. On the following few days the hoarding scores reach a peak, and as many as 120 pellets may be returned in a one-half hour period. After this peak has been reached, the daily hoarding scores may decline slowly and then reach an average which will be maintained for a long time.

During this period of hoarding there are often marked day-to-day variations in hoarding scores, but very rarely does a rat stop hoarding altogether.

3. *Deprivation.* One of the most important factors affecting hoarding is deprivation of the material to be hoarded. Although it has been shown that deprivation is not necessary in order to elicit this behavior, it always both facilitates the onset of hoarding and increases the amount of material collected.

Deprivation consists in putting rats on limited feeding schedules. Usually about 15 grams of pellets are given the rat before each hoarding trial. If half an hour is allowed for this feeding period, the rat soon learns to finish eating before the hoarding trial begins. If the rats are not fed immediately before the trial, they will take time to eat the first pellets they return to the cage, in order to satisfy their hunger. Under these conditions, of course, hoarding does not proceed as well as when feeding precedes the trials.

4. *Extinction.* Hoarding may be extinguished or sharply reduced by placing the rats on continuous food supply. The high level of hoarding may persist for several days after the satiation period has been started, but then it will drop off sharply, usually to a lower value.

5. *Recovery.* If, after hoarding experiments have been discontinued for some time, or rats have been under satiation conditions, deprivation conditions are re-established, rats will immediately resume their high hoarding activities. In general, during this recovery period, each rat will duplicate its original hoarding curve. Rats which had high hoarding scores will again have high scores, and rats which hoarded less previously will again do the same.

6. *Pre-hoarding activity.* Very few rats will begin their hoarding activity by running to the bin and returning a pellet. In general, rats will at first very slowly stretch out of the cage, then enter the alley and thoroughly explore it near the cage, during which time they may make many escape trials. Some rats may spend days, or weeks, on this exploratory or on escape behavior, before they actually begin to hoard.

No place like home

7. *Familiarity with the hoarding apparatus.* A rat feels most comfortable, of course, in its home cage, and therefore deposits the hoarded pellets in it. When rats which have hoarded for a number of days are then put into different cages, their hoarding activity is markedly changed. The number of hoarded pellets is greatly reduced; rats were found to hoard only about one tenth as many in a new, strange cage. It was found, however, that they dropped a good many pellets into the alley in front of the cage. Though there was never any alley hoarding when the home cage was available, this was found to be the case in about 58 percent of the trials when the strange cage was substituted.

During the first days after the substitution of a strange alley, rats again spent considerable time in exploring the new alley and consequently hoarded much less. After several days, however, the daily hoarding scores again reached the same magnitude as they had before the substitution.

Even when the pellets in the food bin are changed to new ones, rats will hoard less for one or two days, until they become familiar with the smell of the new pellets. It was found that on the first day after the introduction of new pellets, average hoarding scores dropped to one third—after which they rose again.

These experiments point to the importance of "familiarity" as a factor in hoarding. Although a hoarding drive always exists, the hoarding activity cannot be demonstrated until the animal has become familiar with all elements in the situation. Any change of the rat's environment will therefore temporarily reduce or abolish the hoarding activity.

Behavior patterns

8. *Stereotypes.* An interesting observation is that there is a good deal of difference in the patterns of behavior of individual rats during hoarding experiments *and* that individual rats maintain their stereotyped behavior throughout the experimental period. Some rats, for example, always make a dry run before they begin hoarding during each trial. Another rat may circle the food bin, or sit on the pellets in the bin for a while before hoarding.

The persistence of this stereotyped hoarding behavior is a marked phenomenon, although the amount of hoarding will vary greatly in successive trials.

9. *Preference of hoarding material.* In one interesting experiment rats were deprived of water, but not food, and then were allowed to hoard water-soaked cotton pellets. It was found that water hoarding proceeded in the same manner as pellet hoarding usually does—a maximum number of pellets being hoarded during the first few days of hoarding, and then fewer pellets in every trial.

When comparative groups of rats showed the same hoarding behavior for water and for food pellets, the two groups were alternated for food and water hoarding. All the rats then hoarded more of the material of which they were deprived. However, both groups hoarded about two and one-half times more food pellets than they hoarded water pellets.

When rats were given the choice of hoarding food pellets or saccharine-sweetened mash, which was placed in bottle caps, they all hoarded the sweet mash to the exclusion of the food pellets.

When, however, wooden blocks, which looked and smelled like the pellets, were mixed with pellets, the rats refused to hoard the wooden blocks. And when only blocks were put into the bin, there was no hoarding at all.

10. *Hoarding of the hamster.* The hamster is, of course, a much better known hoarder than the rat, and one may question whether the conditions for hoarding

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in rats also apply to the hamster. In a number of experiments with hamsters it was found that all the conditions and influences which affect hoarding in rats are equally applicable to the hamster—the only difference being that hamsters hoard more. This fact offers assurance to the experimenter that the findings of experiments with rats—which are experimentally much more flexible—are also valid for other animals.

The experiments which have been reviewed here clearly establish hoarding as an experimental behavior which can be regularly studied. It is a motivated, unlearned, and complex behavior that must compete with other activities which the rat will "instinctively" practice, such as avoiding strange situations (i.e., leaving the alley, exploration, and escape).

II. GENETIC FACTORS

Several investigators, working with different strains of rats, have noted differences in the amount of hoarding done by the rats. At Caltech an investigation has been conducted to determine some of the genetic factors underlying the hoarding activity of rats. Simultaneous hoarding tests were given to three homozygous strains of rats (i.e., each strain has been highly inbred and is known to be different from the other strains). Two of these strains showed marked differences in their hoarding performance; a black hooded strain gave a median score of 47 pellets per rat for each trial, whereas an Irish strain had a median of only 7 pellets (see chart, p. 22).

