The COMPUTER and YOU

Although what a man can do with a computer has been deeply explored, less attention has gone to what computers do to men. Results of a survey show that some users fear that thinking and the aesthetic appeal of science may suffer. Nevertheless those who use them most are most convinced that they will come to use them more, and at least one commentator thinks that those who think sloppily with computers would also think sloppily without them.

By Robert J. Spinrad

The folk wisdom of most nations has a proverb that comments on man's discomfort with new ideas or experiences. In English the saying is "You can't teach an old dog new tricks." In Slovene it is, "The tree must be shaped when it is young." One does not normally think in these terms, however, when discussing the deliberations of science because scientific thought reputedly represents the ascendancy of objectivity over subjective predilections. The professional scientist is thought of as one whose training enables—or rather compels—him to grasp the *new* if it can help him in his search.

One of our profound "new tricks", the digital computer, is now pervading all of science. Brookhaven, for example, has fourteen digital computers, and five more are on order. All fields of research use them. More than half of the machines are directly connected to experimental apparatus.

In my work with digital computers it has become apparent to me that science is not of one mind about this new tool. In fact it is viewed in many different and contradictory ways by working scientists. Thus I thought it would be interesting to explore these opinions. To do so I prepared a three-part questionnaire (see illustration) that I distributed to the more than 400 members of the scientific staff of my laboratory. In the first part I established the basic facts of the individual's computer use and programing ability. The second part probed the scientist's technical and aesthetic reaction toward the role of computers in his field. These questions were put in a somewhat impersonal, multiple-choice format. The third part was a question soliciting general comments or any further remarks provoked by the multiple-choice questions. Each individual was asked to identify himself only by field of research and approximate age.

Response was rather good: about half of the scientists took the trouble to fill out the questionnaire and return it. Replies ranged from a perfunctory completion of the multiple choice questions to, in one case, a short essay on pre- and postwar science. They were, on the whole, quite thoughtful and, as expected, conflicting. That is not to say that all the responses expressed different points of view. Most replies reflected a practical and somewhat pragmatic attitude toward the new tool. Consider, however, the divergence in

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QUESTIONNAIRE
on the scientist's use of digital computers

1a. Field of research (e.g. molecular biology, organic chemistry, etc.) _____

b. Field of graduate study if different from above _____

2. Approximate age _____

3a. How much of your research time do you spend making use of computers?

☐ None ☐ Less than 10% ☐ about 25%
☐ about 50% ☐ 75% or more

b. Do you find this time increasing or decreasing?

☐ increasing ☐ remaining about constant ☐ decreasing

4a. Do you know how to program computers? ☐ yes ☐ no

b. If not, do you feel you will have to learn? ☐ yes ☐ no

c. Do you, or will you, require your students to learn?

☐ yes ☐ no ☐ some of them

5. In your field, do you think that the role of computers will increase more rapidly than in other fields?

☐ will move more rapidly
☐ will keep pace with science in general
☐ will grow at a slower pace than in other fields

6. Certain areas in your field have profited more from the use of computers than have other areas. Do you find your interests growing more toward or away from these computer-aided studies?

☐ toward computer-aided areas
☐ not relevant
☐ away from computer-aided areas

7. We have all seen situations where having access to a computer has had the effect of making a man's thinking sloppy. Are people outgrowing this, or is this trend continuing?

☐ outgrowing ☐ continued danger

8. Putting aside for the moment questions of research efficiency and effectiveness, do you "aesthetically" prefer the pre-computer era of science?

☐ no
☐ I have no aesthetic reaction
☐ yes

9a. In your reading of the scientific literature in your field you have probably noticed an increase in the number of papers on computer-related topics. Do you find yourself reading these papers?

☐ yes ☐ less than the others

b. Do you find these papers technically on a par with the other papers?

☐ yes, generally ☐ no

10. I would appreciate any further comments you might care to make.

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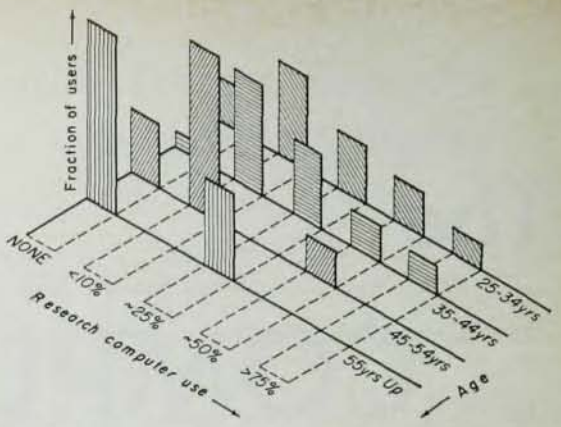

Fig. 1. Physical scientists' use of computers in research is displayed in three dimensions. Fraction of respondents who use them is displayed as a function of age and amount of use.

view expressed by these two respondents. The first, a solid-state physicist said,

> Computers as applied to sciences are a truly phenomenal technical step forward. My students tackle problems which would have been out of the question some years ago.

