SESSION II ADDRESS

LEE W. GREGG, *Carnegie-Mellon University, President*

On-line instrumentation in psychology: Dildo or the real thing?

JOSEPH B. SIDOWSKI
University of South Florida, Tampa, Florida 33620

The impact of laboratory digital computers as reflected by research publications is evaluated.

I am certain that some of you are intrigued by the title of this presentation, "On-line instrumentation in psychology: Dildo or the real thing?" The on-line instrumentation reference requires little clarification. We are attending this Conference because of our interest in on-line computers. The word dildo, of course, is not listed in computer dictionaries, but it is an instrument that requires an interface. It is said that great care and skill are put into dildo manufacture and, as with the laboratory computer, there are a number of versions available. Both the laboratory computer and the dildo are sometimes purchased by males out of sheer curiosity. More often, both are purchased for purposes of self-gratification. But my reference to dildo effects as related to laboratory computers will become clear as we go along. I will try not to mention the term again.

The primary purpose of this presentation is to examine the reported uses of laboratory computers in research as reflected in professional journal publications. At the first meeting of this Conference in 1971, I presented an address, "Various uses of minicomputers in psychology" (Sidowski, 1972), which focused on small laboratory computer systems. At that time, a large number of different minicomputers were being marketed (Sidowski, 1970) and some were being used or purchased by psychologists. The reasons for some purchases were unclear. As I noted elsewhere (Sidowski, 1972), some treated the laboratory computer as a solid gold Cadillac to be seen and admired by all. Many machines were merely placed on display to be shown to visitors; others were used to carry out statistical analyses that could have been done on a calculator. Psychologists with an overabundance of grant funds

were sometimes swayed by the sweet and sultry tones of the friendly computer company salesman. Ever-present hardware types involved themselves in figuring out which circuits made the little lights go on and off so rapidly. Most were ill-prepared for software and interface involvement or problems. But the serious scientists were excited by the potential of the laboratory digital computer in research. Not only could these digital machines operate on-line, but they could do it in real-time, and that was really something. Indeed, in his 1968 book on *Real-Time Computers in Psychology*, Uttal emphasized the importance of the contingent capabilities of laboratory computers and, in his 1971 address to this Conference, real-time contingent capabilities were reemphasized; also emphasized was the ability of the laboratory computer to open new theoretical and empirical doors, and to provide new techniques for analysis of problems that could not have been handled previously (Uttal, 1972). In a more recent paper, however, Uttal indicated that, after a decade of laboratory computer use, contingent procedures were not so influential, although they were fairly easy to implement (Uttal, Note 1). The apparent reason was that our statistical techniques and reporting procedures were not well enough developed to handle contingent results, and that many computer users who had tried contingency programming reverted to more conventional procedures. The same sentiments were expressed by Donald Norman in addressing this Conference (1973). Norman noted that grant applicants who tried to justify purchase of a computer often stated that the machine was required to allow the researcher to make presentations of stimuli contingent upon responses. He went on to state that such justifications were nonsense, not because the statements were not true, but because psychologists did not know what to do with response-contingent presentations that messed up statistical

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analyses and made experimental results more difficult to interpret. Norman pointed out that it was the research areas that did not rely on careful designs or standard assessments that used response-contingent methodology, e.g., operant conditioning. Experimenters in these areas used other methods of control.

So it appears that the early hopes that great research insights would develop from the response-contingent control capabilities of relatively small laboratory computers have not been sustained. Although some of our colleagues, e.g., Uttal, have on many occasions praised the laboratory process control real-time computer as perhaps the most significant advance in psychological history, the same individuals now show concern. And for good reason: The payoff in terms of published results has not been impressive.

At the first meeting of this Conference, I reported the results of a computer survey covering a number of psychology journals over the period 1965-1970 (Sidowski, 1972). Only 11 authors provided 52% of the citations reflecting use of a laboratory computer as a research tool. Included in this group were Bliss, Blough, Mayzner, Pollack, Pribram, Uttal, and B. Weiss. A survey of the same publications covering 1971 showed little change (Sidowski, Note 2). Over the same 5- to 6-year period, journals representing social, personality, and child psychologies showed virtually no citations of on-line laboratory computers. A 1974 review of the same journals showed little significant improvement. But it is the "basic" experimental journals that should be examined for a more detailed look at the number of laboratory computers used as research instruments.

