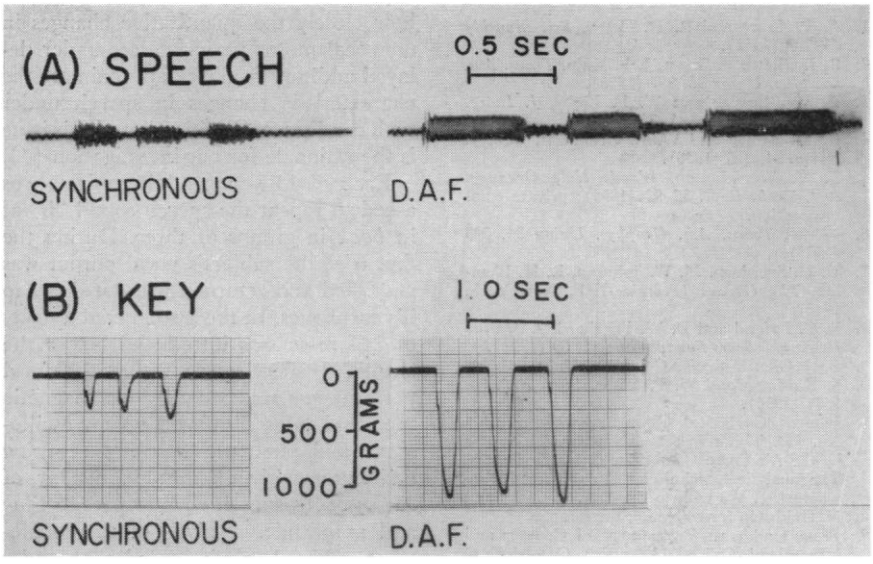

Fig. 1. (A) Oscillograms of a group of three articulations of the speech sound "b." The height of each sound display is proportional to vocal intensity. Under delayed auditory feedback, increases occur in vocal intensity, in phonation time, and in the time between sounds. Errors in number are not shown. (B) Display of amplitude and time characteristics of a group of three taps on a key. The downward displacement from the base line is proportional to the pressure exerted on the key by the subject. Under delayed auditory feedback, increases occur in pressure, in the time the key is held down, and in the time between taps. Errors in number are not shown.

the observed changes in motor performance than the fact that auditory feedback per se was interfered with. The fact that such marked changes followed a delay in auditory feedback indicates that there are critical time periods within which the sensory feedback accompaniments of a motor operation must be received to insure optimal motor control. Exceeding such critical time periods for auditory feedback is probably more disorganizing with respect to the motor operations studied than removal of auditory feedback altogether. More generally, it is possible that similar temporal alterations in sensory feedback may have similar effects on widely divergent motor functions. The parallel nature of the changes in speech and key tapping following the same delay in auditory feedback is consonant with this idea.

Performance under delayed auditory feedback probably also reflects mechanisms operating to restore control of a disordered motor function. Types of sensory feedback other than auditory—for example, tactile and proprioceptive—function in both speech and key tapping. It is possible that the increased amplitude characteristics of speech and key tapping under delayed auditory feedback operate to increase the amount of sensory feedback returning along undisturbed channels. The similarity of the changes in speech and key tapping with delayed auditory feedback may indicate that similar mechanisms operate to restore control in widely divergent motor systems.

The fact that key-tapping behavior can be so radically altered by delaying the auditory feedback of clicks raises the question of the usefulness of this technique in clinical audiometry. Presumably, the patient with psychogenic deafness, or the malingerer, would show the described changes in key tapping if he heard the delayed clicks. We are also exploring this application of our findings.

RICHARD ALLEN CHASE
SETH HARVEY
SUSAN STANDFAST
ISABELLE RAPIN
SAMUEL SUTTON
Departments of Otolaryngology and *Psychiatry, Columbia University,* and *New York State Department of Mental Hygiene, New York*

References and Notes

1. Delayed auditory feedback is obtained through some simple modifications of standard tape recorders. See G. Fairbanks and R. Jaeger, *J. Speech and Hearing Disorders* 16, 162 (1951).
2. G. Fairbanks, *ibid.* 20, 333 (1955).
3. H. Kalmus, P. Denes, D. B. Fry, *Nature* 175, 1078 (1955).
4. This work was supported by a U.S. Public Health Service grant (B-1686) from the National Institute of Neurological Diseases and Blindness.
5. A lack of linearity in the relationship between the pressure of a tap and the intensity of sound produced makes the parallel with the speech experiment incomplete. In the speech experiment the intensity of the auditory feedback is directly proportional to the intensity of speech.
6. It should be noted that under delayed auditory feedback an occasional subject measurably *decreased* the time he held down the key and measurably *decreased* the time between taps. Similar observations were made for speech.