The second, a high-energy physicist, tells us,

> The most interesting thing about the computer revolution is how little influence they have had, not how much. I cannot think of any important advance in science due to computers.

This is certainly a striking difference in attitude but one I had repeatedly encountered before. My object, therefore, was not merely to elicit these responses but rather to see whether there was any pattern to them—to see whether one attitude could be associated with physicists and another with biologists or whether age or training could be correlated with response. I confess to being only partially successful in this search. I did not find any sharply defined associations but rather only general trends and predilections that are, nevertheless, of interest.

Pattern of response

The most noticeable correlation is between the scientist's age and the likelihood of his using computers in his research. Older men tend to use them less. Figures 1, 2, and 3 give some insight into this. They represent the distribution of research computer use as a function of age group in three broadly defined areas. The question was particularly worded to reflect the proportion of research use to avoid biasing the response. (Older men are more likely to have heavier administrative responsibilities.) Results show that scientists in the first two decades of their careers tend to spend more of their research time using computers than their older colleagues.

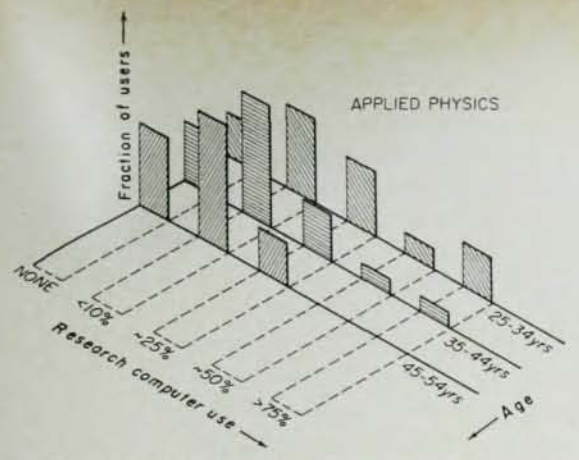

Fig. 2. Applied physicists show a use pattern similar to that of the group that includes all the physical scientists. Dimensions on the graph are the same as those of Fig. 1.

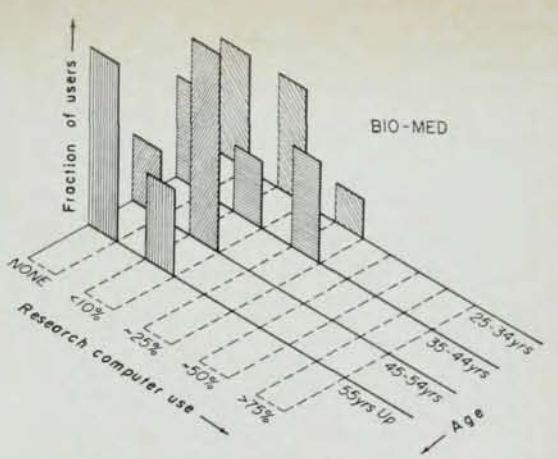

Fig. 3. Biological and medical scientists, according to this use pattern, have a smaller commitment to computer use than their colleagues in the physical sciences.

Another clear, and expected, result was the much lower present commitment of individuals in the biological and medical sciences to research that involves computer use. Compare Fig. 3 with Figs. 1 and 2. (Interestingly, the biological-medical respondents, in answering question 5, anticipated less change in their use of computers than did those in the physical sciences.)

Although it is not my purpose here to reflect on the reasons for these age-linked trends, Fig. 4 may suggest part of the answer. This figure presents a measure of the individual's competence in using computers—whether the respondent knows how to program—as a function of age. The obvious connection between ability to use a tool and the probability of thinking in terms of its use must be considered. As the bar graph shows, the older a scientist is, the less likely he is to know how to program, with only about one in ten of the most senior men being knowledgeable in this area.

