Table 1. Number of trials (and errors) to criterion for subjects with the hippocampus resected and for control subjects, on the "self-ordered" and "externally ordered" sequence tasks and discrimination tasks with varying intertrial intervals.

Task	Trials to criterion (errors)	
	Resected subjects (N = 4)	Control subjects (N = 6)
Ordered sequences		
"Self"	932* (574)	298 (133)
"External"	1897† (1476)	1216 (728)
Discrimination trial spacing		
5 seconds	108 (38)	100 (39)
30 seconds	66 (23)	76 (22)
3 minutes	42 (18)	49 (21)
6 minutes	27 (7)	26 (6)

* Three of four did not reach criterion in 1200 trials. † One of four did not reach criterion in 3000 trials.

groups was significant at $<.01$. Moreover, no hippocampal subject reached criterion before the added feedback light was instituted, as did three of the six control animals. The added feedback improved the performance of all animals.

The performance of the hippocampectomized subjects was further analyzed to determine if simple response perseveration could account for their inferior performance in the sequential tasks. One could be led to this conclusion from the results of the "self-ordered" task, where this was the only possible type of error. The data from the "externally ordered" task, however, do not support a perseveration hypothesis. Perseveratory errors (responding to the same panel) either within or across trials were not significantly more prominent in either group. Individual monkeys in both groups did on occasion display stretches of perseveratory behavior, but no consistent result obtained. It is of course possible that a breakdown of sequential responding could be manifested as perseveration in some situations (as in the "self-ordered" task), but it appears that this is only one of possible alternative behaviors.

Following completion of the two sequential tasks, two of the previously unoperated control monkeys received bilateral hippocampectomies. All animals were then retrained to criterion on both problems 2 weeks after these operations. For these retention tests, the "self-ordered" sequence was tested first, followed by the "externally ordered" task.

The retention results were rather ambiguous. Clear differences occurred between the two newly hippocampectomized subjects and the other monkeys. On the "self-ordered" problem, these two animals took 160 and 346 trials to re-reach criterion. In contrast, the other four hippocampectomized subjects retrained in an average of 48 trials. However, this result was reversed for the "externally ordered" sequence. The two "retention" hippocampectomized subjects retrained in only 73 and 33 trials, as compared with an average of 147 for the other hippocampectomized subjects and 168 trials for the control subjects. A deficit in retention occurred in the "self-ordered" task, while on the "externally ordered" problem, these same subjects retrained in fewer trials than the other animals. One possible explanation for this result is that the hippocampectomized "retention" subjects benefited from the extra practice on the first task, this benefit showing up on the second task.

Following these retention tests, the "short-term" memory hypothesis was investigated. All subjects were trained to a criterion of ten consecutive correct choices on each of four different visual discriminations. The DADTA apparatus was again used to present the four different pairs of numerals which served as stimuli. One of the stimuli of each pair was consistently reinforced, and the position of the two stimuli was varied randomly across the 16 panels.

On these four problems, each discrimination was presented with a different intertrial interval (5 seconds, 30 seconds, 3 minutes, 6 minutes). The order of the presentation of the four tasks was balanced.

It was assumed that if any short-term memory impairment occurred, it would be more apparent on the discriminations with the longer intertrial intervals. No impairment occurred among the hippocampectomized animals on any of the discriminations. Both groups took, on the average, fewer trials to criterion on the problems with longer intertrial intervals. Since the order of presentation of the problems was balanced, transfer effects from one discrimination to another cannot be a factor in this result. It is of course possible that the discriminations were easier at the longer intertrial intervals, although there was no a priori reason to suspect this. Table 1 summarizes the data of this experiment with regard to "self-ordered," "externally ordered," and varying intertrial interval discriminations.

Our conclusion is that bilateral hippocampal lesions interfere selectively with the acquisition of behaviors which involve the execution of sequential responses. We found no indication of "short-term" memory deficits with two-choice visual discriminations over intertrial intervals up to 6 minutes. This result is similar to that of Orbach *et al.* (*9*), who found no retardation of learning a simple visual discrimination in widely separated trials by monkeys with primarily amygdala and hippocampal lesions.

No emotional changes were noted in these animals, although further tests utilizing the galvanic skin response are in progress to investigate this possibility (*10*).

