(a saccadic suppression) usually of about 0.5 log unit with a maximum of 1.5 to 2.0 log units (*7*). At light intensity levels well above threshold, there is apparently no suppression for stationary objects (*8*).

A second type of neuron gives an excitatory response to a stationary stimulus but fails to respond during an eye movement. These cells can provide information about the stimulus when the eyes are stationary but not when the eyes are moving. Over a quarter of the cells studied were of this type. Because of these cells, the total number of cortical cells responding to a stimulus is smaller when the eyes are moving than when the eyes are stationary and this is consistent with the rise in threshold for a stimulus during an eye movement. The mechanism responsible for the failure of these cells to respond during rapid eye movements might be either that they are insensitive to rapid stimulus movements or that there is some active blanking process associated with eye movement which prevents a response. Resolution of this problem would require a comparison of rapid stimulus movements in front of a stationary eye with rapid eye movements across a stationary stimulus.

The discharge rate of a third type of neuron is suppressed during a rapid eye movement. This is true even though the most effective stimulus when stationary on the receptive field center produces an excitatory response. The suppression response requires visual input and is not produced by the eye movement alone (or a "corollary discharge" of the eye movement) since there is no suppression with eye movements made in total darkness. This type of cell therefore does provide information about the stimulus when the eyes are moving, but information different from that provided when the eyes are stationary. This suppression might be a specific indicator within the visual system that an eye movement has occurred. Such information on eye movement might in turn be used at some later stage in the nervous system to produce the perceptual blanking during rapid eye movement.

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References and Notes

1. G. Westheimer, *Arch. Ophthalmol.* **52**, 932 (1954); A. F. Fuchs, *J. Physiol. (London)* **191**, 609 (1967).
2. E. Bizzi, *J. Neurophysiol.* **29**, 861, 1087 (1966).
3. E. V. Evarts, *Electroencephalogr. Clin. Neurophysiol.* **24**, 83 (1968); ———, *Meth. Med. Res.* **11**, 241 (1966); M. L. Wolbarsht, E. F. MacNichol, Jr., H. G. Wagner, *Science* **132**, 1309 (1960).
4. E. V. Evarts, *J. Neurophysiol.* **31**, 14 (1968).
5. The eyes during fixation are referred to as being "stationary" even though the small eye movements of physiological nystagmus are always present in the awake animal.
6. D. H. Hubel and T. N. Wiesel, *J. Physiol. (London)* **148**, 574 (1959); R. H. Wurtz, *Physiologist* **10**, 352 (1967).
7. F. C. Volkman, *J. Opt. Soc. Amer.* **52**, 571 (1962); B. L. Zuber, L. Stark, M. Lorber, *Exp. Neurol.* **14**, 351 (1966); B. L. Zuber and L. Stark, *ibid.* **16**, 65 (1966); G. W. Beeler, Jr., *Vision Res.* **7**, 769 (1967). No suppression was found by J. Krauskopf, V. Graf, K. Gaarder [*Amer. J. Psychol.* **79**, 73 (1966)].
8. W. R. Uttal and P. Smith, *Percept. Psychophys.* **3**, 257 (1968). Suppression of a moving stimulus during an eye movement has been reported by R. W. Ditchburn [*Opt. Acta* **1**, 171 (1955)] and E. G. Gross, H. G. Vaughan, Jr., E. Valenstein [*Electroencephalogr. Clin. Neurophysiol.* **22**, 204 (1967)].

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Neolithic Economic Autonomy and Social Distance

Abstract. *The following hypothesis was tested in the prehistoric Mogollon culture area of the American Southwest: increasing dependence on agriculture leads to increasing social distance between the minimal economic units needed to make agriculture a successful economic base. Both variables covaried positively. As dependence on agriculture increased, villages became more endogamous.*

Archeology provides a unique laboratory for measuring the interaction of social variables through time. The hypothesis that increasing dependence on agriculture increases the social distance between minimal economic units (measuring social distance in terms of endogamy and exogamy) was tested in the Mogollon culture area of the American Southwest.

To determine the changing degree of social distance between villages (that is, fission) from A.D. 400 to 800, plain, undecorated potsherds were collected from the surfaces of six sites in the Hay Hollow Valley east of Snowflake, Arizona. Surface collections were also taken from five villages in the same location that dated from A.D. 1000 to 1300. All the pottery was dated by reference to dendrochronologically controlled ceramics. This use of tree-ring-dated pottery types allowed control over both the length of occupation of the sites used, and of the intervals used to measure culture change.