Included on the graph is an indication of the stage in their professional career that the various respondents had reached when the great growth of computers in science had just begun. I think it no accident that the younger men—those who show the greatest knowledge—were still in the "learning" part of their careers at that time. Those over 40 had to be self-motivated and self-trained in these techniques. Interestingly, more than 90 percent of the respondents indicated that they would want some or all of their students to learn programing—regardless of whether they themselves knew how. Sixty percent who did not currently know how to program felt that they would have to learn.

In an effort to determine the scientists' view of the computer's role in their particular fields I asked them to estimate the computer-use growth

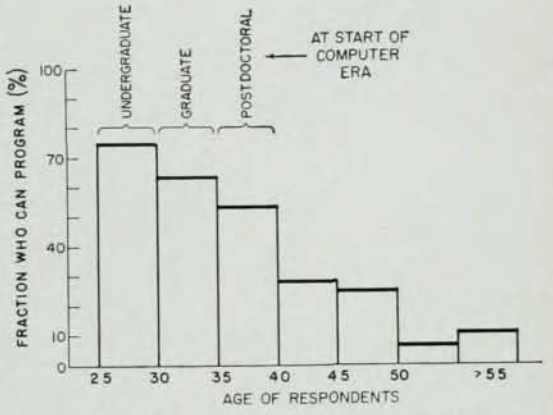

Fig. 4. Who can program? The answers to this question show that older scientists are less likely to know how than younger ones.

pattern in comparison with other disciplines (question 5). The implicit assumption was that computer use would grow in all of science. Therefore, an answer, "will keep pace with science in general," already allowed for normal growth. An interesting result was that in almost every field the predictors of extraordinary growth greatly outnumbered those who expected slower growth. The overall averages were: more rapid growth 39 percent, slower growth 7 percent, and keeping pace 54 percent.

Familiarity brings respect

Examined in more detail, it could be seen that the heavy users expected still heavier use and the modest users predicted a smaller increase. Thus among high-energy experimental physicists (the most computer-committed group) 75 percent estimated a more rapid growth and 21 percent expected only average growth. Among biological-medical scientists, by comparison, 23 percent ex-

pected more rapid growth, 19 percent less rapid growth, and 58 percent predicted average increases.

Reflecting the expectation of a larger role for computers was the scientists' response to question 3b inquiring about their own rate of computer involvement. Forty-eight percent found their time commitment increasing, and only 3 percent found themselves using computers less.

Question 6 dealt with the trend of the individual's research interests toward or away from computer-aided studies. Fifty-three percent found themselves moving toward the areas that profit from computer use, and four percent experienced the opposite effect. The remaining 43 percent did not find computer use a relevant factor in their plans.

Fifty-five percent of the respondents found themselves reading computer-related papers in their field as readily as the more familiar ones. Eighty-two percent considered those that they read technically on a par with others in the scientific literature.

Among the most illuminating returns were those that included comments. A number of the respondents made remarks (sometimes extensive) about issues raised by the questionnaire. There seemed to be particular concern over the role of the computer in removing a man from direct contact with his work. A 27-year-old theoretical physicist worried,

> Computers have made possible the peculiar situation that a man may publish the results of a computation performed with a program that has grown over the course of several years under many hands. The entire structure of the program is known to no one, and hence, in some sense, there is no one who knows precisely what calculation has been performed.

A chemical physicist was concerned that the digital computer fostered

> the tendency for people to believe that their data that have been processed through a computer are now beyond question. This is bad. To some extent the computer is a hypnotic drug.

Another physicist commented,

> It is often very difficult to follow what another investigator has done when he makes extensive use of computers in processing his data. Thus we have to accept a lot more "on faith" than did the pre-computer generation. This could result in a serious drop in the quality of research.

Do computers injure thinking?

Question 7 suggested that ready access to a computer might encourage a man to imprecise thinking. The response was mixed, with about two out of three seeing this as a continued danger.

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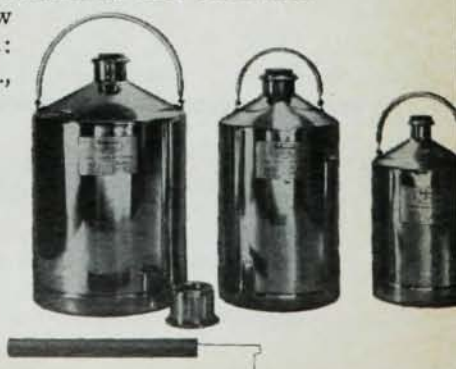

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One chemist who answered that way went on,

> There remains the question, which probably cannot be answered, whether those who think sloppily with computers would not think sloppily without them. Perhaps computers do not induce sloppy thinking but provide massively greater opportunities for revealing it.

