however, responses to S− are extinguished during discrimination training, S− may function as an aversive stimulus. According to this hypothesis, a shift of the peak or of the area of a generalization gradient, away from S−, would be described as a shift away from an aversive stimulus.

H. S. TERRACE

Department of Psychology, Columbia University, New York

References and Notes

1. H. M. Hanson, *Science* **125**, 888 (1957); *J. Exptl. Psychol.* **58**, 321 (1959).
2. H. S. Terrace, *J. Exptl. Anal. Behavior* **6**, 1 (1963); *ibid.*, p 223.
3. C. B. Ferster and B. F. Skinner, *Schedules for Reinforcement* (Appleton, New York, 1958).
4. D. B. Blough, *J. Opt. Soc. Am.* **47**, 827, (1957). The values of the neutral density filters were computed as follows. On the basis of Blough's table of photopic sensitivity, a zero increment in density was assigned to the stimulus at which the least sensitivity was obtained (440 mμ) and the largest increment was assigned to the stimulus at which the most sensitivity was obtained (560 mμ). These values were then corrected for the different transmittances of each monochromatic filter. The decrements in intensity at each stimulus were: 490 mμ, —0.3; 510 mμ, —0.5; 520 mμ, —0.6; 530 mμ, —0.6; 540 mμ, —0.8; 550 mμ, —0.8; 560mμ, —0.9; 570 mμ, —1.0; 580 mμ, —1.0; 590 mμ, —0.9; 600 mμ, —0.8; 610 mμ, —0.7; 630 mμ, —0.5; 650 mμ, —0.1; 670 mμ, 0.0.
5. It should be noted that the asymmetrical distribution of area above and below S+ is not due to the fact that a different number of stimuli above and below S+ were used in the generalization test (eight below and six above S+). Asymmetrical distributions of area would also be obtained if the number of responses to the two lowest stimuli (490 and 510 mμ) were omitted from the calculation of area.
6. H. S. Terrace, *Science* **140**, 318 (1963).
7. I thank D. B. Moody and E. Richardson for their valuable assistance. This research was supported by NIH grant MH-05770-02 and NSF grant GB-1629.

3 February 1964

I.Q., Genetics, and Culture

I was rather surprised to read in *Science* (13 Dec. 1963, p. 1477) a report entitled "Genetics and intelligence: A review," by L. Erlenmeyer-Kimling and L. F. Jarvik, purporting to show that "Individual differences in behavioral *potential* reflect genotypic differences; individual differences in behavioral *performance* result from the nonuniform recording of environmental stimuli by intrinsically nonuniform organisms" (italics in original). Whatever the truth of the report's thesis, if any, it cannot be supported by the type of correlation data presented.

In the first place, the nature of environmental influences on intellectual development have by no means been elucidated, and it does not follow that individuals reared together were subjected to similar effective environmental influences or individuals reared apart to dissimilar ones. At the risk of overstating the obvious, I give two examples of the difficulty: rival siblings may be exposed to very different environments though reared in the same home and surroundings, and placing a Negro child in the home of a white foster parent will not make the environment for that child similar to that of his foster brothers and sisters. In the second example, the differences will arise in part from skin color, which is genetically determined, but will be caused by the cultural implications of that color, not by genetic limitations associated with it.

Secondly, there is a long and unsettled controversy over how intellectual *potential* is to be measured. I personally suspect that I.Q. and other tests measure to a considerable degree the extent of cultural (environmental?) conformity between those who construct the tests and those who take them. An intelligent Eskimo would fail I.Q. tests, but I suspect that Erlenmeyer-Kimling and Jarvik would fail to survive an Arctic winter. Since a reliable, independent measure of intellectual potential does not exist, the matter cannot be settled. However, to me the pertinent experiments are those which demonstrate that performance on I.Q. tests is altered by changes in environment.

In the same issue (p. 1436) appears a confusing long article with a similar thesis by J. Hirsch, who sets the physiologists and the behaviorists in a windmill which he labels "believe in the initial uniformity of individuals" and then charges them pellmell with the lance of genotypic uniqueness. He then attacks "reductionism," the fallacy of which he states to be the assumption of a "one-one relation between different levels of organization," and on the next page discusses the one-to-one relation between genes and behaviour.

