Over the last 5 years, technological advances have resulted in specialized technical aids, such as electronic communication devices, computer input devices, and environmental control systems, which have made it possible for many persons who are severely physically disabled to enjoy greater functional independence within the home, school, workplace, and the community. This paper focuses on environmental control systems and discusses how occupational therapists match environmental control systems with clients' needs.

One of the first environmental control systems on the market was the POSSUM, developed in the 1950s in England primarily for persons with polio. The POSSUM system was a centralized unit with all of the peripheral devices connecting directly into the CPU. POSSUM was rather large in size and, thus, most suitable for long-term use in only one location. Many refinements have since been integrated into environmental control systems. Over the years manufacturers have improved the packaging, increased user versatility, added more specialized accessories, integrated wireless BSR technology, increased portability, improved the appearance, and lowered the cost of environmental control systems. Since 1970, a number of companies have applied microprocessor-based technology to develop the current range of commercially available systems.

In 1982, LeBlanc and Leifer wrote that "every physical disability reduces man's capacity to transmit, receive, or process information" (p. 17). However, diagnosis alone does not determine an individual's candidacy for an environmental control system. Each person's needs must be evaluated separately, and his or her potential for an environmental control system must be based on the total needs and the specific...
environment of each individual. It is the occupational therapist's job to determine if the client's needs will be satisfied with an environmental control system and which features and capabilities will be required. The purpose of this article is to outline the steps that need to be taken to successfully match environmental control systems with a client's needs. Although the technology has come a long way since the days of the cumbersome POSSUM, the ideology behind environmental control systems has remained the same: purposeful control by the individual over his or her environment.

Evaluation of Client

The first stage in determining what variety of environmental control system is appropriate for the client is the physical and psychosocial evaluation. The therapist should determine the client's comprehensive neuromotor status by examining the client's (a) muscle strength and range of motion, (b) endurance or ability to resist fatigue, (c) sensation capabilities, (d) visual/aural/perceptual status, and (e) gross and fine motor coordination. These physical aspects will help to determine what kind of transducer (or activator device) best suits the client's capabilities and will help the therapist assess how easily the client will be able to process the visual and auditory feedback necessary to successfully operate the system.

The transducer (or control switch) will vary with different environmental control systems. Operation can be achieved through one or more options as follows:

- a dual control interface (i.e., sip-puff, rocking lever)
- an input controller for a powered wheelchair
- a computer
- an electronic communication aid
- a voice recognition component

The choice of transducer will depend on the results of the physical evaluation. For many high-level quadriplegics (i.e., C1 to C5), the sip-puff (pneumatic) dual control switch is frequently preferred. It converts breath pressure into an electrical signal that controls the on/off operation of an electrical device (see Table 1). Naturally, whatever physical activity is chosen will need to be the one most easily performed by the client. A nonspeaking client can use the electronic communication system to control the environmental control system.

The second stage of the evaluation involves the cognitive status of the client. The motor-planning skills, short- and long-term memory, and cognitive processing skills of a potential environmental control system user need to be considered. The therapist must (a) assess the client's capability for learning new tasks and (b) determine the most complementary method of integrating new skills with old activities. A client who shows the cognitive ability to perform the steps involved in operating an environmental control system should be considered a viable candidate for using this technology.

The client's motivation and functional capabilities also need to be considered when an environmental control system is prescribed. The therapist will need to identify the specific tasks, both current and future, that the client would like to perform. Expectations must be tempered with realism and should remain within the client's range of safety and judgment. Additionally, the therapist needs to determine what other equipment the client already has to see how the environmental control system will mesh with the existing equipment. Will the client need an environmental control system on a short- or long-term basis?

In the fourth and final area of the evaluation, the therapist must assess the client's environment and daily routine. The accessibility of the residence (i.e., use of assistive devices or a wheelchair) will make a difference in the ability of the client to operate different kinds of systems. The availability of personnel to assist the client and of funds to support the system will also affect the choice of an appropriate environmental control system.

<table>
<thead>
<tr>
<th>Environmental Control Unit Peripherals Operated via Wireless BSR Modules</th>
<th>Operational Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lamp</td>
<td>on/off + dim/brighten</td>
</tr>
<tr>
<td>Radio</td>
<td>on/off</td>
</tr>
<tr>
<td>TV</td>
<td>on/off</td>
</tr>
<tr>
<td>Fan</td>
<td>on/off</td>
</tr>
<tr>
<td>Tape recorder</td>
<td>on/off</td>
</tr>
<tr>
<td>Various other household appliances</td>
<td></td>
</tr>
</tbody>
</table>
Environmental Control System Considerations

In choosing the appropriate environmental control system, the therapist should examine each model’s standard features—what it does and doesn’t do and what the optional capabilities are (see Table 2). This information should enable the therapist to determine whether or not the environmental control system will be compatible with the client’s other equipment, support personnel, and environment. Questions to be considered include the following:

- How difficult will the system be to operate?
- Does the product have a reputation for reliability and durability?
- Is it easy to install?
- Is it portable?
- Is the manufacturer likely to be around in 5 years to support or repair the system?
- What sources of feedback are available (e.g., auditory, visual)?
- What are the training requirements necessary to operate the system successfully?

