delivered to the cat's paws through the grid floor of the restraining box, and simultaneously the center rod was returned to its initial position. On each trial individual licks were counted and used to compute the ratio $D/S$, where $D$ represents the number of licks during the 20-second depth presentation and $S$ represents the number of licks during the 20-second interval immediately preceding the depth presentation. Intervals between successive trials varied, and daily sessions consisted of 20 to 25 trials.

Once the cat suppressed reliably on every trial, binocular depth thresholds were determined by varying randomly on each trial the distance the center rod was moved. The excursion of the rod was kept between 11 cm and the lowest value which failed consistently to produce suppression. During these trials we continued to pair rod movement and shock regardless of the depth value involved, in order to ensure that the cat associated shock with *any* change in depth, not just the 11-cm training value (*8*). Testing was continued until at least eight trials for each distance were completed. After binocular testing the procedure was repeated for each of the two eyes separately; the nontested eye was again occluded with an opaque lens.

The graphs in Fig. 2 present the results for a normal cat (Fig. 2A) and for two alternately occluded animals (Fig. 2, B and C). The abscissa is scaled in decreasing values of depth expressed in both real distance and equivalent minutes of disparity. Each point represents the average suppression ratio at various depth values; dashed lines and arrows mark 50 percent suppression, which is the conventional definition of threshold with this technique. Most significantly, notice that a normal cat allowed to use both eyes together (open symbols) can detect a disparity of less than 4 minutes; in terms of distance this is one-tenth the magnitude of the smallest depth detectable when the animal is forced to use either eye alone (half-filled symbols). Of course, the display used in this experiment offers other cues to depth (for example, changes in visual angle) besides retinal disparity (*9*). However, all cues *except* disparity would be available whether the cat views the display with both eyes or with only one eye. Thus the decided superiority of binocular over monocular performance strongly indicates that the normal cat was utilizing stereopsis in the binocular situation. In contrast, the alternately occluded cats performed no better using both eyes together than they did using either eye alone. In fact, the thresholds obtained for alternately occluded cats allowed to use either one eye or both eyes were quite similar to the monocular thresholds for the normal cats. This deficit in binocular depth perception indicates that the alternately occluded cats fail to utilize retinal disparity information and instead rely exclusively on monocular depth cues. Moreover, this deficit probably is permanent, for after the early rearing period, but prior to testing, both these cats received nearly 2 years of normal binocular experience during which disparity information was always available.

Since the only evident physiological consequence of alternating occlusion is a permanent diminution in the proportion of cortical cells responsive to stimulation of either eye, it is reasonable to conclude that these binocular neurons are crucially involved in stereoscopic depth perception. Indirect evidence suggests that stereoblindness in humans may result from similar physiological deficits (*10*).

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**References and Notes**

1. D. H. Hubel and T. N. Wiesel, *J. Physiol. (Lond.)* **160**, 106 (1962).
2. In the cat, binocular cells sensitive to retinal disparity have been found in visual areas 17 [H. B. Barlow, C. Blakemore, J. D. Pettigrew, *J. Physiol. (Lond.)* **193**, 327 (1967); T. Nikara, P. O. Bishop, J. D. Pettigrew, *Exp. Brain Res.* **6**, 353 (1968)] and 18 [J. Pettigrew, *Nat. New Biol.* **241**, 123 (1973)]; as well as in the superior colliculus [N. Berman, C. Blakemore, M. Cynader, *J. Physiol. (Lond.)* **246**, 595 (1975)]. There is some question concerning the percentage of binocular cells in area 17 which show disparity selectivity [D. H. Hubel and T. N. Wiesel, *J. Physiol. (Lond.)* **232**, 29 (1973); H. B. Barlow, C. Blakemore, R. C. Van Sluyters, *ibid.* **242**, 38 (1974)], but it is generally recognized that this disagreement stems from technical problems involved in monitoring residual eye movements in the paralyzed preparation.
3. P. O. Bishop, in *Handbook of Sensory Physiology*, R. Jung, Ed. (Springer-Verlag, New York, 1973), vol. 7, part 3.
4. D. H. Hubel and T. N. Wiesel, *J. Neurophysiol.* **28**, 1041 (1965).
5. ———, *J. Physiol. (Lond.)* **206**, 419 (1970).
6. J. Smith, in *Animal Psychophysics*, W. Stebbins, Ed. (Appleton-Century-Crofts, New York, 1970).
7. R. Blake *et al.*, *Vision Res.* **14**, 1211 (1974).
8. In this previous work (*7*) using conditioned suppression as a psychophysical technique, we have observed that cats, once trained to suppress upon presentation of a conditioned stimulus, also suppress to other suprathreshold stimuli as well; the animal seems to be sensitized to any perturbation in the visual display. For this reason the technique is ideally suited for measuring stimulus detectability; on the other hand, to study discriminative behavior with the use of conditioned suppression, whereby presentation of one class of stimuli is paired with shock but another class is not, requires more prolonged training [H. S. Hoffman, in *Animal Discrimination Learning*, R. M. Gilbert and N. S. Sutherland, Eds. (Academic Press, New York, 1969)].
9. A method of stereoscopic presentation which is devoid of monocular depth cues is the random-element stereogram [B. Julesz, *Foundations of Cyclopean Perception* (Univ. of Chicago Press, Chicago, 1971)]. Several considerations, however, dissuaded us from employing this elegant technique in our experiments. First, construction of such stereograms must take into account information about the minimal disparity resolvable by the cat; but prior to the experiments summarized in Fig. 2 this information was unavailable. Indirect evidence (*2*) suggested that the cat possesses rather crude stereoacuity by human standards, and it has been suggested that the disparity-selective neurons in cat cortex may be ineffective in extracting disparity information from patternless, random-element stereograms [Barlow, Blakemore, Pettigrew (*2*)]. Also, naive human observers usually require some time before the depth in random-element stereograms is apparent, and it is possible that for a cat the disparity would not be of sufficient salience to capture its attention. These considerations suggest that the use of random-element stereograms could have led to an erroneous negative result. Consequently, we employed a more conventional depth display, much like the one used successfully in earlier work on stereopsis in the cat [R. Fox and R. Blake, *Nature (Lond.)* **233**, 55 (1971)].
10. D. E. Mitchell and C. Ware, *J. Physiol. (Lond.)* **236**, 707 (1974).
11. Supported by NIH grants 5-S05-RR07028, EY-00321, and EY-01268. We thank M. L. J. Crawford for help with the physiological recordings, and R. Sekuler and A. G. Leventhal for comments on the manuscript.