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References and Notes

1. B. Milner and W. Penfield, *Trans. Am. Neurol. Assoc.* **80**, 42 (1955).
2. W. B. Scoville, *J. Neurosurg.* **11**, 64 (1954).
3. A. E. Walker, *A.M.A. Arch. Neurol. Psychiat.* **78**, 543 (1957).
4. H. Klüver and P. C. Bucy, *J. Psychol.* **5**, 33 (1938).
5. J. W. Papez, *A.M.A. Arch. Neurol. Psychiat.* **38**, 725 (1937).
6. K. H. Pribram, *Ann. Rev. Psychol.* **11**, 1 (1960).
7. ———, K. W. Gardner, G. L. Pressman, M. Bagshaw, *Psychol. Repts.* **11**, 247 (1962).
8. K. H. Pribram and L. Weiskrantz, *J. Comp. Physiol. Psychol.* **50**, 74 (1957).
9. J. Orbach, B. Milner, T. Rasmussen, *Arch. Neurol.* **3**, 230 (1960).
10. Supported by grants from the U.S. Public Health Service (MF-17,131; MY-3732-C2) and the Department of the Army (MD-2073). A preliminary report was presented at the American Psychological Association meetings in St. Louis, Mo., on 5 September 1962.

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Continuous Extraction during Treatment with Ultrasound

Abstract. *A variety of constituents from plants can be extracted in an apparatus of simple design in which the plant material and fresh supplies of solvent are exposed together in an ultrasonic tank.*

A simple, yet efficient, extraction apparatus was designed and constructed for use in extracting medicinally active substances from plants. The apparatus was needed initially for work in which ultrasonic energy was an adjunct in extractions from alkaloid-containing plants and plant parts. The conventional Soxhlet apparatus and various modifications (*1*) are unsuitable for this purpose because the extraction thimble is situated above the solvent supply, and therefore the plant material and fresh supplies of solvent cannot be exposed

Table 1. Alkaloids recovered with a Soxhlet-type extractor and the new extractor. Each figure represents the average value of three assays (milligrams of alkaloid per 10 g sample of *D. stramonium*).

Maceration time (hr)	Alkaloid content of extract after 3 hr (mg)	
	Soxhlet	New extractor
½	27	30
1	29	30
2	30	33
24	38	35

together in an ultrasonic tank (*2*). Our new extractor was designed so that the sample could at the same time be subjected to ultrasonic energy and exposed to the recycling solvent; it has been used effectively for routine extractions of a variety of plant materials.

The extractor (Fig. 1) has four separable parts: a solvent or boiling flask *F*, connecting tube *E* with sintered-glass filter *C*, extraction flask *B*, and condenser *D*.

The sample to be extracted and the macerating solvent, if used, are put into the extraction flask *B* which may be placed either in an ultrasonic tank, if exposure to ultrasound is desired, or supported suitably for conventional extraction. For ultrasonic work the glass extraction flask was replaced with one made of hard polyethylene (*3*).

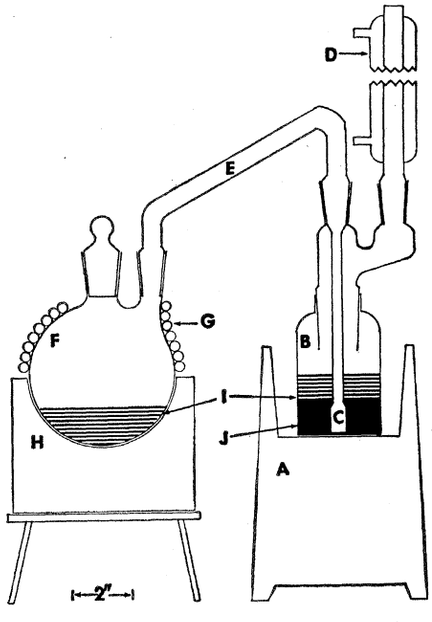

Fig. 1. Cross section of the new extractor: *A*, ultrasonic bath or suitable support; *B*, polyethylene or glass extraction flask; *C*, sintered-glass filter; *D*, condenser; *E*, glass connecting tube; *F*, solvent flask; *G*, cooling coils; *H*, heating mantle; *I*, solvent; *J*, material being extracted.

