creased at an approximately linear rate to 5.5°C. Control and exposure data were obtained between 3.9° and 5.3°C. A blower (100 ft³/min) provided airflow from above. The airflow, measured below the empty chamber with a hot-wire anemometer (Datametrics Airflow Multimeter Model 800 VTP), was approximately 6 m per minute in the region of the lever and increased to approximately 18 m per minute at the opposite side of the chamber.
10. Microwaves were transmitted to the horn via a coaxial cable to a coaxial-waveguide adapter. The feeder horn with a 6.5 by 7.5 cm rectangular aperture directed the microwaves toward the chamber floor 44.5 cm below with the E field parallel to the axis established by the response lever and infrared lamp. The designated power density specifies that value at the lever. A Narda Model 8315 probe calibrated against an NBS XD-1 probe was used to map the field. With the back wall removed, the field was measured at the level of the lever at nine locations in a 10 by 10 cm grid with loci 5 cm apart covering the central area of the chamber. The distribution of power densities varied within 11 percent of the mean value. The field was also mapped with a smaller probe fabricated by J. Ali (U.S. Environmental Protection Agency) which enabled measurements to be made at loci close to the chamber walls. There was close correspondence between the two sets of measurements. The energy absorption rate per unit mass was estimated according to the relationship $P = 4.186\ C\Delta T/t$, where C is the tissue specific heat in calories per gram per degree Celsius (in this analysis, $C = 0.83$), ΔT is the temperature increase in degrees Celsius, t is the duration of exposure in seconds, and P is watts per kilogram [C. C. Johnson, *J. Microwave Power* **10**, 249 (1975)]. A YSI 423 probe inserted 6 cm into the colon measured the temperature of a pentobarbital-anesthetized rat encased in a Styrofoam block during a brief exposure to microwaves [Lu *et al.* (*11*)]. Delta-t, the rate of temperature change, included a correction for the rate of temperature change immediately preceding the exposure. The absorption rate was approximately 8.4 W/kg at a power density of 41 mW/cm², resulting in a specific absorption rate of 0.20 W/kg per milliwatt per square centimeter.
11. S.-T. Lu, N. Lebda, S. Michaelson, S. Pettit, D. Rivera, *Radio Sci.* **12(S)**, 147 (1977).
12. These data are the results of the second exposure session. After studying three rats, we found that the results from the first session were similar to but more variable than those from the second. Since such an outcome might be attributable to the novelty of the microwaves, an effect often seen during initial exposure to drugs and other stimuli, we decided to focus on the data from the second sessions of those three rats plus three others. The following are the means (standard errors in parentheses) of the proportion of time the heat lamp remained on at each power density for all six rats. For the first exposure session: 0 mW/cm², 0.364 (0.017); 5 mW/cm², 0.333 (0.040); 10 mW/cm², 0.324 (0.032); and 20 mW/cm², 0.273 (0.029). For the second exposure session: 0 mW/cm², 0.326 (0.009); 5 mW/cm², 0.298 (0.015); 10 mW/cm², 0.264 (0.020); and 20 mW/cm², 0.199 (0.011). Thus the two functions are similar, but the variability from the second session is less, as would be expected, after previous experience.
13. Serial correlation within individual rats was examined by the Durbin-Watson test [J. Neter and M. Wasserman, *Applied Linear Statistical Models* (Irwin, Homewood, Ill., 1974)], which confirmed the absence of an effect from the previous 15-minute exposure and the suitability of the linear regression model.
14. Using randomization tests [A. R. Feinstein, *Clinical Biostatistics* (Mosby, St. Louis, 1977)] we compared results for the six rats at each power density with all control periods, with only the preceding control period, and with the adjacent exposure to a different and nonzero power density. Two-sided P values were less than $P = .003$ except for 5 mW/cm² against all zero exposures and 5 mW/cm² against adjacent 10 mW/cm² ($P = .02$). These results provide additional confirmation of the sensitivity of the procedure as well as an independent check of the regression analysis.
15. That interpretation is consistent with the conclusion reached in numerous studies of behavioral thermoregulation, including those of Weiss and Laties (*7*) and Carlisle (*8*).
16. See N. W. King, D. R. Justesen, and R. L. Clarke [*Science* **172**, 398 (1971)] for an example of a different sensitive procedure. We did not attempt to determine the limits of the sensitivity in the present study; instead, we wanted to determine if the thermal action of microwaves could produce behavioral change in the absence of reliable, measurable changes in colonic temperature.
17. S. M. Michaelson, W. M. Houk, N. J. A. Lebda, S.-T. Lu, R. L. Magin, *Ann. N.Y. Acad. Sci.* **247**, 21 (1975). In addition, using the exposure system and behavioral contingencies of the present experiment, we measured the rectal temperature of two rats at 0900, 1200, and 1500 hours immediately after they were exposed to 0, 5, 10, and 20 mW/cm² for 15 minutes each. The respective mean temperatures were 37.4°, 37.7°, 37.7°, and 37.4°C for one rat and 37.7°, 37.7°, 38.0°, and 37.5°C for the other, indicating that the microwaves did not produce ordered changes in rectal temperature but did produce such changes in thermoregulatory behavior.
18. Although a compensatory change in behavior occurs, we do not know if the overall absorbed heating is constant across conditions. Certainly, the spatial distributions of absorbed energies differ between microwaves and infrared heat. The relationship between electromagnetic energy and transduced thermal energy is complex. For example, see R. A. Tell, *An Analysis of Radiofrequency and Microwave Absorption Data with Consideration of Thermal Safety Standards* (U.S. Environmental Protection Agency Tech. Note No. ORP/EAD 78-2, Washington, D.C., April 1978). For present purposes it is sufficient to assume at least an ordinal relationship between the two.
19. V. G. Laties, *J. Physiol. (Paris)* **63**, 315 (1971). See also A. C. Catania [in *Operant Behavior: Areas of Research and Application*, W. K. Honig, Ed. (Prentice-Hall, Engelwood Cliffs, N.J., 1966), p. 213] and P. de Villiers [in *Handbook of Operant Behavior*, W. K. Honig and J. E. R. Staddon, Eds. (Prentice-Hall, Engelwood Cliffs, N.J., 1977), p. 233] for a comprehensive introduction to the study of concurrent schedules.
20. We thank C. Cox and H. T. Davis for the statistical analyses, and C. A. Wallen for criticism of the manuscript. We thank J. Ali and EPA for assistance in mapping the microwave field. This paper is based on work supported in part by postdoctoral fellowship F22 ES01804 (awarded to S.S.) and grant ES-01247, both from the National Institute of Environmental Health Sciences, and in part by a contract with DOE at the Department of Radiation Biology and Biophysics, University of Rochester, and is Report No. UR-3490-1537.

