would be expected for *any* discriminable aspect of the imprinted stimulus.

The over-all increase during the course of testing presents a difficulty for the assessment of generalization gradients, since this effect is confounded with stimulus difference to flatten the gradient. It would be advisable to use shorter testing periods and to balance test values systematically with regard to order of presentation. But the development of following behavior to other stimuli than the training value supports the evidence from the generalization gradient that leads us to question any extreme specificity of the "object-acquiring" process (*8*).

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References and Notes

1. K. Lorenz, *J. Ornithol. Leipzig* **83**, 137 (1935).
2. H. Moltz, *Psychol. Bull.* **57**, 291 (1960).
3. J. Jaynes, *J. Comp. and Physiol. Psychol.* **49**, 201 (1956).
4. R. Hinde, W. Thorpe, M. Vince, *Behavior* **9**, 214 (1956).
5. N. Guttman and H. Kalish, *J. Exptl. Psychol.* **51**, 79 (1956).
6. E. Hess, *Science* **130**, 133 (1959).
7. H. Schaefer and E. Hess, *Z. Tierpsychol.* **16**, 161 (1959).
8. This report is condensed from an undergraduate honors project submitted by the senior author, who is now at the University of Missouri. It was supported by funds from the Dension University Research Foundation and by grant M-2414 from the National Institutes of Health. We acknowledge the suggestions of James Polt on experimental procedure and the aid of Sheldon Canfield in designing the apparatus.

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Identification of Small Animals by Proximity Sensing

Abstract. Individual deer mice are identified by magnetic proximity sensing. Approach of an animal wearing a small ferromagnetic collar unbalances an excited inductance bridge which triggers recording circuitry. In conjunction with conductance proximity sensing, the techniques can identify four individuals. Some results on the tendency of two females to follow one another are cited.

Studies of social interactions among small animals have been hampered by lack of techniques for automatic identification of individuals. Limitations are particularly serious for studies of nocturnal animals. Past work with these has hinged either on laborious direct observation or upon observation of end positions (*1*). The identification methods described herein depend upon the detection and differentiation of small metal collars by proximity switches. Since we have used ferromagnetic sensing most extensively, it has been selected for detailed illustration.

A general program of our laboratory has been to develop techniques that enable a broad spectrum of behavior of small animals to be monitored automatically for long periods (*2*). The behavior of a pair of female deer mice, *Peromyscus maniculatus*, has been studied in detail, first the behavior of each animal individually, and then the behavior of both in consort. Ferromagnetic proximity sensing enabled a large fraction of the combined activity to be assigned to one individual or the other.

The chief prerequisite of an identification station (Fig. 1*A*) is that the animals must approach to within about ¼ inch of the sensor face (*a* in Fig. 1*A*). The station illustrated penetrates the sidewall (*b*) of an experimental enclosure and dovetails into the cut-out area of a partition (*c*) which divides the enclosure into two compartments. Animals are identified during passage between these compartments, one of which contains the nest, and the other an activity wheel and food and water. This single station gives a high degree of individual activity assignment.

The ferromagnetic method utilizes a magnetic proximity sensor (Honeywell #SB84A), the pick-off element of which is a two-pole excited inductance bridge. Near approach of ferromagnetic material reduces the reluctance of the flux paths linking the coils of the bridge, thereby unbalancing it. The resulting signal triggers recording circuitry. Ferromagnetic collars each consist of two open 0.3-g rings of 0.035-inch soft iron wire closed snugly about the animals' necks. Nonferromagnetic dummy collars are made of soft copper wire.

The magnetic proximity sensor (*d*) comprises a portion of the wall of a circular passageway (*e*) counterbored into two matched ¼-inch-thick Plexiglas plates (*f*). A shutter (*g*) of 0.045-inch stainless steel rotates upon a ball bearing (*h*) press-fitted into its arm. This bearing fits lightly upon a ⅛-inch shaft (*i*) through the plates (*f*). A recess milled into the plates' inner surfaces provides pivoting freedom for the shutter, which occludes all but a semilenticular area of the passageway adjacent to the sensor. To effect passage, the animals simply brush aside the shutter (which gives way easily), necessarily apposing their collars to the sensor face (*a*).