In much the same vein, an endocrinologist said,

> My guess would be that a computer might amplify the sloppiness of someone's thinking so that it would be annoying whereas it was previously capable of being ignored. In my field the usefulness of a computer is strictly limited by the knowledge available for its input. When small improbables are put in, big ones come out.

A differing point of view, however, was expressed by a 33-year-old biophysicist who felt that,

> Computer studies of a biological subject tend to make one organize the problem better.

A question that inquired as to the individual's "aesthetic" preference between the pre- and post-computer eras of science (question 8) provoked a lot of wide-ranging comment. From the statistical point of view, the overall response indicated some 40 percent liking the present situation, another 40 percent having no aesthetic reaction, and the remaining 20 percent preferring the "old days". These proportions were not appreciably different among the various disciplines. Scientists 50 or more years old were about evenly divided when they expressed a view.

The written comments tended to dissect the question, as in this response from a high-energy physicist:

> The answer to question 8 is a "no" [he prefers the present] insofar as I believe that the goals of science in any period of time are the formulation of laws of nature in as simple a way as possible. Therefore the computer is to be regarded as a useful tool to this effect and not a substitute for analytical thinking and concise solutions to problems. If you mean by "computer era of science" the era that substitutes numerical answers for formulas that provide a deeper insight into problems, then my answer would be "yes".

A chemist chose to comment on a broader, though allied question:

> To answer question 8, I have taken the resultant of the attractions and repulsions of postwar science. The attractions are the power, precision, virtuosity, sensitivity, and the novelty of ingenious devices. The repulsions are gigantism, anonymity, the rise of the public-relations officer, the confusion of the spectacular and the significant, and excessive redundancy in publication. I have added in the attraction of prewar science, namely the novelty and power and beauty of the scientific ideas. The fact that the vast masses of postwar data are interpreted in terms of basic theory that,

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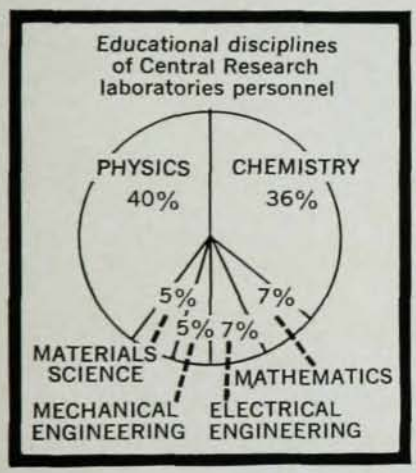

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except for minor modifications, is exclusively prewar, is, perhaps, more to the credit of our predecessors than to our own discredit. The fact remains that in the prewar days our struggles were to understand ideas whereas our postwar struggles are to understand devices.

He answered that, in net, he preferred the precomputer era.

Scientist-programer relations

A number of the scientists used the questionnaire to remark on a broad variety of topics related to computers and computer use—though not necessarily to the purposes of this survey. Quite a few dealt with the relationships of the scientist with the programer and with the mechanics of getting a problem solved. One rather interesting comment was made by a physical chemist who listed himself as spending about 50 percent of his research time using computers:

> What is needed among physical scientists is an awareness of what computers can do. What is needed in scientific laboratory administration is the provision of many more applied mathematicians and programers to relieve the scientist of the time-consuming technical details of computer use. Such provision has not kept pace with the availability of computers. It is ridiculous to spend megabucks for computer rental and balk at a few hundred thousand for personnel. I would personally never touch the computer if competent people were available to do all the necessary liaison work.

A high-energy physicist, who spends less than 10 percent of his research time using computers, made a suggestion:

> I feel that scientists should make greater use of professional programers. This should start in graduate school. I feel that too many students get involved in programing, data analysis, and display too early. They substitute these activities for new thinking and approaches to the understanding of physical problems. After some time the computer dominates their life and the progress of their research.

A similar point of view was expressed by a solid-state physicist who felt that,

> The greatest danger in the future is increased indulgence in numerology, that is, calculating something not because of fundamental interest, but merely because it can be calculated.

In summary it seems to me that the use of computers in science is just emerging from a tempestuous adolescence with the promise of a rounded, healthy maturity still before it. I think all will agree with one of the physicists that,

> The sooner the computer and its ramifications are accepted as just another research tool and not a bogeyman or utopia, the better.