The plain-ware pottery types used from the period A.D. 400 to 800 are called Forestdale Smudged, Forestdale Red, and Forestdale Plain. These wares contain a measurable degree of color variation defined by the Munsell soil color charts. All the sherds from each of six sites were classed on the basis of the Munsell color categories and counted. Only those sites where the proportions of the types were constant were used. Variation due to function was not allowed to affect the results of the experiment. Variation in a single vessel due to differential firing was submerged in the Munsell categories and consequently held constant.

Design elements on black-on-white painted pottery provided the stylistic variability measured on the later pottery collections from A.D. 1000 to 1300. This variation was quantified (Fig. 1).

An initial assumption was made that pottery was manufactured exclusively by women. It was further assumed that grandmothers and mothers taught daughters how to make pottery and that this knowledge was passed on in the female line. On the basis of these assumptions, we know the women were localized if their craft products were localized (*1*). Further, if females were recruited to a village from outside, they would bring to any given village a series of style traditions which would make that village's pottery more variable than it would be if all the wives in a village were born and enculturated within its limits. Hence, the more variable ceramic styles in a village were, whether these are measured by color variation or by design elements on painted pottery (*2*), the more exogamous a village was. Conversely, the less variation in female-produced goods in a village, the more endogamous the village was (*3*) (Fig. 1).

Variability is accounted for by the diversity in the enculturation tradition. This is not to deny a certain amount of individual peculiarity for potters. I would suggest, however, that the proportion of idiosyncrasies does not vary through time and consequently it can be held constant.

Trade is a means of introducing variation into potting traditions. Assuming that trade affects a small region like the Hay Hollow Valley equally, then all

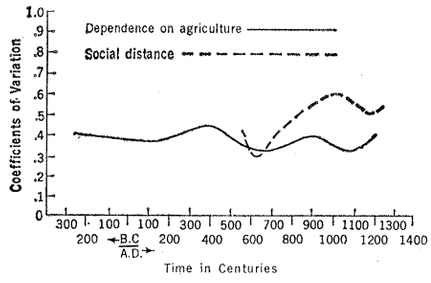

Fig. 1. Covariation between dependence on agriculture and social distance (*5*). Dependence on agriculture is determined from variability of the tools used in a village. Social distance is determined on the basis of endogamy in a village (greater social distance equals more endogamy) as revealed by the color variation (A.D. 400 to 800) or design elements (A.D. 1000 to 1300) of pottery produced.

micro-traditions have an equal chance of being influenced by it. Variation introduced through trade can be selected for or against, incorporated into potting traditions or not. If the variation becomes part of local tradition it can be regarded as subject to the same patterns of enculturation and transmission as indigenous variation. Presumably, sherds from traded vessels can be identified and excluded from the analysis.

The data used to measure changing dependence on agriculture come from the Reserve area in western New Mexico. The Hay Hollow Valley and the Reserve area are similar, but not identical, laboratories. To measure changing dependence on agriculture in this region it was hypothesized that a diversified or generalized economy like hunting and gathering would have a more varied tool kit than would a less diversified or specialized economy like agriculture. Since hunters and gatherers would tend to utilize more and different resources, they would tend to have a greater total variety of tools than would agriculturists. Among hunter-gatherers this can sometimes take the form of single tools capable of performing a large variety of functions. People dependent only on agriculture would tend to have proliferated a few types of tools to answer their more specialized needs; for example, many kinds of corn grinding stones, but few types of scrapers or projectile points. If this tool kit variability were quantified and graphed, dependence on hunted-gathered products should produce results different from those characterizing dependence on agriculture (*4*). Most economies in the prehistoric Southwest would fall somewhere on the continuum between the two types of economic bases (*5*) (Fig. 1).