28 October 1958

Great Basin Petroglyphs and Prehistoric Game Trails

Abstract. Aboriginal petroglyphs ("rock-writing") in western and central Nevada have, up to now, remained a puzzle to archeologists as regards their function and location. Recent field investigation strongly suggests that these are connected with hunting magic, presumably aimed at success in the chase, and that they are located along routes of deer migration.

In the summer of 1958, assisted by Albert B. Elsasser and Eugene R. Prince, we carried out archeological reconnaissance in northern and central Nevada (*1*). Among the types of sites studied were those at which the primary evidence of activity of man takes the form of geometric and naturalistic designs pecked into boulder and cliff surfaces. These designs, called petroglyphs (*2*), occur in greatest quantity in North America west of the Rockies. (*3*).

Despite the numerous sites known, and studies made of western North American petroglyphs (*4, 5*), there is no evidence thus far presented which satisfactorily accounts for the occurrence of petroglyphs at certain locations. Cain's conclusion (*4*, p. 54) that "all such aboriginal carvings . . . were simply a medium for expressing some emotion over a spiritual or concrete event" is typical in its vagueness and points up the failure of students of the subject thus far to arrive at specific functional conclusions.

Our recent field observations show that in western and central Nevada nearly all petroglyphs occur along deer migration trails, at spots where the animals could be shot with bow and arrow. The petroglyph designs are therefore to be understood as evidence of the practice of compulsive magic by hunters, aimed at insuring success in the chase (*6*). From several deer hunters and state and federal wildlife service field men who have studied local deer migrations, we learned in detail of a number of routes which deer follow. In the late fall, when snow starts to fall, the deer follow these routes out of the high mountains into lower country, where they winter. The deer return by these routes to higher elevations as the snow melts.

At certain points, especially at the mouths or along the courses of washes or canyons through which the deer travel, are locations which are ideal for hunting from ambush. Thus, where a wash has cut through a rock reef and the canyon narrows to form a chute or gate, or where a canyon is narrow with a boulder-strewn bench perched above the defile, or in a saddle or pass, the moving animals (particularly if driven from the rear) could be forced to run past concealed archers. Preferred hunters' positions appear to have been at those spots where the ani-

mals could be shot from above at very close range. It is at such locations that one finds petroglyphs in western and central Nevada, and a long migration trail which crosses a series of valley floors and low mountain ranges has such hunting sites (and petroglyphs) scattered along it at appropriate points.

Where deer, in moving downward to snow-free elevations, remained in the same mountain range, such sites are either correlated with some other circumstance or are absent entirely. Thus, in arid valleys petroglyphs may be found in the close vicinity of a water tank or spring. Here the purpose was apparently to aid in the taking of such animals (perhaps antelope) as came to the spot to drink.

Where deer herds are abundant, as in westernmost Nevada where the animals move east to lower country from the high eastern ranges of the Sierra Nevada mountains, petroglyph sites are most abundant; this quantitative factor may be construed as an indication of the amount of game, the density of human population, and the intensity of hunting. Other petroglyph sites occur along such major streams as the Walker, Carson, and Truckee rivers, which rise east of the crest of the Sierra Nevadas and flow out to empty into the saline lakes of the western Great Basin. The narrow flood plains of these streams served as migration trails, and petroglyphs are found at certain points where the deer had no alternative but to pass through a bottleneck. Often at such sites blinds made by piling up a circle of rocks to a height of 2 or 3 feet are found.

The authorship of petroglyphs is a difficult matter to settle. Our evidence shows that petroglyphs were made over a long period of time, since at most sites designs show not only stylistic variety but also great variation in weathering or accumulation of desert varnish, some elements appearing very fresh and others being nearly indistinguishable from the deep chocolate-hued, patinated surface of the basaltic rock. Evidence from archeology and linguistics agrees in showing that the Northern Paiute of western Nevada are relatively recent occupants of the area. The Northern Paiute, and, in fact, all of the recent tribes of the Great Basin, deny that they or their ancestors made petroglyphs. We have, accordingly, some basis for believing that petroglyphs can be attributed to the groups which occupied the area before the Northern Paiute appeared on the scene some time within the last thousand years, though at the same time cultural loss in late prehistoric times among the recent Shoshonean tribes cannot be ruled out.