The extracting solvent is placed in flask *F*. The solvent flask is heated and cooled by connecting the heating mantle *H* to a two-cycle electric program timer. The duration and intensity of heating and cooling cycles must be experimentally determined for a particular solvent or mixture of solvents. During the heating cycle the solvent is vaporized and passes through the connecting tube and the sintered-glass filter before it enters the extraction flask. The solvent vapor condenses while flowing into the extraction flask and causes enough agitation of the ground plant material to permit considerable exposure to the solvent. When nearly all of the solvent has passed into the extraction flask the program timer initiates a cooling phase. During this phase, cold water, which is continually circulating through the coils *G* that surround the solvent flask, causes condensation of the remaining solvent vapor in the flask. The condensation results in the formation of a vacuum. The extract in flask *B* is siphoned through the connecting tube and into the solvent flask; the sintered-glass filter prevents passage of solid particles. When most of the extract has been removed from the extraction flask, air enters the tube at *C* and stops the flow of extract. The timer, if appropriately set, allows the process to be automatic and continuous.

The efficiency of the new extractor was compared with that of a Soxhlet extractor (Table 1). *Datura stramonium* samples were macerated in 80 ml of solvent (ether 20, alcohol U.S.P. 12, and ammonia 8 parts by volume) and extracted for 3 hours. The alkaloid content of the extract was determined according to the U.S.P. assay procedure for *Belladonna* leaf (*4*).

The new extractor is slightly more efficient than the Soxhlet extractor, especially for short periods of maceration. The difference in alkaloid yield after long periods of maceration is not very great. However, the mixing action produced as the solvent bubbles through the sample is a distinct advantage because it promotes wetting of the sample by the solvent and enhances diffusion (*5*). The absence of an extraction thimble eliminates the possibility that desired constituents will be adsorbed on the thimble. Alkaloid adsorption on the walls of the polyethylene or glass containers has not been observed.

The amount of material which can be extracted conveniently in the Soxhlet-type extractors is limited at any one time by the capacity of the thimble or extraction column. In the new apparatus the size of the container can be varied according to need and can be adapted for both macro- and micro-extractions.

The new extractor has been used efficiently for the ultrasonic extraction of alkaloids from solanaceous plants (*5*). This apparatus should be a useful tool not only for investigating the extent to which sources of energy other than heat can be utilized productively for extracting constituents from plants but also for overcoming many of the technical difficulties in routine extractions (*6*).

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References and Notes

1. L. C. Craig and D. Craig, in *Techniques of Organic Chemistry*, A. Weissburger, Ed. (Interscience, New York, 1950), vol. 3, p. 171; H. Kleinmann, in *Handbuch der Pflanzenanalyse*, G. Klein, Ed. (Springer, Vienna, 1931), vol. 1, p. 83; N. W. Pirie, in *Modern Methods of Plant Analysis*, K. Paech and M. V. Tracey, Eds. (Springer, Berlin, 1956), vol. 1, p. 26.
2. We used three commercial ultrasonic generators and cleaning tanks: Bendix Aviation Corp. model No. UC-4X8, National Ultrasonic Corp. model No. 100, and Circo Ultrasonic Corp. model No. 125T.
3. W. F. Head, Jr., H. M. Beal, W. M. Lauter, *J. Am. Pharm. Assoc. Sci. Ed.* **45**, 239 (1956); W. F. Head, Jr., and W. M. Lauter, *ibid.* **46**, 617 (1957); P. E. Wray and L. D. Small, *ibid.* **47**, 823 (1958).
4. *United States Pharmacopeia* (Mack, Easton, Pa., 16th revision, 1960), p. 77.
5. A. E. DeMaggio and J. A. Lott, in preparation.
6. We thank Dean R. A. Bowers and Dr. J. Cross for encouragement and assistance. Supported by the American Foundation for Pharmaceutical Education and the Rutgers Research Council.

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Diffusion of Gases from Alveolus to Precapillary Arteries

Abstract. *A cardiac catheter with a platinum electrode just proximal to its tip, "wedged" in a branch of the pulmonary artery, was used to demonstrate the appearance of hydrogen or oxygen at the tip of the catheter after inhalation of these gases.*

Prior to 1959 little attention was paid to pulmonary diffusion paths in the lungs aside from the path across the alveolocapillary membrane itself. In 1959 Weibel (*1*) stated that oxygen diffuses from the air spaces into all adjacent tissues. Recent work in this laboratory has shown that transport of gases from