In 1970 over 275 articles were published in the *Journal of Comparative and Physiological Psychology* (JCPP). Approximately two of these reported the use of a computer: One was an IBM-360 for EEG spectral analysis, and the other was a signal averager (CAT). The number of laboratory digital computers reported in JCPP has been slight. In the year 1974 about 1½% of the approximately 270 articles cited the machines.

The *Journal of Experimental Psychology* (JEP) contained over 1,900 articles in the 6-year period, 1959-1970 inclusive. Slightly less than 1% of the articles reflected any computer use and 25% of these were commercial signal averagers. In 1972 the figure was slightly less than 2%; in 1974 approximately 5% of the JEP articles reported the use of laboratory computers in research.

The journal of *Perception & Psychophysics* has consistently published research using lab computers, and the percentage has fluctuated slightly over the years 1970-1974. About 10% of the 1970 articles cited the machines, but a large proportion of these were of the PDP-5, -7, and -9 varieties. The 10% cited in 1974 were predominantly in the PDP-8E, -8I, and PDP-12 computer families.

About 13 articles in *Memory & Cognition* (10% of 1974 publications) reported laboratory computer use; two of these were large systems (PDP-15). *Cognitive*

Psychology cited only a few systems for all of 1974, as did the *Journal of Verbal Learning and Verbal Behavior*.

Approximately 15% of the 1974 research reports in the *Journal of the Experimental Analysis of Behavior* (16 of 108 articles) indicated the use of laboratory computers. Virtually all of these machines were employed in on-line response-contingent situations.

Two neurophysiological journals were surveyed, and both showed a surprising decrease in the total number of articles reporting the use of any kind of computer for whatever purpose. For the journal *Electroencephalography and Clinical Neurophysiology*,¹ approximately 36% of the 1970 publications cited some sort of a computer. By 1974 the number dropped to 23%, and in 1975 the figure was 22% of the total. The *Journal of Neurophysiology* showed approximately 28% of its 1970 articles noting any type of computing machine. In 1974 the figure was 25%, and in 1975 it dropped to about 17%.

The number of machines of all types reported in the neurophysiological vs. "psychological" journals is impressive. Tepas (1974) reported a survey of articles in *Electroencephalography and Clinical Neurophysiology* over a 15-year period from 1957 to 1972 which indicated that over 45% of the reports involved some sort of automatic data processing. But in two symposia reports (Sidowski, Notes 2 & 3), I noted that a large number of the computing systems cited in neurophysiological journals were dedicated commercial signal averagers of the Fabri-Tek and Mnemotron CAT types. In 1970, for example, about 69% of all computers reported in *Electroencephalography and Clinical Neurophysiology* were of this type; in 1972 70% were commercial signal averagers. In 1975, however, the figure dropped to approximately 33%, with the remaining machines representing laboratory digital computers of the PDP-8, PDP-12, and IBM-1800 types, most of which also were used for signal averaging and analyses. The number of Fabri-Tek and Mnemotron CAT type averagers reported in the *Journal of Neurophysiology* from 1970 to 1975 varied yearly from approximately one-quarter to one-third of all computers cited. For 1975 about 13 of a total of 101 articles noted laboratory digital computer use. Ten of these systems were of the DEC PDP-8 or -12 varieties.

In summary, what do these surveys indicate concerning happenings in laboratories in the past several years as reflected in journal research publications?

(1) Overall, more laboratory computers are being cited in research reports. But the figures are unimpressive, extremely so given the hundreds of machines now in the hands of psychologists.

(2) Reports on on-line real-time response-contingent uses are minimal except in studies using operant conditioning procedures. These are reflected in publications of the *Journal of the Experimental Analysis of Behavior* and in biofeedback experiments reported in *Psychophysiology*.

(3) Research of the types reported in the *Journal*

of *EEG and Clinical Neurophysiology* and the *Journal of Neurophysiology* show widespread use of laboratory digital computers of the PDP-8 and -12 varieties. But the predominant functions of the machines are to average neural signals and analyze data, oftentimes off-line. Commercial signal averagers of the Fabri-Tek and CAT types continue to be reported in significant numbers.

(4) Research reported in the "classic" and prestigious journals in experimental psychology, namely, the *Journal of Comparative and Physiological Psychology* and the *Journal of Experimental Psychology*, very seldom involved the use of laboratory computers.