Self-cutoff circuitry is employed to reduce any possible disturbance of the animal that might be caused by magnetic attraction of the collar in the field of the sensor coils. Thus, the sensor and amplifier (Honeywell, No. R7107A or R7110A) are not energized until the shutter is lifted, which closes the shutter microswitch (*j*) by cam action (*k*). The transistorized amplifier and sensor are armed instantaneously (see Fig. 1*B*) through the normally open terminal of this microswitch (microswitch No. BZ-RW8435). Upon being triggered, the amplifier disarms itself and the sensor within 35 to 50 msec by negative feedback involving a rocker-arm impulse relay (Potter & Brumfield, No. PC11A). Upon firing of this relay, a first pathway in series with the normally open terminal of the microswitch is opened, with concomitant closing of a second pathway in series with the normally closed terminal. When the shutter closes, after the amplifier relay has been triggered, a potential is applied through the normally closed terminal of the microswitch (in series with the now closed second pathway) to the coil of the impulse relay. Refiring of this relay reestablishes the normal series pathways. Thus, field effects are limited to a small fraction of a second, which turns out to be negligible in practice.

Each opening of the shutter is recorded by one channel of an Esterline-Angus 20-channel event recorder and counted by a parallel Veeder-Root magnetic counter. Each triggering of the sensor is recorded on an adjacent channel and counted on a second counter (Fig. 1*C*). Thus, scoring of a passage by both channels and counters identifies the animal with the ferromagnetic collar; scoring by only one channel and counter identifies the other occupant. Passages are sufficiently frequent that strip-chart recording without auxiliary digital printout should be at a chart speed of not less than 1 foot per hour.

An illustrative record of passages of two mature female deer mice between enclosure compartments is reconstructed in Fig. 1*C*. As an example of information obtained by using this identification technique, some findings on the tendency of these animals to follow one another to and from the nest are cited.

During a 1-week period, animal A (iron collar) entered the empty nest 60 times; animal B (copper collar), 189 times; unidentified, 14 times. In the same period, A left the nest when both

