though in most cases nonassociative factors such as simple activation or sensitization cannot be ruled out; no independent test of learning was performed (*15*). Similarly, findings that rat pups prefer to consume fluids and solid foods that have been adulterated with the flavor of the mother's diet (*16*) might reflect simple habituation to the previously novel taste rather than associative learning.

More recent studies showing that 11- to 17-day-old rat pups perform more efficiently in runways and mazes when reward is the opportunity to suckle dry nipples generally support the current finding that suckling for milk is more rewarding than dry suckling (*17*). They do not, however, necessarily demonstrate the pup's ability to form an association *while* suckling. If one views instrumental and classical conditioning as different processes, performing a response in order to suckle (like performing a response in order to eat) is conceptually quite different from acquiring a response during suckling (which might be more analogous to acquiring an association while actually eating). Thus, the two most noteworthy findings of my experiments are that infant rats acquire new associations while actually suckling and receiving milk and that they display these newly acquired conditioned preferences in a situation removed from the suckling environment. These results bring us closer to an understanding of what an infant might learn as a natural consequence of suckling.

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6. Each of these four groups, and each of the groups mentioned later, consisted of ten pups, five of each sex. Pups within each group were drawn from eight or nine different litters. During deprivation, pups were placed in a warm (36°C), moist (50 percent humidity) incubator. The dam was rendered passive by an intraperitoneal injection of urethan (2 g in 10 ml, 1 ml per 100 g of body weight), which also blocks the naturally occurring milk-ejection cycle [D. W. Lincoln, A. Hill, J. B. Wakerley, *J. Endocrinol* **57**, 459 (1973)]. The dam was placed on her side in a warm (32°C) plastic tub. Pups suckled one at a time.
7. The intraoral cannula was installed at the start of the deprivation period. It consisted of a length of fine polyethylene tubing (PE-10, Clay Adams) with one flanged end, which rested on the pups tongue. The cannula was placed toward the rear of the pup's mouth and did not interfere with nipple attachment or sucking [W. G. Hall and J. S. Rosenblatt, *J. Comp. Physiol. Psychol.* **91**, 1232 (1977)]. Milk was delivered through them to the rear of the tongue, where the nipple usually rests during suckling, and was responded to as if it came from the nipple. The milk formula siphoned to the pup was commercially available half-and-half. Siphoning was accomplished by suspending a 1-ml syringe 30 cm above the suckling pup, attaching the external lead of the cannula to the syringe, removing the plunger from the syringe, and filling it with milk. Pups received an average of 0.75 ml of milk during the hour, but, because the frequency and intensity of the pups' sucking affected the rate of flow, some received as little as 0.45 ml and some as much as 1.25 ml. Isolated pups (pups not suckling the mother) received an average of 0.54 ml, with considerably less variance. Pups did not "stretch" while receiving milk.
8. Scented shavings were prepared by sprinkling 2.5 ml of orange extract (A & P) onto 500 ml of pine shavings and shaking them thoroughly. During conditioning, a small batch of shavings (1 to 2 g) was held by a clip 2 cm from the pup's nose. If the shavings were placed closer to the nose or scented more strongly, the pups would back-treadle and sometimes come off the nipple; although they would almost always reattach, conditioning was almost always unsuccessful.
9. Similar effects in even younger pups were first reported by I. B. Johanson, W. G. Hall, and M. H. Teicher (paper presented at the annual meeting of the International Society for Developmental Psychobiology, Atlanta, 2 to 4 November 1979).
10. The percentage of time spent on the pine side by pups in these two groups, as well as pups in the isolated orange + milk group, was conversely less. For the suckling orange + milk group this figure was 19 percent; for the suckling orange group, 37 percent; and for the isolated orange + milk group, 24 percent.
11. Pups received an average of 0.40 ml of milk during the 30 minutes and an average of 0.65 ml of water. In the backward group, about 5 minutes passed between the time milk delivery was terminated and the time the orange odor was introduced.
12. It is still theoretically possible that simultaneous exposure to milk and odor results in differential attention to the odor (and thus, possibly, differential habituation) in a way the backward or water groups do not address. Discrete presentations of milk and odor, both simultaneously and in control contingencies, might help clarify this issue, but such procedures, like most classical conditioning paradigms, are still subject to the objection that differential attention and habituation might result only in those conditions in which associative learning is most likely [P. J. Durlach and R. A. Rescorla, *J. Exp. Psychol. Anim. Behav. Process.* **6**, 175 (1980)]. A study based on sensory preconditioning procedures, in which the value of the milk reward is changed from positive to negative after conditioning, seems a promising way to address this problem.
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15. Sucking is such a highly probable behavior that unambiguous demonstrations of associative learning as indexed by the response are difficult. For example, noncontingent presentations of milk are likely to increase sucking just as response-contingent presentations do, and presentations of a discriminative stimulus, even in the absence of milk, might increase sucking.
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18. Supported by NIMH grant MH32429. I thank I. Johanson, T. Hall, and M. Teicher for suggesting some of the methodology and M. Hofer, D. Gillan, and N. Spear for helpful comments.

