although the selective assessment of specific emotional or affective responses that are of primary interest in this area has continued to present both methodological and theoretical problems. The purpose of the present report is to describe a method, based on earlier animal experimental work (*1*), for producing and selectively measuring emotional behavior in experimental animals and to present some data that illustrate the use of this method for investigating the behavioral effects of amphetamine and reserpine (*2*).

Rats and monkeys that had been deprived of solid food and liquids for 24 hours or more were trained to press a bar for a reward of water (rats) or sugared orange juice (monkeys). Initially, the animals received a drop of the liquid reward every time they pressed the lever (continuous reinforcement), although they were rapidly shifted to a schedule on which the bar-press produced the reward only occasionally (average, once in 60 seconds). When the response rates had stabilized on this variable-interval reinforcement schedule during experimental sessions that lasted several hours or more, a conditioned emotional response of the "fear" or "anxiety" type was superimposed upon the lever-pressing behavior (*3*). Briefly, this conditioned "anxiety" response consisted of suppression of lever pressing, crouching, defecation, and immobility upon presentation of a clicking noise that had previously been paired with a painful electric shock to the feet. In the present study, the clicking noise was presented at 7-minute intervals during the experimental session and continued for 3 minutes before termination with the grid shock (approximately 1.5 ma) to the feet. Programming of the experimental procedure and recording of the animals' behavior were accomplished automatically by timers, magnetic counters, cumulative-work recorders, and associated relay circuits.

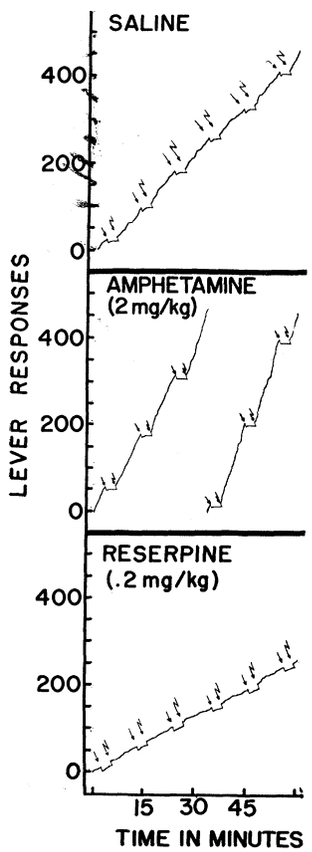

Fig. 1. Sample cumulative-response curves for rat AA-26 showing the effect of amphetamine and reserpine on lever pressing and on the conditioned emotional response. The oblique solid arrows indicate the onset of the conditioned auditory stimulus, and the oblique broken arrows indicate the termination of the conditioned stimulus contiguously with the brief, unconditioned grid-shock stimulus to the feet.

The behavior pattern that develops as a consequence of this procedure is illustrated for one of the rats by the cumulative-response record in the top ("saline"-control) section of Fig. 1. A marked depression in lever-pressing rate is apparent during the 3-minute clicker periods, which are indicated by the short offset sections of the cumulative curve between the straight ("clicker") and broken ("shock") arrows, although the stable lever-pressing rate is maintained throughout the 7-minute intervals between emotional-conditioning trials. After establishment of this pattern, the ratio of the number of lever responses during the clicker periods to the number of lever responses during the nonclicker periods has been found to remain stable (showing no consistent trend) during more than 80 to 100 experimental hours.

The center section of Fig. 1 illustrates the effects of a relatively large dose of amphetamine administered intraperitoneally to the same animal 1 hour prior to this behavior sample. The total number of lever responses during this 1-hour period shows more than a 100-percent increase over the saline-control session, although the rate increase is accounted for completely by increased lever pressing in the 7-minute periods between emotional conditioning trials. The number of lever responses during the 3-minute clicker periods is actually seen to decrease under the influence of the drug.

In contrast, daily intraperitoneal injections of 0.2 mg/kg of reserpine were found, after 4 days, to produce a decrease of more than 50 percent in the total number of lever responses during the 1-hour session for this same animal, although the conditioned suppression of responding during the 3-minute clicker periods was virtually eliminated. The lower section of Fig. 1 shows that, despite the over-all depression in lever pressing, the animal, under the influence of this drug, continued to respond throughout the 3-minute clicker presentations at the same rate as during the 7-minute intervals between conditioning trials, even though the pain shock continued to be paired with termination of the clicker.

