The tendency of the geometric means to fall close to a straight line in a log-log plot shows that apparent or subjective viscosity is a power function of physical viscosity. The exponents for the three experiments, given by the slopes of the visually fitted lines in Fig. 1, are 0.42, 0.43, and 0.46. Since the procedure of magnitude estimation often gives a slight underestimation of the value of the exponent, a representative round-number value for apparent viscosity may be 0.5.

There appears to be little if any difference attributable to the sense modality used in the evaluation of a given ratio of viscosities. In the first experiment the observers shook or turned the glass jars and watched the fluid. Since shaking had no effect on the more viscous liquids, the jars had to be turned slowly and the judgment of viscosity was based almost wholly on visual effects. In the second experiment the observers could see nothing, but they could feel the viscosity with the aid of the rod. In the third experiment they both saw and felt the viscosity. These procedural differences seemed to have no consequential effect on the power functions.

Variability. Since each observer was allowed to choose his own modulus or "unit" for his subjective scale, this factor was partialed out before the variabilities were computed. For each experiment a grand mean of the logarithms of all the judgments was first obtained. The mean of the logarithms of the estimations by each observer was then subtracted from the grand mean and the difference was added to the logarithm of each of that observer's estimates. This operation leaves unchanged the slope of the magnitude function for each observer, but it minimizes the sum of the squared deviations of his estimations around the regression line for the group (*4*).

The vertical lines in Fig. 1 show the interquartile range of the judgments after the variability attributable to the modulus has been removed. The extent of the variability suggests that apparent viscosity is not a particularly difficult judgment to make.

Inverse Judgments. The fact that apparent viscosity grows approximately as the 0.5 power of physical viscosity was confirmed in two additional experiments. The procedures were the same as for the first and third experiments on viscosity, except that the observers were asked to judge fluidity instead of viscosity. The geometric means of the magnitude estimations of the inverse aspect approximated a reciprocal function, an outcome that has been demonstrated with nine other continua (*5*). And as typically happens, the fluidity function departed from a good power function in the direction of being concave downward.

The observers reported more difficulty in judging fluidity than in judging viscosity, but this may have been due to their prior experience with judgments of viscosity. Before more is said about judgments of fluidity, it would be desirable to obtain a new population of observers and to counterbalance the order of judgments. A more uniform (logarithmic) spacing of the stimuli may also prove desirable (*6*).

Relation to other continua. Apparent viscosity belongs to the group of perceptual dimensions that seem to depend on more than a single sense modality. Another example of this class is the apparent hardness produced when rubber samples are squeezed between thumb and finger, which involves touch, pressure, and muscular strain. The method of magnitude estimation has shown that apparent hardness grows as the 0.8 power of physical hardness (*7*). Another presumably complex continuum is the roughness of emery cloths stroked with the fingers. The apparent roughness grows as the 1.5 power of the diameter of the grit particles (*8*). No obvious explanation suggests itself for the wide differences among the exponents that govern these various continua, but the invariance of the principle that, on every prothetic continuum, equal stimulus ratios produce equal subjective ratios remains a matter of deep interest.

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30 March 1964

Origin of Noctilucent Clouds

In a recent report of observations of a noctilucent cloud in Arizona, Meinel and Meinel (*Science*, 3 Jan. 1964, p. 38) demonstrate that its drift vector indicated an origin from the Pacific Missile Range area. They write: "No data confirming the launching of a ballistic missile are on hand; however, the evidence seems quite conclusive."

But the evidence seemed inconclusive to me, and I queried the director of information at Vandenberg Air Force Base. He wrote, "A Minuteman ICBM was launched from Vandenberg AFB, California on 2 November 1963 . . . at approximately 2:30 P.M." This datum certainly adds weight to the missile-exhaust hypothesis of the origin of these clouds, but not enough, in my opinion, to exclude other hypotheses. The evidence for the hypothesis now rests only on the following data: nine of the clouds were observed on days when space vehicles were launched; and of these nine, two were traced to the Pacific Missile Range area.

Several questions are not answered by the hypothesis. If the clouds are formed by missile exhaust, how can this happen in the manner of natural noctilucent cloud formation, as suggested by Meinel, Middlehurst, and Whitaker (*ibid.*, 20 Sept. 1963, p. 1176)? No explanation is offered for the extraordinary shape and size of the Flagstaff cloud reported by McDonald (*ibid.*, 19 Apr. 1963, p. 292), or for the fact that it was accompanied by a smaller cloud of the same shape. How could missile exhaust be converted into two rings, the larger of which was 35 km wide? And why are there missile launchings that are not followed by sightings of these clouds?

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10 January 1964