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Difference in Brain Densities Between Chronic Alcoholic and Normal Control Patients

Abstract. *The densities of the brains of 11 chronic alcoholics were compared with those of 11 age-matched normal control subjects. Densities were determined from the density numbers generated by computerized tomography at three levels of the brain—the highest level of the lateral ventricles and the next two higher levels—with adjustments made to control for possible artifacts in the data. The advantage of the dominant hemisphere over the nondominant hemisphere was lessened in alcoholics.*

The relationship between alcoholism and structural changes in the brain has been of great interest. Most recently, computerized tomography (CT) scans of chronic alcoholics have found larger lateral ventricles and sulcal enlargement, two indices of structural changes in the brain (*1-3*). However, these techniques were not able to take full advantage of the power of the CT scan to reveal localized damage in the brain and thus left open the question of lateralized impairment in the alcoholic, as has been hypothesized in many psychological studies (*4*). Our study was designed to use more sophisticated measures of CT scan density changes to investigate the hypothesis of specific localized changes in the brain of the alcoholic.

In past studies, the ventricular and sulcal measurements have always been indirect measures of actual changes in brain density, on the assumption that decreased brain density will lead to less brain mass and subsequent ventricular and sulcal enlargement. However, one can directly measure the density of brain areas as a whole through the use of a CT scan, since its pictures are simply analog representations of the density numbers generated by the CT procedure. The numbers themselves offer much greater potential than films in terms of localization of dysfunction and the identification of more subtle disorders. The use of the CT scan in this manner is useful in such disorders as brain atrophy (*5*). Our study was designed to determine whether there are density changes in the brain of the chronic alcoholic that can be identified by this technique.

The subjects for the study were 11 chronic alcoholics diagnosed according to the DSM-III criteria (6). The patients were an average of 29.36 years old [standard deviation (S.D.) = 6.4 years] and had obtained an average of 11.91 ± 1.9 years of education. They had been drinking for 8.27 ± 5.62 years. The control group consisted of subjects who had received CT scans but were later determined to be normal after additional tests and extensive neurological evaluation beyond the CT scan. Control subjects, matched to the alcoholics by age (within 1 year), were 29.09 ± 1.8 years old. There were no differences in age and education (matched-sample t-tests). The two groups consisted of nine males and two females each. Excluded were potential subjects older than 45 years (to avoid the possibility of age-related changes) and those who dropped out of school for educational reasons (to rule out possible early brain injury). No patient with a history of seizures or any brain injury was included; this eliminated subjects for whom the seizures were believed to be related to alcohol withdrawal as well as patients with other disorders.

All patients received a CT scan (EMI-1010) administered by the Department of Radiology at the University of Nebraska Medical Center. Either 11 or 12 separate slices for each patient were obtained. No scan was included in the study which had indications of movement artifact or any other procedural problems. No patient was included for whom there was evidence of a neurological disorder on the CT scan, nor for whom landmarks in the brain could not be identified. No scan with evident movement disorder was accepted. No patient was included whose midline was not approximately central to the cerebral hemispheres or for whom the angle of the CT scan cuts was unusual. For each patient, three slices of the CT scan were identified. (No other slices were examined.) The first slice, labeled level A, was the level at which the highest lateral ventricles were seen (usually slice 4B). Level B was the next higher slice, and level C the next. These slices were chosen since they offered the best evaluation of higher brain areas without encountering significant apical artifact.

From each of the slices chosen, we obtained the 160 by 160 density printout yielded by the scanner. On the printout, the contour of the skull was identified by localizing density numbers greater than 100 (such values must be determined for each machine individually). We established an inner circumference by counting in 5 pixels from the inside edge of the skull (one pixel is represented by each density number) (Fig. 1). In this way we eliminated the numbers most affected by bone artifact on our scanner. Only numbers inside this circumference were included in data collection and analysis.