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Chimpanzee Problem Comprehension: Insufficient Evidence

Premack and Woodruff (*1*) showed a chimpanzee (Sarah) videotaped scenes of a human actor struggling with problems. The video image was then frozen and Sarah picked one of two photographs as a "solution" to the actor's problem. Sarah's performance on this task was said to have permitted examination of "the animal's knowledge about problem-solving—its ability to infer the nature of problems and to recognize potential solutions to them" (*1*, p. 532).

Premack and Woodruff do not present any evidence, independent of Sarah's choice of photographs, to indicate (i) that she saw the videotaped sequences as problems to be solved, (ii) that she perceived her choice as representing a solution to the portrayed problem, and (iii) that she understood either the elements of the problems or the nature of the solutions or if faced with the problem that she could solve it herself. These factors cannot be presumed to be the inherent bases for Sarah's choices of photographs unless it is independently demonstrated that the scenarios were, in fact, problems in Sarah's perception and that she understood their video presentation. Failure to demonstrate this allows for the possibility that the dynamics of the scenarios were beyond Sarah's comprehension and that her choices of alternative photographs were based on simpler strategies than those suggested by Premack and Woodruff. If the scenarios were not perceived as problems by Sarah, then her choices obviously could not have been solutions.

On what other basis might Sarah have selected the alternatives which she did? It seems reasonable to conclude, given the variety of previous training paradigms which Sarah has received, that she could have used relatively simple match-to-sample strategies, none of which would require an understanding of either the problems portrayed in the videotape or that her choices represented solutions. For instance, it is clear, from the video stills and photographs presented by Premack and Woodruff (*1*, p. 533), that problems 1 and 2 of the banana-attainment series could readily have been solved by a straightforward matching response of the photograph to the scene held on the monitor on the basis of physical similarity of the images themselves. Problems 3 and 4 present a more difficult match-to-sample choice; however, Sarah performed at chance on these.

