the stimulus characteristics of dichotically presented sounds should then enable us to form some conclusions regarding the factors involved in this differential processing.

Backwards-speech sounds were presented dichotically with the aim of discovering whether such highly unfamiliar, meaningless sounds would be processed in the same way as other speech sounds; that is, whether there would be more accurate perception of those sounds arriving at the right ear. The backwards speech was obtained by recording trisyllabic nonsense words on a half-track, dual-channel tape recorder, and then inverting the tape and playing it back in the normal direction. The result is something quite unusual and unfamiliar, somewhat resembling a Slavic language.

The subjects were 14 female and 10 male undergraduates in psychology; all were right-handed and had no known hearing defects.

On each trial the subject was first presented with two different backwards-speech sounds simultaneously: one to the left ear and one to the right. After a 4-second interval, four more backwards-speech sounds were played one at a time, two of them being identical with those played dichotically. The subject's task was to identify which two of the four he had heard presented dichotically. Each of the four positions of the sequence was used equally often for each ear. There were 12 trials, yielding a maximum possible score of 12 for each ear. For half the subjects the earphones were reversed from normal so that any asymmetry in the tape or apparatus was counterbalanced over ears.

This multiple-choice recognition procedure is identical with that used for melodic patterns, for which it yields a left-ear superiority (*2*), and for trisyllabic nonsense speech for which it yields a right-ear superiority (*4*). The backwards-speech sounds were never referred to as speech, but as "nonsense sounds."

The mean score for the left ear was 4.6 or 38-percent correct (S.D., 2.1); for the right ear, 7.6 or 63-percent correct (S.D., 2.8). The difference between ears is significant beyond the .001 level (*t*, 4.05; correlated means). Eighteen subjects showed right-ear superiority, four showed left-ear superiority, and two showed no difference between ears. Table 1 compares these data with data from the earlier study (*4*) employing normal nonsense speech.

Table 1. Comparison of left and right ears for trisyllabic nonsense speech under two conditions—forwards and backwards.

Left	Right	*P*
	Forwards	
5.6 (47%)	8.1 (68%)	$<.01$
	Backwards	
4.6 (38%)	7.6 (63%)	$<.001$

The right-ear superiority for backwards-speech sounds indicates that they are processed by neuropsychological systems overlapping those for normal speech sounds, rather than by systems for non-speech sounds; it provides strong support for the suggestion that the critical distinguishing characteristics of speech sounds are not related to meaningfulness, familiarity, or conceptual content (*4*). In a consideration of the acoustic characteristics to which the speech-processing system may selectively respond, Liberman *et al.* (*7*) have proposed that the auditory signals are perceived via the same motor-command signals as those responsible for producing speech. This suggestion implies that only sounds that can be articulated should be processed by the speech system. Our intention in making backwards-speech stimuli was to have inarticulable sounds, but in this we were only partly successful. Although these stimuli are extremely difficult to reproduce, the subjective impression when one tries to hold them in storage for the few seconds until they are identified is that one is treating them as though they were sounds that one could produce. Several spontaneous reports of this kind came from the subjects also. Thus we may not have ruled out the participation of some kind of articulatory mechanism during the "holding" period.

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Frog Germ Cells

In describing an experimental refutation of the hypothesis that amphibian germ cells might be carried to the gonads in the circulatory system, Volpe and Curtis (*1*) appear to be unaware both of the improbability of their hypothesis and of apparently contradictory results.

The movements of primordial germ cells have been traced in a variety of Anura (*2*). After a probably passive displacement during gastrulation, the germ cells are detected in successively more dorsal regions of the trunk endoderm and remain in the mesentery as the dorsal crest of the endoderm is withdrawn. This is presumably an active migration, occurring mainly within the endoderm and before the onset of the blood circulation. Little further migration would be required for the germ cells to reach the adjacent genital ridges.

Despite this, the technique of parabiosis can result in one gonad containing germ cells from both "siamese twins." Using genotypes marked by the presence or absence of nucleoli in *Xenopus*, I obtained such chimeras in seven of the eight twins analyzed (*3*). Minor differences in technique may account for the discrepancy of our results. My twins were attached at an earlier stage and over a more extensive area of the flank: they formed a common region of the midgut, which might serve as a route for germ cell migration. Thus, the converse of Volpe and Curtis' results should not be held to validate their hypothesis, without further experimental refinement.