As to whether the hunter himself or the shaman (medicine man) made the petroglyphs, we incline to the probability that the designs were inscribed by the shaman. Petroglyphs as hunting magic are unknown to the recent Basin tribes, but shamanistic rituals connected with the deer, antelope, or mountain sheep hunt is a widespread Basin practice. If individual hunters made petroglyphs, we should expect to find them randomly distributed and occurring at spots where a hunter was trying to cause game to appear, but this situation clearly does not square with the observed occurrence of petroglyphs. On the whole it appears probable that the ambush hunt for deer or antelope during the seasonal migrations of these animals was in earlier times in the western Great Basin a special type of hunt carried out at traditional spots by a group which was aided by the local shaman.

The fact of great numerical concentration of petroglyph symbols at particular sites, taken together with the clear indication that these designs represent an accumulation, presumably by annual increments, suggests that these hunting spots were traditional. In terms of the aboriginal way of life in the Great Basin, these evidences appear to point to a form of territorial ownership and use like that described by Omer Stewart for the Northern Paiute where groups returned year after year to the same spot to hunt or gather some variety of food. It may be proposed, further, that once a hunting site at which petroglyphs were made came into use, continued success at the spot where petroglyphs were a visible and permanent feature would tend to invest the site with magical power and efficacy which would further enhance its attractiveness as a place for successful hunting. Sites with few petroglyph designs may, therefore, be spots where the hunt was rarely successful, and sites with an abundance of designs may mark important and repeatedly used spots. Our impression is that the Indians took care not to overhunt the deer, as evidenced by the distance separating ambush sites. Overhunting along the trail might cause the animals to seek new routes and perhaps thus become available to another hunting group.

Occupational debris does not occur at most petroglyph sites, partly for the obvious reason that such spots were unfavorable for settlement. Where petroglyphs are found in immediate association with living refuse the latter appears either to postdate the petroglyphs or to be a winter village site which would have been occupied only during the period between the fall deer migration to lower elevations and the return migration in the spring to high country.

Many details of this whole matter remain to be worked out. Among these are the determination of how widespread in western North America was the practice of petroglyphic hunting magic connected with the taking of migratory deer; whether there are known major deer trails which do not have petroglyph sites along their courses; whether there are extended lines of sites which presumably mark former migration trails but which are not recorded as used in the historic period by game; what types of migratory animals were hunted in this manner (*7*); and the dating of petroglyph sites (*8*).

For determining the route of migratory game animals in prehistoric times it is also possible that ancient trails could be identified from air photographs, as was suggested by Crawford (*9*). This method could, however, be applied only in areas where plant cover was more abundant and varied than it is in the arid Great Basin region.

ROBERT F. HEIZER
Department of Anthropology, University of California, Berkeley
MARTIN A. BAUMHOFF
University of California, Davis

References and Notes

1. Support for the research reported here was provided by the National Science Foundation (G3916). The cooperation of the Nevada State Museum, through its director, J. W. Calhoun, is gratefully acknowledged.
2. *Pictograph*, in current usage, refers to similar designs painted on rock surfaces.
3. R. M. Tatum, *Am. Antiquity* 12, No. 2 (1946).
4. H. T. Cain, *Petroglyphs of Central Washington* (Univ. of Washington Press, Seattle, 1950).
5. L. S. Cressman, *Univ. Oregon Publs. in Anthropol. No. 2* (1937); R. P. Irwin, *State Hist. Soc. Idaho, Biennial Rept.* 12 (1929–30); J. H. Steward, *Univ. Calif. Publs. Am. Archaeol. and Ethnol.* 24, No. 2 (1929).
6. We cannot, at this point, even guess whether (among others) the hope of the petroglyph author was to increase his chances for a successful arrow aim, or to compel the deer to make their appearance.
7. B. M. Hazeltine, manager of the Sheldon Antelope Refuge in northeastern Nevada, has supplied detailed information on antelope migrations. The trails in this area correlate in every particular with the occurrence of petroglyphs as given in this paper for deer. At the extensive site near Grimes, southeast of Fallon, Nev., probability favors antelope as the animal hunted rather than deer.
8. A paper describing the evidence now in hand on these subjects is in preparation. We have data on petroglyphs from about 150 sites in Nevada.
9. O. G. S. Crawford, *Archaeology in the Field* (Praeger, New York, 1953), pp. 60–62, 214, plate 5a–b.

22 December 1958