The results obtained with this technique have been replicated with several animals (rats and monkeys) (*4*). It is clear, however, that the method described does provide an approach to the selective assessment of specific drug-behavior relationships in the affective sphere while providing a control for the general behavioral and motor disturbances that frequently develop as nonspecific side effects of such drug administration.

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References and Notes

1. W. K. Estes and B. F. Skinner, *J. Exptl. Psychol.* **29**, 390 (1941); J. V. Brady and H. F. Hunt, *J. Psychol.* **40**, 313 (1955).
2. I gratefully acknowledge the technical assistance of Irving Geller and Donald Conrad in the conduct of these experiments.
3. H. F. Hunt and J. V. Brady, *J. Comp. Physiol. Psychol.* **44**, 88 (1951).
4. A discussion of these and other pharmacologic agents is in preparation.

5 January 1956

Cork Virus Leafspots on Triumph Sweetpotato Contain Separated Parenchyma Cells

In the autumn of 1954, leafspotting was observed on specimens of the Porto Rico and Triumph varieties of sweetpotato that were growing beside one another on the same bench in a greenhouse at Beltsville, Md. Close examination of the specimens revealed a distinction between the kinds of spots on the different kinds of specimens.

On the Porto Rico variety there were some leaves with few or many chlorotic spots that were later surrounded for a time by a rather sharp, purple ring. This foliage symptom was transmitted within a month by approach and cleft grafting and is now known to be typical of internal cork virosis on this pigmented variety.

On the Triumph variety, a starchy, nonpigmented type, the spots were chlorotic at first, tending to enlarge and become translucent, and were followed later by necrosis. Microscopic examination of free-hand sections revealed the striking fact that the parenchyma cells were uncemented or free and easily separated from one another (Fig. 1). Pressure on the coverslip made the free cells, with their complement of chloroplastids, move apart and separate. Obviously the something or entity causing the spots

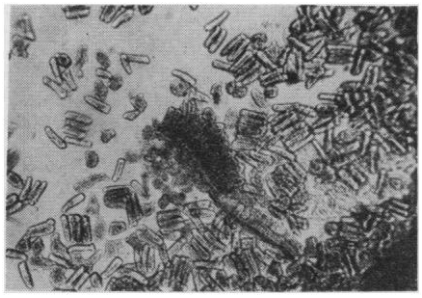

Fig. 1. Parenchyma cells in chlorotic translucent leaf spots on Triumph sweetpotato separated by virus action.

had an enzyme function, and its true nature was proved by the approach-grafting transmission technique to be a virus.

In the autumn of 1955, exactly 1 year later, under similar growing conditions in the same greenhouse, the translucent spots were again prevalent on Triumph leaves. It was then possible, by virtue of the rapid indexing-transmission technique [E. M. Hildebrand, *Science* **123**, 506 (1956)] to index this material on potential indicator plants, and on Scarlett O'Hara morning glory it induced typical symptoms of internal cork virosis within 8 days. Repeated in quadruplicate, this experiment gave identical results each time it was performed—that is, Scarlett O'Hara morning glory showed typical virus-induced symptoms within 8 days. Thus, the translucent spots on the Triumph variety were shown to be symptoms of internal cork disease.

Recent microscopic examination of the translucent leafspots again revealed cell separation that resulted from dissolution of the calcium pectate intercellular substance, presumably by enzyme action. The palisade and spongy parenchyma cells from young spots, when separated from each other, open to view their contents, in which chloroplastids are in great abundance and apparently unaffected. This study makes possible micrurgical studies on the physiology and pathology of these living cells of Triumph sweetpotato leaves.

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9 December 1955

Marine Fishes in Fresh Water

At the risk of pursuing a subject too far, I again wish to correct some errors on the subject of marine fishes in fresh water. I have just read the interesting letter from M. Boeseman, of the Leiden Natural History Museum, on "Fresh-water Sawfishes and sharks in Netherlands New Guinea" [*Science* **123**, 222 (10 Feb. 1956)].