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3 May 1968

The objective of our study (*1*), as clearly stated in our introductory remarks, was to explore "the possibility that the germ cells [of frog embryos] can or do enter, or even occasionally wander, into the blood channels." We are aware of the wealth of descriptive material in the literature on anuran development that would render such an

event highly suspect but, in light of the recent unexpected findings that there are blood-borne primordial germ cells in certain mammals (*2*), we became intrigued that such a happenstance might occur in frogs, notwithstanding the seemingly restricted opportunities for the germ cells to enter the bloodstream. It was a source of keen satisfaction for us to realize a method of testing the idea, although we lay no claim to having provided a definitive answer. Although the hypothesis may seem improbable to Wallace, we would remind him that many advances in science have issued from investigators' pursuing far-flung or unorthodox ideas. The results of Wallace's study (*3*) can not be fully appraised without additional experimentation, but it is our earnest hope that his work and ours will arouse interest and stimulate further inquiry.

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13 June 1968

DDT Residues and Bermuda Petrels

Wurster and Wingate (*1*) state that Stickel (*2*) found DDT residues of 10.6 ppm in bald eagle eggs, that others have reported DDT residues of 120 to 227 ppm in herring gull eggs, and that both species are declining. From this they reason that the suggestion is "that susceptibility varies widely between species," and they conclude that residues of 6.44 ppm in the petrel eggs may account for the fluctuating decline in the reproductive success of the small, protected, and increasing population of the once-considered-extinct Bermuda petrel.

With regard to Stickel's information (*2*), he states that the residues in the eagle eggs "provide little basis for suspecting that DDT in the eggs prevented hatching." Stickel further notes that, while an "occasional" eagle may obtain enough pesticide to place it "in hazard," "most eagles that die in the United States today die of causes other than pesticide poisoning."

Herring gulls and ring-billed gulls have undergone a population explosion to such an extent that the U.S. Fish and Wildlife Service (*3*) has considered measures to reduce their numbers. Dr. W. H. Drury (*4*), director of research, Massachusetts Audubon Society, has urged the immediate burying of garbage at dumps to stop the population explosion of the gulls.

Even if the fluctuations in the ability to hatch of the eggs of the few pairs of Bermuda petrels observed by Wurster and Wingate are not within normal limits for that little-known species, Stickel's comments and gull populations provide little basis for suggesting that DDT residues of 6.4 ppm, which is less than the amount permitted in foods, are of significance.

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18 April 1968

We did not say that herring gulls were declining, but that they had "very low reproductive success" on Lake Michigan. The two factors must be kept separate. Gull populations are exploding because increased pollution with human wastes expands their niche, a factor that more than offsets the effects of insecticides. An explosion in scavenging, garbage-eating gulls, accompanied by declines in predatory birds, is a good example of ecosystem degradation whereby a diverse avifauna is being replaced by large numbers of fewer species.

Stickel's paper was written before the importance of hepatic enzyme induction by chlorinated hydrocarbon insecticides was appreciated. These enzymes are relatively nonspecific and cause hydroxylation of steroids, including estrogen (*1*). Estrogen mediates calcium metabolism in birds, and hormonal balance affects reproductive success and population size (*2*). The sudden appearance of calcium-deficient eggshells (*3*), associated with declining reproduction and population size among carnivorous birds on two continents, can be explained by the coincidental introduction of DDT into the world environment during the late 1940's (*4*).

It was recently reported that DDT has estrogenic activity in rats, and it may suppress gonadotropic hormone secretion (*5*)—a distressing thought now that much of the world's biota are contaminated with DDT residues.

Hepatic enzyme induction occurred in rats fed as little as 1 ppm of DDT in the diet, and was associated with the storage of 10 ppm of DDE or DDT in fat (*6*). Since humans average 12 ppm in their fat (*7*), present tolerances in foods may be obsolete. We wish that environmental scientists could share McLean's complacence that current residues in petrels, people, and other organisms are without significance.

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