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## Stratigraphic Correlation

The methodology proposed by Southam *et al.* (*1*) represents a potentially important step forward in the analysis of stratigraphic correlation, albeit a somewhat tentative one. They list quite properly the three conditions of the Bernoulli experiment requisite to the use of the binomial distribution for the analysis. It is important to consider these conditions a bit more closely, as in fact any of the three may be violated in important cases. Departures from the Bernoulli conditions are the statistical equivalents of the facies problem that has plagued stratigraphy from its outset. Because the facies problem is disguised in the statistical treatment, it may pass unnoticed by some readers. Its presence does not invalidate the methodology, but does necessitate some special caution. The proposed methodology does not provide a route around the facies problem, but what is more useful, a way through it.

Taking the Bernoulli conditions out of order, condition (ii) requires that the outcome of each observation be one of two mutually exclusive and exhaustive possibilities—in the present context, that there be no possibility of ties. Ties are, in fact, quite common, particularly at unconformities (it is for precisely this reason that unconformities were very early given great emphasis in stratigraphy). The presence of ties creates no great difficulties and may be dealt with in either of two ways: by resorting to the trinomial distribution, or by neglecting ties and resorting to the conditional binomial distribution. The latter approach is implicit in the authors' presentation.

Condition (iii), that "the probability $p_{ij}$

of the outcome $\tau_i < \tau_j$ is the same on each repetition," is not in general met except on a local scale. This is apparent in cases, where lithostratigraphic units are time-transgressive or biologic components migrate (both cases being well known). In such cases the $\tau_{iK}$ or $\tau_{jK}$ will clearly be functions of a locality index $K$, and in general $P_{ijK} = Pr(\tau_i < \tau_j | K)$ will vary with $K$. The authors dismiss this problem on the basis that condition (iii) "is well approximated on a regional basis." That, of course, depends on how one defines a region and what one considers a good approximation.

The situations with conditions (ii) and (iii) will be apparent to most experienced stratigraphers because of all too familiar aspects of the facies problem. Condition (i) is more deceptive because of a common misunderstanding of the implications of stochastic independence. It must be defined here by what appears to be a roundabout approach. Let the relationship between two events $i$ and $j$ be represented by a random variable $r$ such that if $\tau_i < \tau_j$ at locality $K$, then $r_K$ will be defined to be 1, and if $\tau_i > \tau_j$ at locality $K$, then $r_K$ will be defined to be 0 (*2*). It is clear that if any one observation involving $i$ and $j$ be considered alone, the expected value of $r$, denoted $E(r_K)$, is just the $P_{ij}$ of the authors at locality $K$. Let us now denote two arbitrarily chosen observations by $K = 1$ and $K = 2$. From the definition of stochastic independence, condition (i) is met if and only if $E(r_2 | r_1) = E(r_2)$—read as "the expected value of $r_2$, given a value of $r_1$, is the same as the unconditional expectation of $r_2$." If this is true, then it will not matter in the least where the observations are made. Any experienced stratigrapher will agree that the same ordering is more likely if two observations are made in one highway cut than if they are made a thousand miles apart—this very point is apparent in the introductory comments of Southam *et al.* This being true, then by definition the observations are not stochastically independent. We should say in this case that propinquity induces a correlation between $r_1$ and $r_2$. Indeed, it is just when we have observations sufficiently removed that the correlation becomes negligible for most $i, j$ pairs that we say we have crossed a facies boundary.

