stimulation but shortened the duration of stimulation selected.

Animals selected the food pellets significantly more often than the inedible objects, but an appreciable number of inedible objects were also carried (10-minute average: 40 food pellets, 26 inedible objects). It would be difficult to determine whether the edibility of the food pellets or their familiarity or ease of carrying was a more important influence in their selection. Animals that previously had displayed stimulus-bound eating did not exhibit a higher ratio of food pellets to inedible objects selected. Furthermore, even though a 23-hour period of food deprivation both significantly ($P < .05$) increased the number of round trips and significantly shortened the average stimulation duration selected, the ratio of food pellets to inedible objects selected decreased (10-minute average: 51 food pellets, 52 inedible objects).

In several instances, mice were placed on the stimulation side of the test chamber, and these too were picked up and deposited unharmed on the OFF side. On a few occasions the rats picked up their own tails and attempted to carry them to the other side. Viewed collectively, these results supported our view that object-carrying is a basic unit of behavior which can be studied independently of food-hoarding and maternal behavior. Similarly, the fact that there were no differences either between males and females or between those animals that did and did not display stimulus-bound eating also supports this position.

Although the objects carried by rats when hoarding, nest building, or retrieving pups vary, the transporting is invariably from a more open and vulnerable location to one that is relatively familiar and protected. Ethologists have stressed the necessity of the prior establishment of a home or sleeping site before carrying behavior is displayed in a new environment (*5*). It has also been hypothesized that hoarding may be a function of the difference in security between the home area and the place where food is found. In the present context, the animal's control over the stimulus may impose a structure on the test chamber that parallels the differentiation between the open field and the home area. We have also determined that when the significance of the sides of the chamber is reversed, the animal adjusts to this modification and carries objects from the new ON side to the OFF side of the chamber. These latter results suggest that the alternation of internal states induced by the stimulus onsets and offsets may be more important for the initiation of carrying behavior than any specific spatial configuration. These changes in internal state may be a central reflection of the differentiation between open field and home area.

In a subsequent study we calculated the average duration of the stimulation and nonstimulation periods selected by the animals and programmed the equipment to deliver the stimulus in accordance with these parameters. The stimulation was presented, therefore, in a regular sequence without regard to the animal's behavior or location. Initially, if the animals happened to be stimulated on the previous ON side, they picked up an object and started to carry it to the opposite side; if they were stimulated on the previous OFF side, they seldom picked up an object. As there was no consistent relation between the animals' location and the stimulus onsets and offsets, the carrying of objects was terminated within several minutes. Those animals that previously had exhibited either stimulus-bound eating or wood-gnawing reverted to this behavior, but those that had not displayed only general locomotor exploratory behavior.

Several conclusions seem justified by the results: (i) object-carrying by rats is a unit of behavior that may be investigated separately from maternal behavior and food hoarding; (ii) the diversity of sites capable of eliciting carrying behavior suggests that it is unlikely that a specific hypothalamic area mediates this behavior and raises the possibility that the behavior is organized elsewhere in the nervous system; (iii) hypothalamic stimulation by itself does not elicit carrying behavior unless it occurs under conditions which permit a consistent relationship between alternating internal states and the physical space; (iv) the behavior elicited by hypothalamic stimulation should be viewed from the perspective of the environmental conditions which initiate species-specific response patterns prior to the postulation of motivational states related to biological needs.

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Pheromone Response in Pine Bark Beetles: Influence of Host Volatiles

The effectiveness of population-aggregating pheromones of pine bark beetles *Dendroctonus* spp. is strongly activated by naturally ocurring volatiles from the resins of pine trees (*1, 2*). *trans*-Verbenol detected in the hindgut of female *D. ponderosae* and other species of *Dendroctonus* was essentially inactive when tested in field olfactometers on flying beetles in forests of white pine *Pinus monticola* in Idaho in the late summer of 1967. However, when *trans*-verbenol was sprayed on log sections of *P. monticola* that had low attractive properties, beetles were attracted in appreciable numbers from the forest in spite of competition from natural sources of attractants (*3*). This effect on *trans*-verbenol was traced to resin of *P. monticola* and particularly to alpha-pinene, a major component (32 to 60 percent) of the oleoresins.

A similar effect with alpha-pinene on the pheromone of *D. frontalis* was observed in Texas the following spring. After the pheromone had been isolated, identified, and given the trivial name of "frontalin" (*4*), it was demonstrated that it was active alone but that alpha-pinene and *trans*-verbenol would accentuate the pheromone activity of the synthetic compound (*5*). Because of these effects of the host factor in population aggregation in these two species, we abandoned all efforts to bioassay pheromone activity in association with log sections or standing trees because of the obvious danger that the results would be confused by host volatiles.