After speaking of *Pristis microdon* and its occurrence in both fresh and salt water, he goes on to say "For some species, there are strong indications of breeding in fresh water, a well-known habit of the specimens in Lake Nicaragua." What does he mean by "specimens," sawfish or sharks? The reference is probably to sharks. But no one has ever presented any proof that sharks breed in Lake Nicaragua. Contrary to the oft-published statement, Lake Nicaragua is not landlocked, since it is connected with the sea by its outlet, the San Juan river.

Bigelow and Schroeder, in their monumental work on the sharks of the western Atlantic, mention rapids in the upper San Juan and seem to believe that these prevent sharks from passing up or down the river. From extended observation of fish migrations in tropical rivers with rapids, I have no doubt that in the rainy season sharks are able to make the trip in either direction. Bigelow and Schroeder merely infer that the Lake Nicaragua shark is landlocked and breeds in the lake, but they do not present any proof and do not directly claim that such is the case.

Further on Boeseman is inclined to adopt the theory of gradual upheaval and gradual replacement of salt water by fresh water to explain the presence of essentially marine fishes in rivers and lakes. As an example he cites "jacks (Carangidae)—which do not usually invade fresh water by free will."

This was an unfortunate selection, for certain species of jacks freely enter fresh-water rivers and lakes when they are available. *Caranx sexfasciatus,* which occurs from China and Japan to Australia, and from South Africa to the Hawaiian and Society Islands, enters fresh water in large numbers, usually remaining until they are a year or year and a half old. *Caranx ignobilis,* another jack of equally wide range, also enters fresh water but stays until it is between 2 and 3 years old. These two species are in such abundance in certain lakes that important fisheries at the outlets depend largely on them.

I have records of six species of jacks being taken in Philippine lakes and rivers. In some of these lakes a snapper (*Lutianus argentimaculatus*) is common and is the basis of an important local fishery. In Tahiti and in Luzon I have taken snake eels in mountain streams. When these species and such coral-reef dwellers as species of parrot-fish (Scaridae) are taken in rivers, and stinging scorpion fish (Scorpaenidae) are taken in hill stream rapids 40 km from the sea, one may well revise his ideas about the adaptability of marine fish to life in fresh water. One is hardly safe in excluding any group of littoral fishes. In the Solomon Islands schools of *Abudefduf metallicus,* family Pomacentridae, typical of coral reefs, lived in a deep pool between rapids in a river on Malaita Island.

In the Indo-Pacific tropics at least, a great variety of marine littoral fishes may occur in fresh water. Deep-sea fishes, as well as those of the open sea, may safely be excluded from life in fresh water, but one cannot say offhand that any shore fish is incapable of voluntarily entering and living in fresh water.

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21 February 1956

I gratefully accept the opportunity to reply to a few criticisms that occur in A. W. C. T. Herre's discussion of my previous article on "Fresh-water sawfishes and sharks in Netherlands New Guinea" [*Science* **123**, 222 (10 Feb. 1956)]. In general, I want to state that the indicated errors are mere misinterpretations.

Referring to my paragraph on *Pristis microdon* and the Lake Nicaragua species, Herre assumes that the word *specimens* refers to sharks. Since the whole first part of this paragraph deals with sawfishes, sharks not even having been mentioned in this or the previous two paragraphs, the word *specimens* evidently concerns sawfishes only. Accordingly there is no reason to discuss Herre's statements on sharks in Lake Nicaragua.

Concerning the sawfishes in Lake Nicaragua, Bigelow and Schroeder [*Fishes of the Western North Atlantic* **2**, 39, 40 (1953)] write as follows: "While it may not be strictly landlocked there, in a topographic sense, any more than it is up the Amazon, the fact that Sawfishes breed in the Lake and are rather sluggish in habit makes it likely that most of the local inhabitants are permanent residents." As evidence they give a footnote: "Females taken there dropped their young at the time of capture (Marden, Nat. Geogr. Mag. **96**, 1944: 184)." Although it remains possible that copulation takes place in the sea, the quoted statements seem fairly conclusive.

I completely agree with Herre that sharks are able to pass rapids during the rainy season, but this does not interfere at all with my cautiously formulated statement on the migratory possibilities of sawfishes. Moreover, sawfishes are much more sluggish than sharks and probably experience more difficulties when they try to overcome obstacles.

Herre further infers that I am inclined to adopt the theory of gradual upheaval and gradual replacement of salt water by fresh water to explain the presence of