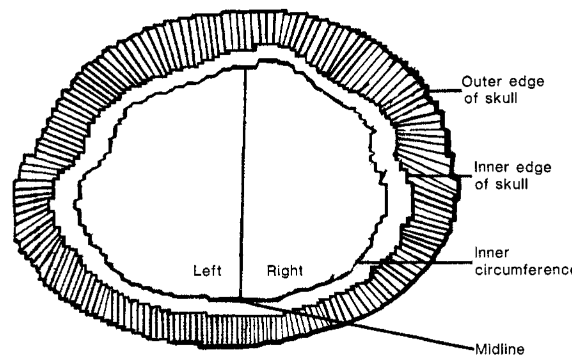

Fig. 1. Computerized tomography printout with margins indicating skull and hemispheric boundaries. The space between the skull and the inner circumference is the area of inaccurate data resulting from the shadowing effect of the skull. The figure is from an actual subject; the density numbers cannot be seen because of the amount of reduction necessary to produce this figure.

We next located the midline between the hemispheres by examining the photographic reproduction of the slice and identifying anatomic landmarks known to occur on the midline, such as the falcine attachments to the skull; numerical values on the CT scan corresponding to these midline features were then isolated. The geometrical location of the midline on most of the scans was the same at each of the three levels, which allowed for a cross-check of the accuracy of the midline drawn for each level.

After the midline was established, every fourth number within the right and left hemispheres was sampled at each of the three levels of the brain, yielding average densities at each level for both the right and left hemispheres. Choice of the numbers was made from the midline outward on each line of the printout for each hemisphere (thus, the fourth number from the midline was the earliest point chosen). This procedure ensured that the points chosen in each hemisphere were equally distributed in terms of their distance from the skull; therefore, any additional artifact not eliminated by moving in 5 pixels from the skull was randomly averaged.

The two groups were compared on all variables with matched t-tests (Table 1). The left hemisphere of the alcoholic was significantly less dense than that of the controls in two of the three levels measured, and there were no significant differences between groups for the right hemispheres.

The groups were also compared for the difference between the right and left hemisphere. In the control group, in only 2 of 33 comparisons was the right hemisphere more dense. Each occurred in the same individual, and the individual's overall average (combining the three levels) was in favor of the left hemisphere. In the alcoholic group, 10 of the 33 comparisons favored the right hemisphere. Six of the 11 patients had at least one right hemisphere score higher than the comparable left hemisphere score. In three of these subjects, the overall left hemisphere mean (over the three slices) was less than the right hemisphere mean (7).

In order to further study this difference, the density difference between the two hemispheres was calculated at each level for each subject (Table 1). As can be seen, two of the differences between the different scores were significant (α = .05).

Table 1. Differences between controls and alcoholics on measures of density between and within the cerebral hemispheres.

Area	Level*	Controls (N = 11) (Mean ± S.D.)	Alcoholics (N = 11) (Mean ± S.D.)	t	P
Left hemisphere	A	40.6 ± 5.1	39.1 ± 3.4	3.21	< .01
	B	43.1 ± 5.6	41.9 ± 3.8	1.80	
	C	46.4 ± 5.9	45.0 ± 5.2	2.27	< .05
Right hemisphere	A	39.1 ± 5.0	38.8 ± 4.1	0.47	
	B	41.7 ± 3.2	41.3 ± 5.9	0.59	
	C	45.1 ± 5.1	44.5 ± 5.1	1.11	
Hemispheric difference (left − right)	A	1.6 ± 1.7†	0.3 ± 1.8	3.67	< .01
	B	1.4 ± 1.6†	0.6 ± 2.0	1.91	
	C	1.3 ± 2.2†	0.5 ± 2.4	2.50	< .05

*Level A represents the level of the lateral ventricles; levels B and C are the next highest level and the level above that, respectively. †The right-left difference within the group is significant (P < .01).

Overall, the data suggest a deficit in the density of the left hemisphere in young chronic alcoholics, while no deficit could be identified in the right hemisphere. The deficit seems to have reduced or eliminated the left hemisphere advantage in density seen in the control group.

Thus, the data suggest that the left hemisphere is more sensitive physiologically than the right to the effects of alcoholism. On the face of it, this seems to contradict traditional psychiatric and psychological assumptions that the right (or nonverbal) hemisphere is more involved because of losses on tests traditionally seen as nonverbal (*4*). However, the results of such tests can be explained in several ways by our data. First, as Luria (*8*) pointed out, the left hemisphere plays a strong role in so-called nonverbal functions, especially in the parietal and frontal areas. Thus, the findings may simply indicate that damage to the left hemisphere, from a slowly developing disorder like alcoholism, affects visually related functions rather than the more overlearned basic verbal functions (which have long been recognized as resistant to slow brain diseases). The long-term presence of the alcohol may also prevent the right hemisphere from taking over these functions.