Once the need and viability of an environmental control system have been determined, several factors should be considered in the final selection. The first consideration is the position from which the user will want to control the system. The two most common positions—from the bed and from the wheelchair—may require two different transducers or control switches. If the client is able to move independently in a powered wheelchair, he or she may prefer a remote, wireless control. The therapist should also decide whether the increased safety and independence afforded by an environmental control system outweigh the negative factors of potential failure, maintenance, and the expense of purchasing the system. Who will be responsible for assisting the user with system upkeep and maintenance must also be determined as well as who will pay for the environmental control system, the additional accessories, and ongoing training and support.

Classification of Environmental Control Systems

Once the therapist is satisfied that the client meets the physical and psychosocial requirements necessary to operate an environmental control system, he or she can begin to select from one of the three varieties of environmental control systems that will most likely meet the client’s needs (see appendix for a listing of commercially available systems). The following classifications have been developed previously by the first author (Dickey, 1986).

Table 2

| Specialized Accessories and Custom Modifications for Environmental Control Systems |
|---------------------------------|-------------------------------|
| **ACCESSORIES**                 |                               |
| **Telephone.** Permits total independence in all aspects of telephone management, including receiving incoming calls, placing outgoing calls, dialing new numbers, storing numbers into directory, and dialing frequently used numbers from directory. |
| **Call signal.** Produces attention-getting auditory output to seek assistance/help from someone. |
| **Intercom.** Permits user communication link with other remote locations within environment. |
| **AM/FM radio.** Permits user control over on/off, tuning, changing AM/FM status, alarm. |
| **TV Channel Selector.** Permits user control over on/off, volume, channel selection. |
| **Electric bed controls.** Permits user control over features of many electric beds. |
| **CUSTOM MODIFICATIONS**        |                               |
| **Door lock release.** Permits user control over state of door lock mechanism. |
| **Powered drapery.** Permits user control over opening and closing powered drapery. |
| **Closed circuit security system.** Permits user control over checking to see who is at door and opting to allow them inside using door lock release. |
| **Page turner.** Permits user control over page turning. |
| **Video equipment.** Permits user control over VCR equipment. |

Note: a Accessories are typically connected directly to a centralized or combination centralized/modular environmental control system although they can be combined with a control interface to be used as a free standing environmental control unit. b These modifications are made on a custom basis for specific users.

Centralized Systems

With centralized units, the peripherals are connected directly into receptacles located on the CPU. The units that are available commercially vary in the number and type of appliances and devices that they can support. High-voltage (120 V), alternating current receptacles provide the capability of using on/off latching controls. Latching refers to channels that, when activated, lock the function in on until activated again when they are locked off. Low-voltage, direct current receptacles provide for more complex switching functions such as momentary controls for selecting television channels and operating call signals, page turners, and bed controls. Momentary controls hold the function on only while the control switch continues to be activated by the user. Because of their ability to handle several devices and afford the user more specialized control, centralized units are sometimes referred to as master systems. Because of their increased capabilities, these systems generally command a higher price than other systems.
Modular Systems

In modular environmental control systems, each peripheral operated is connected to its own wireless module, which in turn is plugged into a standard wall outlet. In this system, signals travel from the control box over existing wiring, using a special electrical frequency, to individually coded modules located throughout the user's environment. These signals activate or deactivate the corresponding coded peripheral device. Also included in this category are various specialized peripherals which, together with a control interface, represent a functional, independent system. Sometimes referred to as mini systems because of their limited on/off capabilities, modular units are generally lower in price than centralized systems.

Combined Centralized/Modular Systems

Several systems now combine features of both the centralized and modular systems. Typically, devices that require only on/off switching are controlled by the modular method while functions that require low-voltage, momentary control are handled by the centralized method. These interactive systems are also referred to as master systems because they permit the user more specialized control and allow for the use of more devices than does either of the separate systems. They generally command a higher price than the modular systems.

Applications

With their clinical emphasis on the whole person and on maximizing functional independence, occupational therapists have played an important and unique role in the development and implementation of environmental control systems. The following case studies reflect different user needs and identify a number of potentially appropriate systems for each case.

