Letters

Space Effort: The Third Culture

Growing opposition to the space budget, as reported by D. S. Greenberg [*Science* **140**, 790 (17 May 1963)], must remind many an amateur historian of previous occasions when fads were opposed by a body of sensible men: anatomy of the human body in medieval Italy, or sailing westward from Spain to India in 1492. Moreover, it is unfortunate that, just as we have become used to C. P. Snow's idea of "Two cultures," a third should appear on the scene to isolate one group of engineers from another. Hence this effort to find a common ground for reasonable discussion.

Between the new space-effort culture and the two older ones there are at least two communication bridges: (i) modern science and engineering has much to gain from billions of dollars spent on space technology, and (ii) the possible shift of national prestige symbols away from nuclear stockpiles should gladden the hearts of all but the most extreme anti-scientists.

The first bridge is closely associated with astronomy and astrophysics. Almost all the techniques involved in putting men on the moon are directly applicable to research of immediate importance: photography and spectroscopy of celestial objects from outside the earth's atmosphere, radio astronomy from the sheltered back side of the moon, samples of the unweathered lunar surface, magnetic and seismic data, lunar materials for use in deeper space probing, full sampling of meteoroids, and many others. It should be admitted that unmanned space-probes will be most suitable for several of these experiments, but the NASA programs (Orbiting Solar Observatory and Orbiting Astronautical Observatory) certainly allow this. The links with meteorology, geology, physics, chemistry, and even biology and psychology are clear enough that most professionals in these fields have an interest in one or more technical aspects of the space effort.

What about the charge that the man-in-space program is overfinanced, drawing many men away from more significant research effort? In the field of astronomy, again, this has already had drastic effect, but it promises also to attract a great many more young scientists into the field. After a brief shortage of professionally trained men, astronomy certainly stands to expand and prosper from the space age. Those who argue that there is only a limited supply of competent research talent to be divided between Culture Two and Culture Three should examine the wastage rates in the earlier years of our educational system and explain unemployment among high school and college graduates.

Because opposition to the space budget is mainly political in nature, the second bridge mentioned above (between Culture One and Culture Three) should be more fully exploited. There may well be other valid reasons for winning the "space race" than an orderly extension of scientific knowledge. The one proposed here is somewhat more subtle than bowing to popular demand; it rests on a pronounced trend in the recent history of international conflict, and the measure of a nation's power.

Technical advances are obviously involved, but in a way that has changed markedly in the last century or so, a period which saw development of artillery, tanks, battleships, submarines, airplanes, and missiles. It is easy to see the increase in tempo; the "lifetime" of weapons, or weapon-systems, has decreased from a matter of decades to that of years. Partly as a result of this, the military force-in-being lost importance as a measure of national power, and it is generally agreed (after the fact) that *industrial capacity* was a significant factor, if not decisive, in the two world wars. Naval tonnage, air squadrons, and standing armies are no longer a simple measure of national prestige and power.

But, since 1945, atomic weapons have brought back the simple measure of force-in-being—atomic stockpiles, plus associated delivery systems, are clearly used as the primary measures of a nation's importance today, though we hope that economic aid is also playing a role.

Now the space race, which has been taken seriously since 1957, offers the hope of a new area of international competition. It is *not* based on the repugnant goal of destructive power, and it has fired the imagination of more people than any one religion or political ideal. In the humanistic terms of Culture One, it provides a purpose comparable with that of the explorers of the 16th and 17th centuries; it complements our technological culture, provides a use for our over-productive labor force, and may make nuclear-tipped missiles as old-fashioned as battleships or castles on the Rhine.

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Operant Conditioning in Planaria: A Criticism

A report by Lee [*Science* **139**, 1048 (15 March 1963)] has suggested that planaria can be operantly conditioned. In the experiment, individual planaria were placed in a circular, clear dish in which a tiny photoelectric beam shown through the center. When the planaria moved through the photoelectric beam, a bright light shining on the animal was immediately shut off for 15 minutes. Since planaria prefer the dark, the shutting off of the light was considered a positive reinforcement.

Although the results were clear cut and objectively obtained, the interpretation of the data as demonstrating operant conditioning is debatable. As is well known, when planaria are exposed to bright light, they become active and seek a darkened area. When the darkened area is found, the animal usually reduces its activity and remains relatively inactive as long as it is not molested. When it is exposed once more to a bright light, it becomes active again and seeks a dark area.

Since the animal is in a restricted en-

vironment, it will find the darkened area more and more rapidly. The fact that it passes through the light beam does not in itself necessarily constitute an instrumental response on the part of the planaria. Rather it cuts the light beam because that is where the animal has consistently found the darkest area. Finding the darkened area is further facilitated by placing a small Plexiglas block over the photoelectric beam.