Alternatively, the destruction of the left hemisphere may cause the right hemisphere to attempt to take over the functions of the left hemisphere. In such cases, some of the normal functions of the right hemisphere may be compromised in favor of the more important verbal skills. This alternative is not as likely as the first. In either case, these results should caution physicians and psychologists from making hasty assumptions relating alcoholics to brain-damaged patients in general.

It is possible to attempt to explain these results by pointing out that alcoholics have larger ventricles than normal subjects. If enlarged ventricles were the major cause of the lower density, however, we would expect both hemispheres to show decreases, as such ventricular enlargement has never been found to be unilateral. In addition, such an explanation would not account for the observed changes in hemispheric relations. The left ventricle could be predicted to be sufficiently larger than the right (by at least 20 percent in this experiment). However, this was not the case in our films, nor has such a phenomenon ever been reported in alcoholics. (It should be noted that such a finding, if true, would be significant in itself.)

Each of these questions, as well as questions regarding more precise areas of reduced density within the hemisphere, needs to be evaluated in future, larger studies. This study, however, has demonstrated both important findings about alcoholism and the utility of density analysis in studying alcoholics.

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Competition in Desert Rodents: An Experiment with Semipermeable Exclosures

Abstract. *Larger species of seed-eating desert rodents were excluded from experimental plots while smaller, potentially competing species were allowed to enter. Density of small granivores on these plots increased to nearly 3.5 times that on control plots but only after 8 months. These results indicate that interspecific competition affects the abundance of desert rodents; they also support indirect evidence that competition for seeds influences the organization of desert rodent communities.*

Although numerous studies suggest that interspecific competition plays a major role in structuring communities of terrestrial vertebrates, few experiments have demonstrated that the presence of one species affects the abundance, distribution, and resource utilization of coexisting species in nature (*1–3*). In part for this reason, the importance of competition in community ecology has been questioned with increasing frequency (*4–6*). Some experimental studies have assessed indirect, short-term consequences of competition, such as shifts in resource utilization after removal of coexisting species (*1, 7–9*); others measured numerical responses of artificially confined populations (*2, 10*). But long-term experiments on unconfined populations, which are most likely to demonstrate realistic community responses to competition (*11, 12*), often are impractical because of the difficulty in maintaining reduced population densities in the face of continual immigration (*8, 12, 13*).

We selectively excluded some species without restricting dispersal of others by taking advantage of size differences among seed-eating desert rodent species. In July 1977 we established eight square plots (50 by 50 m) on a 20-ha site in an area of superficially homogeneous Chihuahuan Desert shrub vegetation. The site is 6.5 km east of Portal, Arizona (*14*). The plots were fenced with 0.64-cm wire mesh, which was buried to a depth of 0.2 m and topped with aluminum flashing. We assigned treatments to plots at random: two replicates of each of four treatments in a 2 by 2 factorial design.

The factor of primary concern in this report is the presence or absence of large rodents of the genus *Dipodomys*. Access of rodents to each plot was controlled by 16 holes of appropriate size cut at equal distances at ground level. Small holes (1.9 cm in diameter) in the fences of four plots excluded the three largest species of granivorous rodents (*Dipodomys spectabilis*, body weight, 120 g; *D. ordi*, 52 g; *D. merriami*, 45 g) but permitted free passage of the four smallest granivorous rodent species (*Perognathus penicillatus*, 17 g; *P. flavus*, 7 g; *Peromyscus maniculatus*, 24 g; *Reithrodontomys megalotis*, 11 g) as well as three species of small omnivorous rodents (*Onychomys leucogaster*, 39 g; *O. torridus*, 29 g; *Peromyscus eremicus*, 25 g) (*15, 16*). Larger holes (6.5 cm) in the fences of the other four plots allowed access to all rodent species. The other factor in this experiment was the presence or absence of large harvester ants, *Pogonomyrmex rugosus*, which forage in columns and were removed by poisoning colonies on two of the four plots subjected to each rodent treatment (*17*).

Our experiment was designed to determine whether the presence of large granivorous rodents limits the abundance of small rodents. Furthermore, if this effect is due to competition for food, we predict that the small granivores should