Client A. Mrs. Taylor, a 45-year-old woman with rheumatoid arthritis, is alone at home most of the day while her husband is at work. She would like to be able to independently operate lamps, the television set, and a fan. Because of pain and severe contractures in her finger joints, limited range of movement, and general weakness, she is unable to manipulate the standard controls on household electrical devices.

Based on Mrs. Taylor's needs for on/off operation of household appliances the following environmental control system options are explored: (a) Scanning X-10 Powerhouse plus control interface, (b) BSR-ESC-8 plus control interface, and (c) 4 Channel ECU plus control interface.

Client B. Tom, a 25-year-old, C4 quadriplegic, uses a sip-puff input controller to operate his powered wheelchair and a mouthstick for painting and to operate a push button telephone. He is moving from his parents' house to an independent living center and wishes to be as functionally independent as possible in telephone management, the on/off operation of lights, fan, and radio; the operation of the television (on/off, channel selection, and volume control); the operation of a call signal to alert central security; and the operation of a bed control. His future projected needs for an environmental control unit are to operate a page turner and to use wireless operation from his wheelchair.

Based on Tom's current and projected future needs, the following environmental control system options are explored: (a) Control 1; (b) Mecca; and (c) Microdec.

Before a final selection is made, both Mrs. Taylor and Tom should have an opportunity to try each system within the settings in which it will be operated. This process will provide additional information regarding ease of operation, transducer (i.e., control switch) options, positioning options, appearance, durability, function versus cost, and other important system characteristics.

Conclusion

Environmental control systems have made significant contributions to increasing the functional independence of people with severe physical disabilities. Through current technology, this population is able to enjoy a higher level of participation in life's many activities, and, in the process, reduce the cost of attendant care. With environmental control systems, many people with severe disabilities can return to the workplace and enjoy increased personal satisfaction.

It is hoped that the role of environmental control systems will be enlarged in the future to include the new technological features of robotics and voice control. Robotics have been considered a promising area of environmental control for several years, and the design of a robot intended for human-service applications is presently being addressed by the Palo Alto Veterans Administration Hospital and Stanford University. The use of voice recognition as an input option for environmental control systems also has been explored because speech is a natural means of communication and may be one of the few remaining functions available to a person who is severely physically disabled (Clark & Roemer, 1977). However, this approach has been plagued by low recognition rates, reduced speeds of input, interference from environmental noise, and poor response to the user's stress and anxiety (Clark & Roemer). Nonetheless, it is likely that these difficulties will be resolved in the future and that robotics and voice control will be im-
plemented as important options in environmental control systems. Advances are currently being made in other areas, including augmentative communication systems and improved control interfaces for wheelchair mobility. Another recent development is the availability of comprehensive systems that permit the user to use one and the same input device to access multiple systems such as a computer, a wheelchair drive, environmental control, and communication. These advances in technology will widen the focus occupational therapists now use to integrate persons who are severely physically disabled with their environment. The goal, however, will remain the same: to promote functional independence in daily living.

Appendix
Commercially Available Environmental Control Systems

I. CENTRALIZED

Control 1
(Custom systems for hospital use)
Manufactured by Prentke Romich Company, 1022 Heyl Road, Wooster, Ohio 44691 Phone: (216) 262-1984 or (800) 642-8255.

4 Channel ECU
8 Channel ECU
Manufactured by Rehab. Technology, Inc, 2815 Orchard Court, Highland, Illinois 62249 Phone: (618) 654-1687

II. MODULAR

Microdec
Manufactured by Medical Equipment Distributors, Inc., 3223 South Loop 150, Lubbock, Texas 79423 Phone: (806) 793-8421 or 800-253-4134

BSR-ESC-8
X-10 Powerhouse
BSR X-10 Command Console
Manufactured by X-10 (USA) Inc., 185 A Legrand Avenue, Northvale, New Jersey 07647 Phone: (201) 784-9700.

Scanning X-10 Powerhouse
Manufactured by Prentke Romich Company, 1022 Heyl Road, Wooster, Ohio 44691 Phone: (216) 262-1984 or (800) 642-8255.

III. COMBINED CENTRALIZED/MODULAR

Control 1
Manufactured by Prentke Romich Company, 1022 Heyl Road, Wooster, Ohio 44691 Phone: (216) 262-1984 or (800) 642-8255.

Mecca
Manufactured by DU-IT Control Systems Group, 8765 Twp. Road 513, Shreve, Ohio 44676 Phone: (216) 567-2906.

Encoscan
Kincontrol
Manufactured by TASH Inc., 70 Gibson Drive, Unit 12, Markham, Ontario, Canada L3R 4C2 Phone: (416) 475-2212.

References


Related Readings