(5) Although an occasional user's name appears more than once in the 1974 journals, there is no longer a small block of individuals dominating published reports of research supported by laboratory computers.

(6) Computers marketed by Digital Equipment Corporation continue to dominate the field, but an interesting change has taken place. In the 1974 journals, the Digital Equipment Corporation PDP-12 is cited as often as all members of the PDP-8 series, including the LINC (about 30 references each in a total of over 1,500 experimental articles). Although the Data General User's Group affiliated with this Conference has a substantial number of members, relatively few of these computer systems are cited as support instrumentation in the approximately 7,000 research publications surveyed from 1970 to 1974 inclusive. The first Data General Nova computer was delivered in 1969; in 1971 at this Conference, I described several systems being used by psychologists.

It is difficult to pinpoint a specific reason why hundreds of psychologist laboratory computer owners and/or users are so poorly represented in research publications. I was surprised to find known computer owners reporting noncomputer-supported research which could have been instrumented optimally with the machines. Maintenance downtime for the computing machine itself is seldom cited as a problem. Lack of technical help and personnel turnover and training sometimes cause interruptions, but so do other things. The seemingly everlasting problems of interface and software remain. In the Spring 1975 Decus Symposium meetings in Miami, panel members of one session felt that many users new to the computer business found themselves caught in a whirlwind of OS/8, ADDS, DOS, RSX, and RSWHAT, when all they really wanted was help in getting their system to run. One purpose of this Conference is to provide a forum to do just that. But, whatever the reasons, it is obvious from our surveys of professional research journals that much of the activity associated with laboratory digital computer use must, in the language of the infant or child psychologist, be labeled "nonnutritive sucking." It appears that, for many owners and users, the substitute object intimacy of the pacifier is more attractive and satisfying than the real

thing. But, no matter how far removed it becomes, perhaps any intimacy is better than none at all.

Of course, laboratory computer users continue to publish descriptions of systems, hardware, and software in the printed Proceedings of this Conference, and in the journal of *Behavior Research Methods & Instrumentation*. At the first Conference meetings in 1971, a large portion of the program dealt with descriptions of various types of systems. It was show and tell time. Thirty presentations were given, 27 of which were published in the Proceedings in March 1972. The meetings since then have generated between 40 and 49 papers annually with an increasing emphasis on software.

In 1969 and 1970 the Computer Technology section of *Behavior Research Methods & Instrumentation* reported little software; most articles dealt with laboratory computer system descriptions or specific hardware items. Over the past few years, software descriptions have increased noticeably.

But what of the future? According to a recent Frost and Sullivan market research report, over the next decade sales of minis will soar from some 150,000 toward the end of 1974 to 2 million; microcomputers will increase from 100,000 to 15 million. This 12-fold gain in minis and 150-fold in micros in 10 years should be accompanied by continuing drops in prices. So psychologists can be expected to purchase more computing machines. In spite of these expected rapid and drastic reductions in prices of minis and microcomputers, it is difficult to agree with a recent editorial in *Science* (Etzioni, Note 4) that "... Instead of feeding data into a central computer, every researcher, indeed soon every research assistant, may have one or more computers at his disposal or linked to his instruments." In the foreseeable instrumentation future of psychology, I doubt that there will be a chicken in every pot.

Ever since Intel Corporation launched its first chip in 1970 (the 4004 4-bit processor), microprocessors have been making waves in the computer industry. With time, microcomputers will make significant inroads in psychology laboratories. Whether their uses will be reported in the apparatus sections of research publications, as are minicomputers, remains to be seen. Needless to say, future surveys of laboratory computer utilization will require some redefinitions.

Interactive graphics have been with us since the early 1960s, when Ivan Sutherland developed "Sketchpad." Since then, interactive graphic systems have been expensive. In the future, they should be much less expensive (and compatible with TV) and more available to the behavioral scientist.

The plasma display terminal that evolved as part of the PLATO computer-aided instruction project at the University of Illinois is now available for small laboratory computer systems at a cost of less than \$3,000. The ability of the plasma display to yield a grid of finger-touch selectable positions, one for each fiche image, should prove popular.