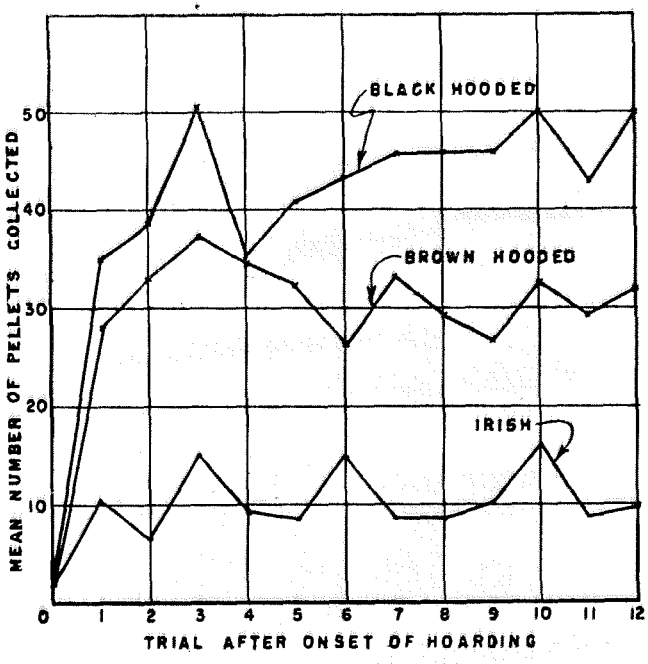
The hooded rats also started to hoard earlier than did the Irish; the median trial for the beginning of hoarding was the fourth day for the hooded and the twelfth day for the Irish rats.

When the hoarding activity was reduced by placing a pile of pellets in the rats' cages at all times, the hooded rats still hoarded some pellets after 16 days, whereas the Irish rats had virtually stopped hoarding on the fifth day.

These results lead to the conclusion that there are indeed genetic factors underlying the hoarding activity. These two strains are now being crossbred, and determinations of hoarding of successive generations will throw more light on the genetic factors underlying hoarding activity.

III. PHYSIOLOGICAL FACTORS

1. *The cerebral cortex and hoarding.* Recent investigations at Caltech on the neural basis for hoarding have yielded some interesting results. By removing small pieces of tissue from different parts of the brain's cortical



Hoarding Scores for Three Pure Strains of Rats

Caltech investigations indicate that genetic factors underly hoarding activity. This chart shows the results of simultaneous hoarding tests given to three homozygous strains of rats. The black hooded strain has a median score of 47 pellets per rat in each test; the Irish strain has a median of only 7 pellets. The hooded rats also started hoarding earlier than the Irish.

surface, the investigator found hoarding activity was greatly reduced when the lesions had been applied to a strip of cortex along the median line of the brain. In one experiment small lesions (averaging about 13 percent of the cortical surface) were applied to a group of 15 rats whose hoarding activity had been determined before and after the operation. As a result of these lesions the hoarding scores (the number of food pellets collected during a series of 20-minute trial periods) of the rats were reduced by an average of 73 percent of the preoperative scores.

As a control experiment, lesions of the same size (13 percent of the cortical surface) were applied to the lateral cortices of 8 rats. There was no appreciable change in the hoarding scores of this group as a result of the operation. When the two groups of rats were compared for other measures, it was found that there were no differences between them. The weights of the rats remained the same. The speed with which they hoarded was the same; it took an average of about 7 seconds for rats in both groups to go to the bin and retrieve a pellet. The latency (i. e., the pre-hoarding period) was also identical for both groups; it took rats in both groups an average of 4.5 days until they began to hoard.

These investigations point to the importance of a restricted cortical area for the control of hoarding activity. The cortical lesions were shown not to interfere with the rats' ability to retrieve pellets. As a matter of fact, since rats were on deprivation feeding, they all had to retrieve a few pellets to their home cages, where they ate them. The chief characteristic of the rats with median lesions were that they would take a few pellets to their cages and eat them there; whereas the control rats, like normal animals, collected a large pile of hoarded pellets in their cages and ate only a few of them.

On the basis of these investigations it can therefore be concluded that hoarding—the accumulation of useful material, such as food—is indeed regulated by a specific area in the brain. Removal of this area does not interfere with other observable activities of the animals. The seemingly irrational behavior of hoarding therefore seems to be based on the orderly functioning of the nervous system—at least in rats.

2. *Metabolic factors in hoarding.* It has been observed by other investigators that changes in environmental temperature have marked effects on the amount of pellets collected by rats. Hoarding scores have been found to increase with lowered temperatures and to decrease when it gets warmer. These investigators then altered the metabolic functioning of the animals by injections of epinepherine, insulin, and glucose—none of which altered the hoarding behavior. When the thyroid metabolism was altered by feeding rats thiouracil, injecting thyroxine, or by total removel of the thyroid glands, it was again not possible to show any changes in hoarding activity of rats.

Hoarding—learned and unlearned

We can say, then, that at the present time hoarding can be demonstrated under the proper experimental conditions. It is a relatively complex type of behavior, involving both unlearned responses and learned activity, because the rat has to perform an act which conflicts with other drives, such as avoidance of strange situations and attempting to escape from a restrictive environment.

Hoarding seems to be motivated by some unlearned drive which will persist for a long time and under adverse conditions after it has once been reinforced. This drive is, moreover, related to certain biological factors. The genetic basis of hoarding has been demonstrated by marked and consistent differences between hoarding scores of different strains of rats. Finally, the hoarding drive seems to be controlled by a specific area in the cerebral cortex, removal of which will greatly reduce, or eliminate hoarding altogether.