The curve labeled dependence on agriculture is derived from the variability in three classes of artifacts—manos, projectile points, and scrapers. It is suggested that, generally, the more variation there is in what is ground or hunted or butchered, the more variation there will be in the tool kit used for those tasks. Ideally agriculture makes a limited number of food resources more available and reliable. As long as these provide for biological requirements, other resources need not be tapped. In a seasonally varied environment hunter-gatherers usually process a greater variety of products to satisfy nutritional requirements than do full-time agriculturalists. If this is the case, then tool kit variability should be a reflection of economy. Agriculturalists should not have fewer tools but would expand fewer categories of tools than hunter-gatherers. This seems to be borne out (Fig. 1) because we know of the same general fluctuations in economic base through the fossil pollen record (*6*). One general exception to the tool kit variability hypothesis may well be the Paleolithic hunting specialists of the Old World and the New World.

From A.D. 400 to 650 dependence on agriculture declined, and exogamy rose (Fig. 1). From A.D. 650 to 900 dependence on agriculture increased as did village endogamy which peaked at about 1000. Dependence on agriculture declined again from A.D. 950 to about 1050; exogamy increased again for roughly the same period. After 1050 agricultural dependence climbed to peak sometime after 1300. The tendency to endogamy did the same. These nearly simultaneous fluctuations substantiate the hypothesis that as agriculture becomes a greater part of the economic base, village endogamy increases (*7*).

The Mogollon area of the Southwest is ecologically homogeneous. There are a number of natural zones, but the topography is broken enough so that most zones are closely juxtaposed in almost any area. Consequently the natural food and raw resources characterizing the zones are also closely juxtaposed. This provided ready availability of conditions and materials needed for successful agriculture. The natural environment fostered isolation. No exchange in economic essentials, possibly excepting salt, seems to have been necessary. None of that limited number of conditions for breaking down the fission that I suggest Neolithic economics inevitably led to was present. There were not differentially available natural food and food-processing resources. Water control never was developed beyond the simple check-dam stage. And the kind of economic competition that produces cooperation between groups of like economy against those of an exploiting competitor existed only briefly for the whole period A.D. 1 to 1300. There were no permanent natural or cultural devices in the Mogollon area for counterbalancing Neolithic fission.

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References and Notes

1. J. F. Deetz, *Dynamics of Stylistic Change in Arikara Ceramics* (Univ. of Illinois Press, Urbana, 1965).
2. W. A. Longacre, *Science* **144**, 1454 (1964).
3. R. Whallon, "The Owasco Period: A Reanalysis," thesis, University of Chicago (1966).
4. This is the reasoning and work of F. T. Plog, of the Southwest Expedition of the Field Museum of Natural History.
5. The statistical device used to quantify both ceramic style variability and tool kit variability is a coefficient of variation. The formula cited here produces a coefficient reflecting the amount of variability in any given collection of materials. For comparison, categories must be analogous from site to site. They must reflect female style, or basic susbsistence activities, for instance. But the number of categories is permitted to vary from site to site, thus accounting for all variation in any class of items at a site. The formula is:

$$c = 1 - \frac{2[\Sigma(c - P)]}{P[n_o - (n_t/20)]}$$

where c is the cumulative percentage of attributes; and $P = 100$. Number of nominal categories in the universe of attributes is n_t. Number of nominal categories in a particular sample is n_o. Twenty is a constant representing a middle point between the least number of categories of variation in one site and the maximum in another. The coefficients vary between 0 and 1. Figure 1 is arranged to allow 0 to represent maximum variation and 1 to show no variation. This formula is the result of the combined efforts of L. R. Binford, F. T. Plog, C. Redman, and R. Whallon.
6. J. Schoenwetter and A. E. Dittert, Jr., in *Archeological Anthropology in the Americas*, B. Meggers, Ed. (Anthropological Society of Washington, Washington, D.C., 1968), p. 41.
7. The mobility of males is not precisely controlled in this experiment, therefore demonstration of endogamy must still be considered tentative.
8. Research done under the auspices of the Southwest Archaeological Expedition of the Field Museum of Natural History, Chicago, under the direction of P. S. Martin; supported by NSF research grants GS-245 and GS-984. Portions of the analysis were done as a doctoral dissertation in the Department of Anthropology, University of Arizona. I thank N. Cohn, T. Earle, E. Howe, S. Menkes, C. Oliver, C. Redman, and C. Vanasse for contributions. L. R. Binford, H. K. Bleibtreu, W. A. Longacre, P. S. Martin, F. T. Plog, R. H. Thompson, and R. Whallon have stimulated and contributed to important aspects of this research.
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