The computer in a briefcase (Dynabook) described in mock-up cardboard form by Norman a few years ago (1973) is now a working system, although not in finalized form. The Interim Dynabook is a completely self-contained system that appears as a small black box connected to a very crisp high-resolution black and white CRT, or to a lower resolution high-quality color display (Kay, Note 5). A disk memory containing about 1,500 page-equivalents of manipulable storage can be inserted into the small unit. Input devices include a standard typewriter keyboard, a chord keyboard for sending simultaneous signals, a mouse which inputs position as it is moved about, and varieties of organ-like keyboards for playing music. Other new input devices may be easily attached, usually without building a special hardware interface. The Interim Dynabook, developed at the Xerox Palo Alto Research Center, is powerful enough to be able to produce real-time half-tone video animation and real-time multiple-voice musical-tone synthesis. The experimental communications medium is *Smalltalk*, a successful extensible language which focuses on representing the meanings of things through descriptions and "gets its syntactic extensibility for free" (Kay, Note 5). Among other characteristics, *Smalltalk* offers a class of turtles that have location, direction, tip-state, ink-color, boundary, and other properties.

Finally, as the number of computers increases in laboratories, more researchers and their students will speak "computerese." Because others will have difficulty understanding and communicating in this language, "computeresians" in most installations will be forced to band together. We can expect most of these souls to join this Conference.

Of course, it is the ultimate use of the above mentioned and other developments that is of concern. Researchable ideas must be generated and implemented to make optimal use of any of these or other developments. And, if the laboratory computer is to enable experimenters to open new theoretical and empirical doors, as I believe it already has done, the techniques and results of investigations must be communicated through professional publications.

Psychologists have not been lax in the past in reporting the use or development of instruments (in a broad "subject on-line to instrument" sense) for research. For example, the earliest published reports on the use of the electroencephalograph in the United States were by psychologists. In a "Special Article" in *Science* (1935), Jasper and Carmichael reported on electrical potentials from the intact human brain. A year later, Donald Lindsley (1936) published "Brain potentials in children and adults" in the same journal. Lindsley also did some of the early work on the electrical activity of human muscle (1935). Several years earlier (1932), Darrow published a paper, "The behavior research photopolygraph," describing the polygraph, later marketed by Stoelting, which became a basic

instrument for on-line psychophysiological measurements. Darrow's early work (1929) was also crucial in pointing out the independence of on-line measures of digital blood volume from those of skin resistance. Feré (1888) co-discovered the electrical skin change phenomenon, but much of the early research on humans and on instruments of measurement in this country was carried out by psychologists. Darrow (1927), for example, wrote of the "Sensory, secretory, and electrical changes in the skin following bodily excitation." Davis (1929) reported on a vacuum tube for stabilizing current during on-line measurements of the galvanic reflex.

The present day research thrust in the study of eye movements reflects an increasing dependence on on-line laboratory computer systems for control, response measurement, and data analyses. But it is difficult to ignore the fact that "The Iowa eye-movement camera" was reported 44 years ago in *Science* by psychologists Jasper and Walker (1931). Lorin Riggs and his students have published articles on the motions of the human eye for years; Riggs' report (1941) on the "Continuous and reproducible records of the electrical activity of the human retina" contributed to retinogram development.

The program of this meeting cites several presentations dealing with the elegant use of laboratory computers in the study of speech and audition. But substantial contributions to our fund of scientific knowledge must stand the test of scrutiny and time. In reviewing the literature, I was surprised to discover that the earliest printed report (at least the earliest that I could find) concerning the use of a camera to photograph sound waves for measuring speech was by psychologist C. E. Seashore (*Scientific Monthly*, 1927), whose laboratory from the 1890s on contributed so much to the development of modern audiometric techniques.

In education and training, psychologists developed machines and programs for on-lining students for automated instruction. In the 1950s a small number of our colleagues were actively involved in the development of computer-aided instruction at such installations as Systems Development Corporation (SDS) and IBM. Some recent developments are reported in the Instrumentation Issues of the *American Psychologist* (Sidowski, 1975; Sidowski & Ross, 1969).

This small sample of activities is sufficiently impressive to allow me to conclude with Oscar Wilde's definition of a grapefruit, which, for some ungodly reason, I believe says something to the small laboratory computer user. Wilde said that a grapefruit was "a lemon that had a chance and took advantage of it."

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NOTE

1. The survey of *Electroencephalography and Clinical Neurophysiology* included all articles published in the Journal, i.e., "main" articles, technical contributions, and clinical studies.