E. E. DANIEL

Department of Pharmacology, University of Alberta, Edmonton

13 January 1964

If Daniel meant to say that our data do not establish our hypothesis, then he is, of course, correct; no quantity of data ever established any hypothesis. If he really meant to say that the data do not support our hypothesis, then we can only refer him and other readers to our report and chart.

Daniel also points out that rival siblings may be exposed to very different environments though reared together. Even if this were true for relevant environmental variables, the data still support our hypothesis.

We should like to reiterate the concluding paragraph of our report, in which the important concept of the "norm of reaction" is briefly discussed: "We do not imply that environment is without effect upon intellectual functioning; the intellectual level is *not* [italics in original] unalterably fixed by the genetic constitution." Just as in the example of phenylketonuria cited in the same paragraph, alterations in performance on intelligence tests following changes in environmental stimulation illustrate the concept of the "norm of reaction."

Incidentally, neither an Eskimo nor anyone else, intelligent or unintelligent, could "fail I.Q. tests."

L. ERLENMEYER-KIMLING

LISSY F. JARVIK

New York State Psychiatric Institute, Columbia University, New York 32

24 February 1964

Temperature of Metallic Objects in Space

The report by C. Butler and R. Jenkins (*1*) on "Temperature of an iron meteoroid in space" shows an application of thermodynamic theory similar to that used some 6 years ago to predict the solar heating of artificial satellites (*2*). Their report generally agrees with the theory (later confirmed by actual measurements on satellites) thus previously developed for temperatures of a solid body in space and in full sunlight. However, they have neglected the factor, for bodies near the earth, of the shadow of the earth. Consideration of this neglected factor would seem to modify very seriously their categorical conclusions that "the equilibrium temperature of an iron meteoroid just before entering the earth's atmosphere will be close to 90°C," and that any assumptions that meteoroids are "quite cold" just before entering the atmosphere necessarily contradict thermodynamic theory.

If a meteoroid enters the earth's atmosphere at night (and such is the case for the vast majority for which the fall is *observed*), it seems obvious that it has not been at equilibrium temperature in sunlight for at least the previous few minutes. Satellites moving across the 12,700-km diameter of the earth's shadow are ordinarily in darkness for up to an hour or more, and meteoroids in eccentric heliocentric orbits, which might traverse a good part of the nearly 1½-million-km length of the umbral cone, would seem liable to much longer eclipses, in spite of their higher relative velocity. Also, there is much greater length and volume of the penumbral cone within which the decreased solar-radiation flux would lower the equilibrium temperature 50°C or more. For a meteoroid whose orbit has been determined, the duration of its pre-entry eclipse could be computed.

Butler and Jenkins's formula shows the equilibrium time of an iron meteoroid 20 cm in diameter, weighing some 20 kg, to be about half an hour. Actual measurements on metallic objects in outer space, such as the artificial satellite Explorer IV, have shown the surface temperature to drop from +50°C to −20°C in about the same length of time in the earth's shadow (*3*). This observation is only a more close-up confirmation of effects noted many years ago on our natural moon. Pettit (*4*) at the Mount Wilson Observatory found that the temperatures of certain areas on the moon, as indicated by their infrared radiation, fell as rapidly as 150°C per hour during a lunar eclipse. Hence I would see no reason to question the authenticity of reports such as that quoted by C. A. Young (*5*), "that one of the large fragments of the Dhurmsala (India) meteorite, which fell in 1860, was found in moist earth half an hour or so after the fall, *coated with ice*."

My conclusion would be that, in general, the temperature of an iron meteoroid just before entering the earth's atmosphere may be anywhere from about 90°C down to much below the freezing point of water, depending upon its size and the duration of its preceding eclipse in the earth's shadow.

RAYMOND H. WILSON, JR.
National Aeronautics and Space Administration, Washington, D.C.