In summary, there is much to be said for the formulation proposed by Southam *et al.* The matrix elements are, however, conditional on geographic or facies conditions of the observations, and the confidence intervals that they calculate are appropriately conditional as well. Recognition of this reality necessitates some modification of their concept, but also opens the way for the application of some very powerful multivariate techniques for studying the interrelationships between the random variables that were used here.

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### References and Notes

1. J. R. Southam, W. W. Hay, T. R. Worsley, *Science* **188**, 357 (1975).
2. The random variable $r$ is related to two of the authors' variables. The $x$ in equation 2 of the original report is

$$x = \sum_{K=1}^{N} r_{ijK}$$

and the matrix element $a_{ij}$ is

$$a_{ij} = \frac{n_{ij}}{N_{ij}} = \frac{x}{N} = r_{ij}$$

the average of the observed $r$'s. Although it was not necessary in the authors' presentation or here, the $r$'s or $x$'s should bear appropriate subscripts.

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## Strategic Arms Debate

If *Science* is about to enter the strategic arms debate, it should do so more carefully: the article by Tsipis (*1*) contains numerous errors, both conceptual and mathematical.

The discussion of nuclear effects on humans is concerned almost exclusively with 1-megaton weapons and hence addresses only thermal effects. In fact, because of the different variations of effects with distance, radiation predominates as a prompt kill mechanism at very low yields and prompt thermal effects are important only at very large yields. Overpressure may be the dominant prompt mechanism at intermediate yields, depending upon the level of protection utilized (*2*). The statement that "by far the most lethal effect of a nuclear weapon is the thermal radiation it releases" is an overgeneralization, even when applied to urban areas where the prompt thermal radiation is augmented by fires and even firestorms. Moreover, a countervalue attack against an industrial area is not identical with a counterpopulation attack and is not achieved "more efficiently, by scattering several small weapons even at random over the area." Only the killing of people can be done with reasonable efficiency this way.

A specialized definition is also used for counterforce. Counterforce implies the destruction not only of missiles inside reinforced concrete silos, as Tsipis defines it, but of missiles in silos regardless of their construction, missiles on soft pads, and missiles in warehouses, as well as of any other military force—bombers, submarines and ships in port, weapons in storage, and army units. However, since the article is concerned only with the specialized case, only that is considered below.

First, however, two points should be made about pindown and interference. The "carefully timed arrival and detonation of reentry vehicles overhead" is not a practical way to facilitate the use of bombers against silos, since the number of reentry vehicles required to do this, while waiting several hours for bomber arrival, is astronomical. If interference does negate the efficacy of all but the first reentry vehicle reaching the silo, then only the most lethal reentry vehicles should be counted in considering the countersilo potential of a force.

As for the "calculus of destruction," it is unnecessary to attempt to precisely fit a curve to the general overpressure-distance ($\Delta p$-$r$) relationship, since the departure from a power of $\Delta p$ is of significance only at values of $\Delta p$ lower than those of interest here. Moreover, equation 1 in (*1*) does not include height-of-burst effects and hence is inappropriate at low values of $\Delta p$. At high values it is approximated by its leading term, and equation 7 can be replaced by

$$r = \frac{Y^{1/3}}{0.408(\Delta p)^{1/3}}$$

where $Y$ is weapon yield in megatons, $r$ is distance in nautical miles, and $\Delta p$ is overpressure in pounds per square inch. [Better fits, valid at high overpressures, can be achieved with other values of the constant, such as 0.43, or better still with other values of both the constant and power of $\Delta p$, such as $0.25\,(\Delta p)^{0.425}$.]

The hardness ($H$) is described by a simple "cookie cutter" model such that the silo is expected to survive if $\Delta p \leq H$, but be destroyed if $\Delta p > H$.

Equation 8 in (*1*), relating the probability ($P_s$) that a silo will survive detonation of a reentry vehicle to the hardness of the silo and the accuracy of the reentry vehicle, is wrong. The correct expression is

$$P_s = 0.5^{(r_o/CEP)^2}$$

where $r_o$ is the distance at which $\Delta p = H$ and $CEP$ is the circular error probable of the reentry vehicle; the free variable $r_s$ is irrelevant. Note that it is 0.5, not $e$, which is raised to the power. An alternative exponential formulation which parallels equation 8 in (*1*) is

$$P_s = e^{(\ln 0.5)\,(r_o/CEP)^2}$$
$$= \exp\,[-0.693\,(r_o/CEP)^2]$$