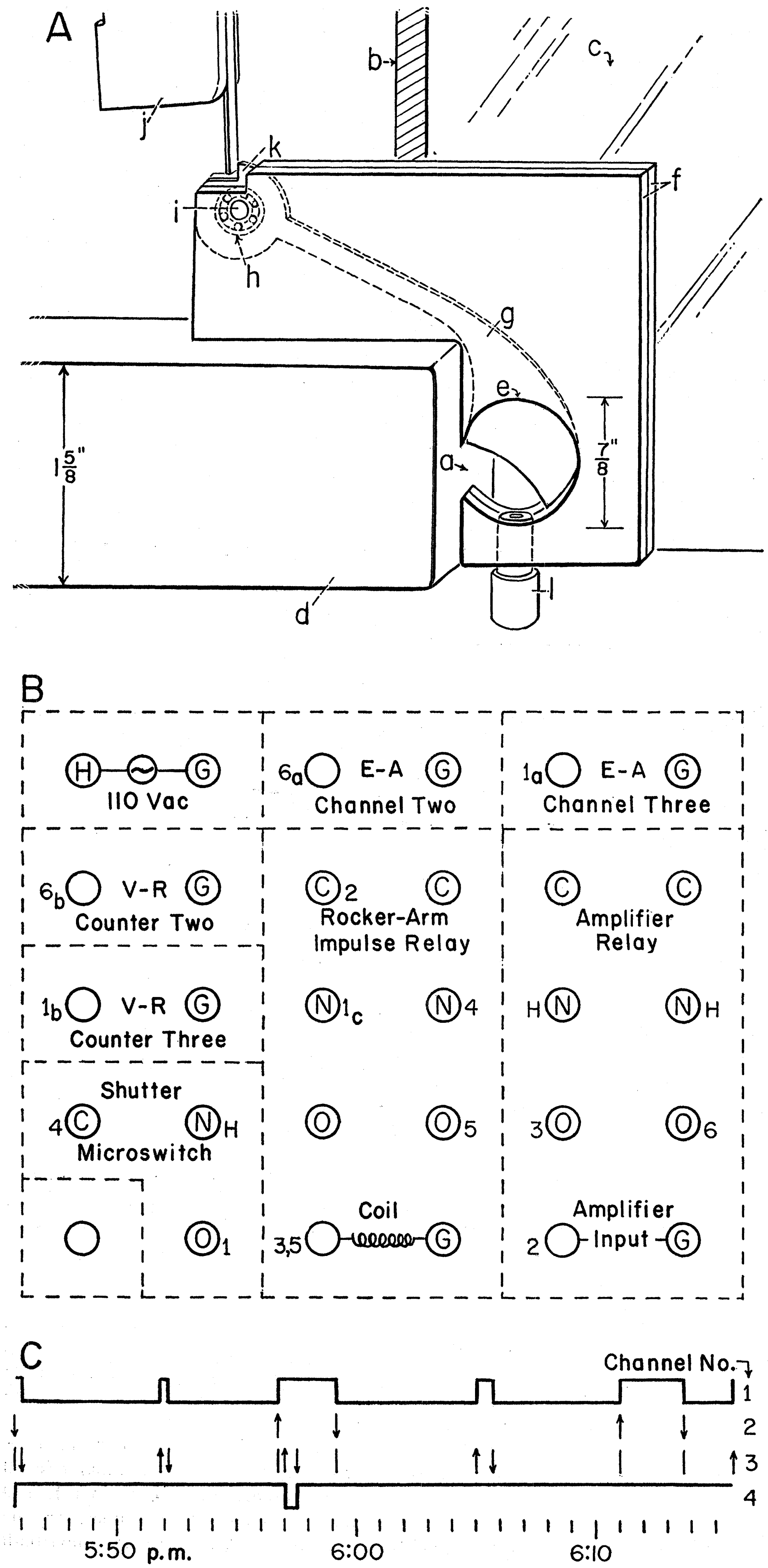

Fig. 1. (*A*) Schematic scale drawing of identification station. See text for explanation of letters. (*B*) Wiring diagram of ferromagnetic sensing circuitry on computer-type panel. Circles represent banana-jack outlets; letters within circles identify functions or connections; letters to the side, connections only. Abbreviations: *H*, hot terminal of 110-volt a-c source; *G*, neutral terminal of 110-volt a-c source; *N*, neutral or common relay or switch terminal; *C*, normally closed terminal; *O*, normally open terminal. Connect all banana jacks marked *H* or *G* with *H* or *G*, respectively, of 110-volt a-c source. Connect pairs of identically numbered banana jacks to one another. Jacks numbered with subscripts need be connected only with jacks identically numbered without subscript. (*C*) Esterline-Angus record of passages of two female deer mice during a ½-hour period. Channel 1, presence in compartment containing the nest; channel 2, signals from ferromagnetic sensor; channel 3, signals from shutter microswitch; channel 4, presence in compartment containing the wheel. Arrows on signal marks indicate direction of movement. On the two occasions when animal B (channel 3) followed closely after animal A (channels 2 and 3), the actual interval was only a few seconds.

were present 41 times; B, 54 times; unidentified, 32 times. Animal B followed animal A into the nest on 50 percent of A's identified entrances, whereas A followed B on only 3.2 percent of B's identified entrances. Similarly, B followed A out of the nest on 61 percent of A's exits, whereas A followed B on only 14.7 percent of B's exits.

The great majority of followings occurred within 3 min. On only 11 of a total of 81 occasions when one animal followed the other did it wait longer than 10 min before following. Since failure of animal X to follow is defined by the return of animal Y to the original location while animal X is still present, many failures to follow simply reflect prompt returns.

B made many short trips to the nest, whereas A visited the nest much less frequently and, in fact, monopolized the running wheel during active periods. It was clear from these and other results that animal A "dominated" animal B. B was prone to follow A, whether into or out of the nest or running wheel or through the passage (see Fig. 1*C*), whereas animal A followed animal B infrequently.

The basic wiring diagram for the ferromagnetic sensor is coded on a computer-type programing panel (Fig. 1*B*). Relay modules and other components plug interchangeably into the rear of the panel. The use of such panels allows great flexibility, and the illustration and practice of wiring are greatly simplified.

Three individuals can also be identified by using ferromagnetic sensing. The soft-iron collar of the third animal should weigh about 1 g. The excitation voltage to the sensor bridge is made reducible with a normally shorted series resistor, so that when it is in series, the amplified just fails to respond to the signal generated by the presence of the 0.6-g collar. Triggering of the normally wired amplifier by either collar now open-circuits the short and also establishes a pathway to a third recording channel. With the short open-circuited, only the presence of the heavy collar can trigger the amplifier. Thus, scoring of a passage by all three channels identifies the animal with the heavy collar; scoring by only two channels identifies the animal with the light collar; while scoring by only one channel identifies the third animal.

For identification of a fourth animal, conductance proximity sensing is employed in conjunction with the ferromagnetic method (see Fig. 1*A*). We have used the Bently D-151 detector (*3*), which is essentially an eddy current sensor. The head (*l* in Fig. 1*A*) of this unit contains a pancake-wound coil pick-off element which is loaded by the near approach of any conducting material (which appears to it as a shorted secondary coil). Loading of the pancake coil generates a change in the radio-frequency output of a regenerative radio-frequency oscillator (modified Colpitt configuration). The d-c envelope of this output is either monitored directly or converted to a digital signal by a "Schmidt trigger" binary switch. The collar of the fourth animal can be of any conducting nonferromagnetic material, but the dummy collar must then be nonconducting (*4*).