References

1. C. P. Butler and R. J. Jenkins, *Science* **142**, 1567 (1963).
2. R. H. Wilson, Jr., *ibid.* **127**, 811 (1958); **128**, 208 (1958).
3. G. Heller, *Am. Rocket Soc. J.* **31**, 344 (1960).
4. E. Pettit, *Astrophys. J.* **91**, 408 (1940).
5. C. A. Young, *General Astronomy* (Ginn, Boston, 1891), p. 435.

27 December 1963

We believe Wilson has overlooked a number of important considerations in our paper. A sphere of solid meteoritic iron 20 cm in diameter, such as he suggests, weighs 32.8 kg. Its specific heat from measurements we have reported (*1*) is about 0.13 cal per gram per degree Celsius, so its total heat capacity is 4260 cal per degree Celsius. The radiating area of this sphere is 1260 cm^2 and on the basis of the emittance values we have reported, the time in the shadow for a change in temperature from 90° to 89°C is about 1440 seconds. These calculations omit the back radiation from the night side of the earth which, if included, would increase the cooling period. Table 1 gives the time required for such a meteoroid to cool to various temperatures when it is in the umbra of the earth.

The formula given in our paper for computing the equilibrium time for an iron meteoroid in space was for the internal temperature equilibrium in sunlight. For the cooling case, the equation is $t = 0.54\ r^2/Z$ where r is the radius and Z the thermal diffusivity. For the example assumed here, the equilibrium time is 360 seconds and is not the controlling factor that determines the cooling rate. A meteoroid would have to follow a very peculiar trajectory to remain in the earth's shadow long enough to cool to the freezing point of water.

Wilson's statement that the "vast majority" of observed falls of meteorites occur at night is not supported by the work of Leonard and Slanin (*2*). They showed that the number of observed falls peaks in the afternoon at about 3 P.M., and further that more than twice as many meteorites are observed to fall during the day as at night.

The reference to Pettit's work has no application to the problem we have treated, since the emittance of the surface of the moon is near unity, like an insulator, not a metal. The very large drop in surface temperature during a lunar eclipse is evidence of very fine dust and its low diffusivity. Likewise, the reference to the Dhurmsala meteorite is irrelevant, for this meteorite is an intermediate hyperstene-chondrite, and our measurements were confined to a Canyon Diablo iron.

Table 1. The time an iron meteoroid 20 cm in diameter must remain in the umbra to cool to specified temperatures.

Temperature of meteoroid (°C)	Time to cool (hr)
90	(Enters shadow)
80	4.1
60	14.1
40	27.7
20	45.7
0	70.8

We agree with Wilson that there is no reason to doubt the authenticity of reports that meteorites coated with ice have been picked up shortly after falling, but all such cases known to us are chondritic. The Colby (Wisconsin) chondrite which fell on 4 July 1917 was so cold when it was dug out of the ground about half an hour after falling that frost formed on it (*3*). The explanation for the formation of frost on both the Colby and the Dhurmsala when picked up has been given by Krinov (*4*).

> When a meteorite reaches the region of retardation, its heated outer layer cools off rapidly under the influence of the low inner temperature and it becomes covered with a thin layer of solidified fusion crust. Upon descending further, after passing through the region of retardation, and while passing through the upper layer of the tropopause, where low temperatures prevail, the outer layer of the meteorite is subjected to further cooling. Cases have been observed where fallen meteorites had temperatures below zero. . . .

Since the solar absorptance and emittance of chondrites have not been measured, we have no data from which to calculate their temperatures.

C. P. BUTLER
R. J. JENKINS
U.S. Naval Radiological Defense Laboratory, San Francisco, California

References

1. C. P. Butler and R. J. Jenkins, *Science* **139**, 486 (1963).
2. F. C. Leonard and B. Slanin, *Popular Astronomy* **49**, 551 (1941).
3. B. Mason, *Meteorites* (Wiley, New York, 1962), p. 14.
4. E. L. Krinov, *Principles of Meteoritics* (Pergamon, New York, 1960), p. 102.

12 February 1964