Very simply, the question is raised as to whether the animal is making a definite response which characterizes operant conditioning or is the animal seeking a given, small area that is darkened when it gets there. The latter interpretation would appear to be the more accurate of the two.

I wish to commend the author and his supervisor for their determined effort to quantify objectively the behavior of planaria. Efforts of this caliber will eventually resolve the issue of conditioning in planaria.

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Halas has suggested that there are two possible interpretations for the results of my experiment. (i) The animals were "making a definitive response which characterizes operant conditioning." (ii) The animals were "seeking a given, small area that is darkened when [they] get there." I would like to propose that the second interpretation is identical with the first, that the procedure of operant conditioning was correctly applied, and that there was evidence of successful conditioning.

The procedure of operant conditioning involves the presentation of a reinforcing stimulus immediately after the emission of a given response. Conditioning is said to occur if, and only if, the response then increases in rate of occurrence, magnitude, or relative frequency, or decreases in latency, as a consequence of this operation (*1*). In my experiment, the reinforcing stimulus was the termination of the bright light, and the response was clearly defined as the planarian's passage through the photocell beam. As one of the measures of conditioning, it was found that the latencies of response for several of the subjects showed a marked decrease under this procedure.

The second interpretation is essentially the same as that given above. The form of the statement could be used to describe any operant conditioning experiment. A rat "seeks" a lever and is rewarded after it presses the lever. In fact, one could easily imagine a rat performing in a similar manner to the planarian: interrupting a photocell beam to turn off an intense overhead light. Although Halas makes no specific mention of taxes or kineses (*2*), he may be implying that the results can be explained in terms of these reactions. Under this assumption, one would expect a uniform pattern of response through the whole session. It was observed, however, that there were progressive changes in response rate indicative of a learning process.

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References and Notes

1. W. S. Verplanck, *Psychol. Rev.* **64**, No. 6, part 2, Suppl. (1957).
2. A taxis is a directed orientation reaction, such as the motion of a planarian away from a light source (negative phototaxis). A kinesis is an undirected locomotory reaction which depends upon the intensity of stimulation.

Citations in Popular and Interpretive Science Writing

Why is it that so much otherwise excellent "popularized" science writing lacks an essential ingredient, a lack that minimizes its lasting value? I have found that scientific publications can be qualitatively evaluated into those which include bibliographic citation data and those which do not. Scientists frequently are stimulated to order publications cited in articles. Is the exclusion of citations a tradition among journalists who prefer to withhold sources of information so as to prevent others from tapping these same sources? Librarians and scientists spend hundreds of hours tracking down precise literature citations which are missing in articles published in otherwise reputable publications like *Scientific American*, the New York *Times*, or *The Sciences*—a task that could be eliminated if brief but complete citations were given. This is certainly false economy and annoying.

As citation indexing becomes more widespread, full citations will become more important (*1*). In the meantime there is more than adequate justification for including the elusive volume, page, and year (*2*). References to "the latest" or "a recent" issue of *Nature* or *Science* are particularly frustrating! This practice is particularly irksome as authors rarely fail to give complete citations for references to their own publication—a form of bibliographic narcissism.

I have protested in vain to *Scientific American, International Science and Technology*, and the New York *Times*. The popular British journal *New Scientist* frequently but inconsistently gives the complete pertinent literature reference. *Science News Letter* is equally inconsistent. The new British newspaper *Medical News* is laudably more consistent.

The exclusion of citations, of course, is a far more serious shortcoming than the abominable practice of dispersing the author's biography on one page and the bibliography on another. The bibliography, of course, in no way resembles the list of pertinent journal citations upon which most interpretations and reviews are based. The science writers, the people who translate English to English, ought to realize that busy scientists and students depend increasingly upon these translations as a means of retrieving scientific information. In his more objective role the science writer reports, hopefully, all aspects of new fields, including historical background and all known divergent viewpoints.

In connection with the foregoing remarks, I believe that it is false economy to eliminate titles of journal articles in references cited in *Science*. This useful "redundancy" not only could do away with the need for many interlibrary loans but also would simplify the writing of papers, since one frequently must incorporate the title of the cited article in an unnecessarily long sentence. I would be perfectly willing to have such information given in five-point type—if space is really the problem. In view of the recent President's Science Advisory Committee recommendation (*3*) on the use of fuller, more exact titles, it is borrowing from Peter to pay Paul when you discard them.

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References

1. E. Garfield, *Science* **122**, 108 (1955).
2. S. M. Garn, *ibid.* **121**, 7A (21 Jan. 1955).
3. President's Science Advisory Committee, "Science, government, and information" (1963), pp. 24, 35.