Numerous tests have been made in field olfactometers with brevicomin, which was identified in the frass of female *D. brevicomis* (*6*). The material has consistently given indifferent results or been totally ineffective. However, when a representative assortment of natural terpenes was tested in conjunction with brevicomin, 3-carene proved to be effective in activating the substance. 3-Carene was superior to myrcene and other terpenes in tests made during the summer of 1968 (*7*).

The failure of brevicomin alone to compete with natural sources of attractants in the forest is distinctly different from the results reported by Bedard *et al.* (*8*). The brevicomin released from a tree in their experiments was probably associated with some natural component of the host. Their data show that myrcene might serve in this capacity, but it would be more logical to assume that 3-carene was responsible since it is a predominant component of oleoresin in ponderosa pine (averaging 38 percent) as compared to myrcene (averaging 15 percent) and is more active unit for unit than the latter.

The ultimate utilization of pheromones of *D. brevicomis* in forest management would not appear to be so bleak as the data of Bedard *et al.* would indicate. As we have reported and discussed in a seminar at the U.S. Forest Service Southwest Experiment Station in January 1969, male *D. brevicomis* produce frontalin. The material is effective in aggregating populations when used alone, but is strongly enhanced by 3-carene. Whereas a mixture of brevicomin and 3-carene attracts a high proportion of males, frontalin with 3-carene attracts a preponderance of females. Since the female is the key to attack density, the use of a three-component mixture of frontalin, brevicomin, and 3-carene may be the ultimate answer to manipulation of *D. brevicomis* populations. It is not clear whether brevicomin will be an essential component in the mixture, but it is being retained for the time being to reinforce aggregation of males in predetermined spots.

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Multiplication of Ice Embryos by Ice-Whisker Shedding

The observation of whiskers by Cross (*1*) on evaporating polycrystalline ice and by Micheli and Licenblat (*2*) on evaporating single crystals supports the credibility of the techniques for ice-whisker replication of Odencrantz *et al.* (*3*), in spite of the uncertainties of the method as pointed out by Smith-Johannsen (*4*).

If a necessary condition for the formation of ice whiskers is evaporation, my data indicate that the possibility of ice multiplication in slightly supercooled clouds by the whisker-shedding mechanism suggested by Odencrantz *et al.* (*3*) should not be ruled out as indicated by Cross's statement (*1*) that "it is therefore unlikely that such splinters would be found in the supersaturated region of the cloud where they could act as ice nuclei." Although no instrument provides a reliable measurement of the humidity of the air between cloud droplets under most conditions, on many occasions I have used either of the two techniques discussed below to detect unsaturated regions in dense clouds. (i) When a dry layer, generally less than a kilometer thick, is present throughout the mesoscale region in which clouds are located, the clouds often penetrate well above this layer. The clouds often show a "necking in" at this level, and later the less vigorous clouds will cut in two. An airborne dew-point hygrometer with a water-separating sample-entry configuration flown in this layer through even vigorous clouds frequently registers an average humidity below saturation. Since small droplets cannot be totally excluded from this instrument, its measurements indicate only an upper limit of humidity. In less vigorous clouds which penetrate the dry layer the average relative humidity is below 90 percent. (ii) If a cloud evaporator with a response of 0.02 second is used together with a Lyman-alpha spectral-absorption hygrometer (*5*) for measurements of total water content, traverses through the upper third of dense cumulus clouds frequently reveal patches 3 to 50 m wide (probably of large vertical extent) which are unsaturated, even if the moisture in the liquid and frozen particles present is included. More frequent occurrences would undoubtedly be found if we could measure the corresponding humidities with a spatial resolution of 3 m and could exclude moisture from the drops in the sample. Ice particles are often found in unsaturated parts of the cloud, even though the overall cloud is supersaturated.

Ice particle concentrations 2 to 4 orders of magnitude higher in clouds than the concentration of natural primary ice nuclei near or under the cloud (*5, 6*) have nearly always occurred in the presence of graupel or liquid drops larger than 100 μm in diameter. This suggests that, if the whisker-shedding mechanism contributes to the profusion of secondary ice nuclei, the shedding is nearly always coincident with the presence of particles larger than 100 μm in diameter. The shedding may occur (i) because of collisions between these larger particles and collisions of small evaporating ice particles with whiskers or (ii) because of the shedding of whiskers in the air stream from graupel falling at high terminal velocity. The same evidence also fits other mechanisms for the multiplication of ice embryos (*7*).

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