People who produce or use scientific literature should find a concise citation system useful, but anyone who is interested will need to balance the advantages against possible disadvantages for his particular purpose. In many cases it will be desirable to supplement the "minimum" citations, for example, by adding the authors' names.

G. E. McCasland

University of Toronto

22 September 1954.

Randomized Targets in Parapsychology

The report by Kendon Smith and Harry J. Canon on "A methodological refinement in the study of ESP, and negative findings" (*1*) is of interest in two respects. First, it reopens some questions about the use of random numbers in experimental work; and second, it challenges a series of experimental studies which for the most part have gone unchallenged. The central point at issue is whether properly safeguarded tests of extrasensory perception, in which stimulus materials are made by tables of "random numbers," are valid.

The authors state that some findings "raise the suspicion that tables of random numbers may not be entirely random; that such tables may, in some small degree, actually embody conventional preferred sequences of digits." So far as I know, absolute randomness has never been claimed, and it is theoretically difficult, in view of sampling theory, to see what the concept could mean. What is meant by preparing random numbers is that one takes pains that each digit be followed by each of the 10 digits in haphazard order. When, as is usually the case, hundreds of such digits are employed in making up "targets" for subjects to guess at, it is hard to see how such material, kept out of all known sources of knowledge of experimental subjects, could significantly coincide with the orders in which subjects make their guesses, except by a process that, by definition, is extrasensory. It is true and important that from time to time a subject may by chance alone call a few items that are related to the actual "target" order; and it is true that in *control* series, brief periods of such parallelism of subjects' calls with targets at which the subjects are *not* aiming is occasionally observed. This is what would be expected from the theory of probability. When one is dealing, as in the case of the Schmeidler experiments (*2*), with hundreds of thousands of experimental calls, it is hard to see what could be meant by saying that failure of randomness in the targets could be responsible for the positive findings consistently obtained in guessing experiments.

In the experimental work reported by Smith and Canon, there were two kinds of targets—a pair of squares in which the left-hand one was blackened, and a pair of squares in which the right-hand one was blackened. The only task for the subject was to guess in each case whether it was the left or the right square that was blackened. This seems to have been an unfortunate choice of target material, since earlier work suggests that the right-left dimension of choice often means little in the type of visual or kinesthetic imagination involved. At least with pictorial material, reversal from right to left, as in a mirror, has been reported (*3*). This is not to suggest that it occurred here; only that no conclusion can safely be drawn from this type of target. The task involved, moreover, in making a choice of one out of two appears from some experimental work (*4*) to be sometimes too insensitive to mobilize the interests and energies of subjects in such experiments; the choice of one out of five seems, as in the work of Soal and Rhine, to be a more sensitive and suitable procedure.

It is of interest to know that there was no significant difference in the scoring levels of those who believed in and those who disbelieved in the reality of paranormal phenomena. Unfortunately, the method chosen by the experimenters is one that makes it difficult to compare the present findings with those of the extensive earlier work reported on this problem.

Gardner Murphy

Menninger Foundation, Topeka, Kansas

References

1. K. Smith and H. J. Canon, *Science*, **120**, 148 (1954).
2. G. R. Schmeidler and G. Murphy, *J. Exptl. Psychol.* **36**, 271 (1946).
3. R. Warcollier, *Experimental Telepathy* (Harper, New York, 1938).
4. S. G. Soal and F. Bateman, *Modern Experiments in Telepathy* (Yale Univ. Press, 1954), especially pp. 300–302.

13 October 1954.

Slide Technique for Bacteriophage Typing of *Staphylococcus aureus*

The phage typing of *Staphylococcus aureus* has become a useful tool in epidemiology, particularly in tracing outbreaks of food poisoning. An agar-petri plate method for typing was devised by R. E. Williams and J. E. Rippon [*J. Hyg.* **50**, 320 (1952)]. An agar-slide method that is simpler and less expensive has been developed in this laboratory.

Twelve 14-mm paraffin rings are simultaneously placed on a serologic slide (2 by 3 in.) by means of an electric ring-making apparatus. (The slides are placed in wooden racks designed for the purpose. These racks may be stacked for convenience.) Nutrient agar (0.5 to 0.7 percent) that has been filtered is pipetted by an automatic serologic pipetting machine (cleaned but not sterilized) in approximately 0.2- to 0.25-ml quantities into each paraffin ring. The agar hardens immediately. One drop of a 24-hr nutrient broth culture of *Staphylococcus* from a 0.2-ml serologic pipette (approximately 0.03 ml) is placed on each agar convexity. The culture dries in 15 to 20 min. Then a similar drop of each phage to be tested is placed on each of the culture-on-agar preparations. After drying 15 to 20 min, each slide is placed in a sterile covered petri dish and incubated overnight at

30°C. The phage action is observed the following morning. The phage reactions on the agar slide are similar to those noted on the agar plate, varying degrees of activity being observed.