Problems 5 to 8 were object-choice tasks in which Sarah was to pick a photograph of an object which could be used to solve the actor's problem. This group of problems could have been solved by selecting the item (key, faucet, and so forth) that had been most frequently associated with the sample object (lock, hose) on the basis of past observational experience (*2*).

The single subject of this study, Sarah, had received extensive training involving both physical match-to-sample and associative match-to-sample tasks. The format of the frozen-video paradigm selected by Premack and Woodruff is virtually identical to the subject's past match-to-sample training and could thereby be expected to produce a "set" toward this type of response.

Testwise chimpanzees can readily learn a series of paired-choice problems on the basis of the first trial's correctness. Therefore, only the first performance reflects the animal's capacity. Premack and Woodruff presented Sarah only eight trial-one choices, on which Sarah was correct on seven. Statistical significance pivoted on one choice on one trial of one problem. The case is, consequently, weak. Furthermore, if Sarah were correct on one or all of the seven problems simply because she used a match-to-sample strategy, the statistical test would have been significant for reasons other than those concluded by the authors.

Premack and Woodruff purport to offer a new set of techniques for the study of the ape's knowledge about problem-solving. However, close analysis reveals that their technique is simply a modified version of the traditional match-to-sample paradigm.

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References and Notes

1. D. Premack and G. Woodruff, *Science* **202**, 532 (1978).
2. S. Savage-Rumbaugh, D. M. Rumbaugh, S. Boysen, *Behav. Brain Sci.* **4**, 555 (1978).
3. Supported by NIH grants HD-06016 and RR-00165.

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We can reject Savage-Rumbaugh and Rumbaugh's hypothesis not only on the basis of the results reported in *Science* (*1*), but also for subsequent tests reported elsewhere (*2*). Our more recent tests again demonstrated that Sarah understood the videotapes shown her and did not simply choose photographs that matched or were associated with the terminal image on the videotape.

We showed Sarah two different human actors confronting the same series of problems, and she was required to choose among photographs of the actors behaving in one of three ways: (i) carrying out a solution to the problem (removing cement blocks from a box), (ii) suffering a mishap (falling under the weight of the blocks), and (iii) behaving irrelevantly (reaching out with a stick). The two actors were originally chosen because we knew from independent measures that Sarah liked one and disliked the other. Her choices reflected her preference. She chose primarily correct solutions for the actor she liked, mishaps for the actor she disliked, and rarely chose an irrelevant action for either (*2*).

The Rumbaughs leave the impression that the photograph Sarah chose matched the terminal image of the videotape, and fail to make clear that the judgment of a match can be made only after one knows the correct answer, and not before. For instance, in problem 2 both terminal image and correct solution involve an outstretched arm, but so does the solution for problem 3. Sarah nevertheless did not confuse the correct solutions to either problem, as one must if one has no other basis for judgment than similarity. Further, problems 5 and 6 both show a cage, lock, and heater; photographs of the key and torch were potential associates of both scenes, yet Sarah chose the key for problem 5 only, and the torch only for problem 6. A knowledge of "what goes with what" is a necessary condition for choosing correctly, but hardly a sufficient one.

Neither Sarah's correct choices nor her errors can be explained by "matching." Solution 4 and problem 4 are the only images of the actor crouched over a box and concrete blocks. No problem could have been solved more easily on the basis of matching; yet Sarah failed this problem repeatedly, despite correction. [Her failure here can be best understood by referring to the original Köhler research (*3*), in which the "removal of stones from a box" was the only problem the apes failed.]

Finally, the Rumbaughs have expressed concern over the statistical significance of the results for Sarah's first-trial performance (seven of eight correct). The statistical decision-making procedure, however, takes into account the greater relative variability of sample statistics based on the small N's by requiring relatively larger deviations from chance in order to achieve a given significance level, and significance depended upon the results of all test trials.

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References

1. D. Premack and G. Woodruff, *Science* **202**, 532 (1978).
2. ———, *Behav. Brain Sci.* **4**, 515 (1978).
3. W. Köhler, *The Mentality of Apes* (Harcourt Brace, New York, 1925).

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