Note added in proof. It has come to my attention that T. Royama used magnetic proximity sensing in a nest recorder to differentiate between the visits of a male and a metal-banded female great tit, *Parus major* [*Brit. Birds* **52**, 295 (1959)].

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References and Notes

1. W. F. Blair and W. E. Howard, *Contribs. Lab. Vertebr. Biol. Univ. Mich.*, No. 26 (1944).
2. J. L. Kavanau, *Ecology*, in press.
3. Bently Scientific Co., Berkeley, Calif.
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Taxonomic Status of the Pygmy Marmoset (Callithrix pygmaea Spix)

In an earlier issue of *Science* (*1*) there appeared a report on the pygmy marmoset as an experimental animal. Because it is possible that this species may become an established laboratory animal, it appears essential that its taxonomic status be correctly determined.

Callithrix pygmaea Spix is a form of the group of marmosets of which the brush-eared marmoset known as *Callithrix jacchus* Linnaeus is typical and of which it is the westernmost representative. This is a true pygmy. It does not deserve generic or even subgeneric rank. The original specimen (*2*) was collected by the German zoologist J. B. von Spix at Tabatinga (now Sapurara) on the north bank of the Amazon River on the Brazilian side of the Brazil-Colombian border, about 250 miles down river from Iquitos in the province of Loreto, Peru, from which area the stock now kept at Los Angeles was derived. It also occurs in the forested area on both sides of the upper Amazon and is known to be common in the area of the Napo, Copataza, and Pastaza rivers in northern Peru and the Oriente Province of Ecuador and along the lower Ucayali River, being on record eastward in Brazil at least as far as the Juruá River (Eirunepé, formerly João Pessoa). The type locality of Lönnberg's *niveiventris* (*3*) is very slightly further east, in the area of the mouth of the Teffé River (Lago de Ipesuna). There is no doubt that this is not different from the original *pygmaea* and that *niveiventris* is not a valid name. The Los Angeles material comes from an area clearly within the range of the original *pygmaea*, west, not east, of the type locality.

These conclusions have been recently confirmed by examination of a series of specimens from localities covering the whole area of distribution of this form, at the British Museum (Natural History), London, England.

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References

1. H. Sobel, C. E. Mondon, C. V. Means, *Science* **132**, 415 (1960).
2. *Cebuella* Gray [*Proc. Zool. Soc. London 1865* (1866), p. 734].
3. *Cebuella pygmaea niveiventris* Lönnberg [*Arkiv. Zool.* **32**, 21 (1940)].

24 July 1961

Carotid and Vagal Afferents and Drug Action on Transcallosally Evoked Cortical Potentials

Abstract. The use of transcallosally evoked cortical potentials to study the action of intracarotidly injected drugs on cerebral synapses has necessitated the demonstration that vagal, baroreceptor, and chemoreceptor influences do not play essential roles in the drug effects observed —for example, the cerebral synaptic inhibitory action of serotonin.

Transcallosally evoked cortical potentials have proved to be very useful tools in studying the effects of drugs on cerebral synaptic function (*1*). In order to obtain central effects with little complication from peripheral ones the drugs have been administered by close arterial injection (injected "intracarotidly"), because this achieves adequate concentration in the ipsilateral hemisphere and the subsequent dilution in systemic blood ordinarily lowers the concentration to a subthreshold level for peripheral effects. Afferent inflow has been reduced by light anesthesia, or curarization (*2*) has been used to eliminate proprioceptive inflow. Since such isolation from the periphery is incomplete, we needed to examine the influence of persisting afferent inflows, such as inflows over cranial nerves, as in the case of the vagus; and, especially because of the comparatively high concentration of drugs bathing the carotid sinus and carotid body due to the intracarotid route of administration, we needed to examine the possibility of baroreceptor and chemoreceptor influences on the transcallosally evoked potentials.

Section of the vagus nerve in the neck, surprisingly, impaired the ability of serotonin to reduce the transcallosally evoked cortical potentials, but, as seen in cat experiments (Fig. 1), this was a temporary, reversible effect. It developed that actual section of the vagus nerve was not necessary, but that a crush would elicit the same temporary hindrance of cerebral serotonin action. Since recovery could be accelerated by subsequent application of cocaine to the cut end or to the crushed region (Fig. 1), and since prior application of cocaine prevented occurrence of the phenomenon, it is concluded that the interference with cerebral serotonin action by vagus section or crush does not imply dependence of serotonin's cerebral synaptic inhibitory