This method was used in comparison with that of Williams and Rippon for some 500 cultures. Since then an additional 500 cultures have been run with the slide method alone. The agar-slide method appears to have these advantages over the agar-plate method.

1) It is a less exacting technique. The plate method requires the use of very fine capillary pipettes, which are difficult to make and handle without breaking. Great care must be exercised in placing extremely small drops, approximately 0.01 ml, on the agar plate to avoid transferring culture from one plate to another and to avoid spreading of the drop over a larger area of the agar than is designated for it by markings on the bottom of the plate.

2) It takes less time to carry out the test with slides. Agar placed on a slide dries almost immediately, whereas when agar plates are poured they must first harden and then be dried for 60 to 90 min.

3) It uses only a fraction of the volume of culture medium required by the plate method.

SYDNEY GOLDBERG

Bureau of Laboratories,
Department of Health, New York, N. Y.

19 August 1954.

Original Adaptive Significance of the Tetrapod Limb

The origin of the tetrapod limb marked one of the major advances in the evolution of the vertebrates. The ancestral crossopterygian fishes had probably supplemented gill respiration with air breathing for a long time, but the reorganization of the paired fins into supporting legs and feet brought a major shift in genetic and functional emphasis, and opened the way for the extremely rich and complex evolution of the land vertebrates. The geologic record of tetrapod origin is still imperfectly known, and there has been much speculation concerning possible events in this transition. The tetrapod limb is usually interpreted as an adaptive modification that was directly useful for land locomotion in the relatively dry Upper Devonian, perhaps enabling the first amphibians to escape overland from receding swamps and pools to areas that might retain more water (*1*). Possible stages in evolution, from ancestral swimming fin through hypothetical intermediates to the walking leg, have been figured by several authors (*2–4*). This note considers an alternate selective advantage that this modification may have given to its first possessors: that, originally, the tetrapod limb may have served chiefly as a more efficient digging adaptation that facilitated estivation in the dry season.

Recent amphibians seek moisture and avoid dryness. Typically, they disperse from increasingly adverse, but still damp, sites only if the surrounding areas are sufficiently moist to attract, rather than repel, invasion. If the adjacent region is dry, they huddle into the damp debris and mud that remain from the evaporating pond. In semiarid climates the predominant amphibians are burrowing forms that can go underground to avoid desiccation. Newly transformed young amphibians normally linger in the vicinity of the pond margins until there is sufficient rain to permit dispersal, and the young of burrowing species commonly "dig in" soon after metamorphosis.

The extant groups of amphibians are, of course, greatly different from the original stock. The earliest known amphibians in the Upper Devonian were considerably larger than most of the modern forms, and in the adult stage they probably bore scales and were more effectively protected against desiccation. But their delicate young stages would certainly be vulnerable to environmental hazards, and a breeding population could not be maintained in an area for a geologically significant length of time unless the successive year-classes in the colony had reasonably continuous access to sufficient moisture to meet their basic needs.

The behavior of many extant vertebrates indicates that both land surface locomotion and burrowing can be carried on successfully without the tetrapod leg and foot. Certain fishes can make temporary or even regular land excursions. For example, the mudskippers (*Periophthalmus* sp.) and the climbing perch (*Anabas* sp.) are well known for their ability to move about on damp land surfaces (*5*). Many kinds of fishes (certain eels, flatfishes, and so forth) habitually secrete themselves in the loose sandy or muddy bottom of their aquatic habitat. Some of the major groups of burrowing land vertebrates are legless (caecilians, snakes, and certain families of lizards); but these legless tetrapods are derived groups, and subterranean habits are their normal way of life rather than a seasonal or occasional adjustment in behavior.

Inferences concerning the possible behavior and ecology of ancient fishes on the basis of habits of highly differentiated modern forms that are only remotely related to them must be made with caution. In some cases, however, there is geologic evidence to support such inferences. For example, it is well known that the extant species of lungfishes of South America and Africa are able to withstand seasonal drouth by burrowing into the mud and estivating, and recently Romer and Olson (*6*) reported the remarkable discovery of Permian lungfishes found in upright cylindrical burrows under conditions that indicate that the individuals had been fossilized in estivating sites. It is apparent that seasonal escape underground from a drying swamp is a very ancient behavior pattern in certain evolutionary lines of dipnoans. The possibility that some of the early crossopterygians were also capable of effective burrowing can only be speculated, on present knowledge. But the skeletal structure of the paired fins of the few crossopterygians in which it is well known, for example, *Eusthenopteron* (*2*), compared with the general trends of foot specialization in tetrapods, suggests that the foot (the part of the limb that has always been the most difficult to account