Robotic aids, those willing servants of mankind portrayed in science fiction, may play an important role in health care in the future. As health care costs increase, new approaches will have to be found to deliver more benefits for the health care dollar. Using adaptive tools such as robots to decrease severely disabled persons' dependence on full-time health care attendants would lessen those costs (Awad & Engelhardt, 1984; Engelhardt & Awad-Edwards, 1985b).

Robotic aids also may improve the quality of health care. Robots can monitor patients 24 hours a day, 7 days a week, and never become bored or upset. Unpleasant menial tasks, such as cleaning urine off the floor, can be performed by the robot, leaving the worker time to provide service in other areas (Engelhardt, 1984). Furthermore, robotic aids can give disabled patients increased control over their environment and increased independence, thus improving the quality of their lives (Leblanc & Leifer, 1982).

Current Uses of Robotic Aids

At present robotic aids are being evaluated for use by persons with spinal cord injuries who have no arm or hand function (C1-C5). One aid, a robotic arm/workstation system, was developed jointly by the Johns Hopkins University Applied Physics Laboratory and the Richmond, Virginia, Veterans Administration Medical Center. It consists of a prosthesis and workstation which has been modified for use by the disabled (Seamone & Schmeisser, 1985). The slow, simple robotic arm is commanded by chin controls. Some of the tasks this system can perform include using a telephone, placing diskettes in disk drives, picking up magazines, and feeding with utensils. These tasks were identified as priority needs after visits to spinal cord injury centers. Other important needs identified were the management of a variety of reading materials; the use of a typewriter, including insertion and removal of a sheet of paper; various hygiene and personal needs; and other vocational tasks.

The robotic system in Figure 1 was developed at the Palo Alto Veterans Administration Hospital and Stanford University (VA/SU). It includes a voice recognition and output unit (a VOTAN, which allows the user to enter commands verbally) and a Unimation PUMA-260 robotic arm, and it is controlled by an IBM AT microcomputer. Patients using this system have completed such varied tasks as combing hair, brushing teeth, washing face, placing and removing food from a microwave oven and refrigerator, and shaving (see Figure 2). The selection of tasks for this robotic system was determined by surveys of spinal cord-injured people and nursing staff of a skilled nursing center.
The spinal cord-injured users requested that the robot assist in activities of daily living such as feeding and picking up objects (Holloway, Lockard, Engelhardt, & Leifer, 1984). The nurses additionally requested that the robot be used as a urine cleaner and an ambulator (aid for walking) (“Hearing,” 1984). The system is also being evaluated for vocational tasks.

Another robotic system, also developed at VA/SU, consists of a robotic arm attached to a mobile base; it has yet to undergo clinical trials.

A robotic aid station was developed by Boeing Computer Services for a quadriplegic working in a business programming environment. It is a voice-activated, microprocessor-based workstation with two RTX robotic arms (Fu, 1986).

**Robotic Aid Survey**

Occupational therapists have observed patients using a variety of assistive devices and adaptive aids; they therefore understand how widely these devices are available and how easily they can be used. We wished to tap this source of information to identify important tasks that could be fulfilled by robotic aids. By conducting a survey, we also hoped to increase therapists' awareness of robotic technology in health care and determine their attitudes toward the use of robots as adaptive aids.

**Procedure.** Four hospitals in the San Francisco Bay area were selected as sites for the survey (a) because they are located in close proximity to the Palo Alto Veterans Administration Hospital and (b) because they rehabilitate spinal cord-injured patients. At each hospital a three-part presentation on health care robots preceded the administration of the questionnaire. The first part consisted of a 5-minute videotape showing industrial robots in action, the VA/SU robot being programmed by voice by a quadriplegic patient, and the preparation of a meal. The second part was a 20-minute slide show illustrating the advantages of health care robots, how they combine the features of personal and industrial robots, and some of the safety features of the VA/SU robot. Also discussed were the four main areas of application of health care robots: activities of daily living and recreational, vocational, and therapeutic applications. The third part was a 3-minute videotape of a robot dancing to choreographed music to demonstrate that the robot has aesthetic as well as utilitarian qualities (Apostolos, 1985).

The 51 occupational therapists within these four hospitals (average age 31.5 years, mean experience 10.87 years) completed a 53-item questionnaire. The questionnaire included multiple choice, true-false, and essay questions.

**Results.** Respondents admired the technical competence of robots reporting them to be valuable, obedient, fun, and intelligent. But they remained slightly leery of them finding them mysterious, difficult, and unfriendly. Respondents indicated they were very interested in robots but were ignorant of their potential.

When asked if they wanted to learn to use the robot, 88% responded positively. Using a 1-to-5 scale, respondents agreed that knowing how to use robots is an asset ($M = 3.81$), that robots can be useful in a vocational environment ($M = 4.38$), and that robots have many beneficial applications ($M = 4.38$). Respondents disagreed that using a robot requires a mathematical mind ($M = 1.78$) or an understanding of electronics ($M = 1.88$).

Fifty-nine percent of the respondents stated that occupational therapists should be the professionals responsible for training patients to use a robot.
whereas 20% stated that engineers, together with occupational therapists, should complete the training.

Over half of the respondents mentioned activities of daily living as the tasks they most wanted a robot to do for patients. Specific tasks mentioned included obtaining items outside the patient’s reach; cooking and meal preparation, feeding; lifting and carrying heavy objects; dressing; grooming/hygiene; turning/ transfers and shifting weight; and elimination functions. Other areas mentioned by respondents in which robots could be useful to spinal cord-injured patients were emergencies, vocational/avocational activities, cognitive training, and coordination training.

The problem respondents envisioned with the use of robots were (a) a potential increase in dependence (20%) and (b) the impersonal character of robots and isolation from human contact (10%). Other problems envisioned in using robots included intimidating hardware, lack of portability, the complexity in set-up, home accessibility, and changing technology.

Discussion

It is highly probable that robots will be used in health care in the future (Van der Loos, Michalowski, & Leifer, 1986; Engelhardt & Awad-Edwards, 1985a) and that their use will be expanded to disability groups other than the spinal cord-injured (“Hearing,” 1984). Occupational therapists will likely be involved in training patients to use robots as adaptive aids and in helping design appropriate environments for robots.

One of the disadvantages in using robots, according to respondents, was the increased dependence robots could create. This problem could be reduced by the therapist’s determination of the optimal time for introduction of the robot during rehabilitation.

A major concern in the use of robots as adaptive aids is cost. The PUMA 260 (the VA/SU robot) costs $35,000 to $50,000, and the Johns Hopkins robot, when available, may cost between $10,000 and $15,000. The mobile VA/SU robot is even more expensive because of the increased complexity inherent in its mobility. These costs are far beyond the $1,000 to $5,000 mentioned by the respondents (68%) for a multipurpose stationary robot. However, the cost of robots has decreased substantially over time, and the increase in demand would further drive down costs. Occupational therapists must also consider the different types of environments required for each kind of robot. Flexible set-ups that maximize both accessibility and a person’s independence will be required. The Veterans Administration has constructed such an environment and is currently evaluating the time required for the robot to learn to use the environment and (b) the proficiency of a stationary robotic arm in completing tasks using a workstation. Problems such as portability, home accessibility, and safety are being addressed in the Veterans Administration’s evaluation of its robotic aid.

Summary

The occupational therapists in our survey were generally positive about robots and interested in learning more about how robotic technology can help people with disabilities. Rehabilitation research and development, education, and training are needed to address the concerns therapists expressed regarding dependency and convenience as well as issues concerning isolation from human contact and cost.

References


