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Patient and staff acceptance of robotic technology in occupational therapy: A pilot study

Marcel P. Dijkers, PhD; Patti C. deBear, OTR, BS; Robert F. Erlandson, PhD; Kathy Kristy; Deanna M. Geer, OTR; Angelo Nichols
Rehabilitation Institute of Michigan, Detroit, MI 48201; Metropolitan Center for High Technology, Detroit, MI 48201; Applied Computer Engineering, Inc., Detroit, MI 48201

Abstract—While the majority of applications of robotics in the field of rehabilitation focus on the development of smart aids for people without upper extremity function, there is also potential for the robot as a therapy "aide." We designed, built, and pilot-tested hardware and software that used a robot to provide muscle reeducation movement patterns after stroke. This is a report on a field trial, in which 11 occupational therapists used the system with 22 patients; each patient averaged 2.2 sessions. Based on information contained in the system database, a log, patient interviews, and therapist questionnaires, we evaluated safety, system utility, and patient and therapist acceptance. The results suggest that robotic treatment is safe and accepted (if not welcomed) by patients. The therapists expressed a qualified acceptance, suggesting several modifications to increase utility. The potential for the application of robotics in rehabilitation therapy is discussed in light of these findings.

Key words: *manpower, movement patterns, occupational therapy equipment, rehabilitation therapy, stroke.*

INTRODUCTION

Robots were first introduced into the field of rehabilitation as mechanical personal care attendants (PCAs), or smart aids. Currently, at least nine different groups in five countries are at work on further development of what is variously called a robotic aid, manipulator, robot arm, or work station (4-6).[1-9] These projects have different premises and goals. The robots are in different stages of development; the only one being marketed commercially (as of this writing) is the Boeing workstation,[3] now known as the PRAB Command 1, a voice-activated personal workstation that makes it possible for a quadriplegic person to perform many clerical and managerial jobs. The Johns Hopkins robot arm (with chin control rather than voice input) can brush teeth and feed.[4] The Palo Alto VA/Stanford robotic aid can do selected vocational tasks and activities of daily living. Other features under development are vision, in the Spartacus project,[5] and mobility, in the Palo Alto VA/Stanford project.[7]

It is likely that in the future rehabilitation robots will be mobile, have vision systems and speech input/output, and will perform a large number of tasks in the home and workplace. Whether they will be affordable and acceptable to people with a disability is yet to be seen. Early evaluation results seem to indicate a positive response (5).[6]

Robot as therapy aide

This project has taken robotics technology in an alternate direction: instead of the robot as PCA, we have worked toward the robot as occupational therapy aide. A search of the literature has shown that this application is rather unique. A recent introduction to robotics and the disabled published in an occupational therapy journal even fails to mention the concept of therapeutic applications (1). Engelhardt (3) lists a number of *possible* uses of robotics in health care settings, including therapeutic ones. Therapeutic applications were actually developed by Khalili and Zomlefer (7) who constructed a continuous passive motion

Address all correspondence and reprint requests to: Marcel Dijkers, PhD, Rehabilitation Institute of Michigan, 261 Mack Boulevard, Detroit, MI 48201.
Robert Erlandson is now Associate Professor, Wayne State University, Detroit, MI. Deanna M. Geer is now with New Life Health Care Associates, Inc., Westland, MI.

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robot; the Cambridge group which built a manipulator to assist in the developmental education of young children with severe physical impairments (6), and Engelhardt and colleagues, who piloted robots for range of motion of wrists and ankles.* However, it appears that none of these applications has gone as far as ours in using the ability of robots to "sense," "think" and "act."

The opportunity for cost savings was one incentive behind our project, which aimed to explore the possible uses of robotic technology in rehabilitation therapy. With demands from third party payors for increased contact time and performance improvement at lower cost and in shorter time, rehabilitation facilities must find innovative means for delivering quality therapeutic treatment without increasing staffs or budgets. A second incentive was improvement in therapy. Even if the cost savings realized are minimal, a robotic system has possible advantages. It can repeat the same movements many times with a high level of precision. Its capacity to count and to time patient activity in great detail enables it to produce objective and detailed reports of patient performance. The objective monitoring of patient progress and the pinpointing of problem areas will contribute to quality therapy.

The aim of this report is to describe the results of a pilot study which explored the safety, utility, and acceptance of one particular robotic-system module designed for stroke movement patterns therapy.

Robotic system: Design and application

Background. Since stroke patients are a large part of the population in any rehabilitation setting, this group was selected for the pilot study, which focused on motor recovery. The stages of muscle reeducation after a stroke focus first on normalizing tone, followed by facilitating basic mass functional movements, and progressing to more isolated advanced functional patterns.

To implement movement patterns in the early stages of recovery, the therapist may move the affected extremity through a variety of therapeutic patterns, while facilitating appropriate muscle responses by stroking, tapping, holding, etc. In later stages, therapist assistance is decreased as the patient begins to move his limb more independently. Patterns increase in complexity as the patient progresses. In the occupational therapy clinic, activities to facilitate these movement patterns may include picking up, transferring, or touching objects at specific points in space as directed by the therapist. The points vary in direction and height depending on individual needs. This treatment has two drawbacks: 1) intensive muscle reeducation requires one-on-one treatment which is limited by time restrictions and staffing issues; and, 2) the therapist has no means of collecting quantitative data on the nature and frequency of the patterns and on patient performance. Although the latter is not critical, the capacity to do so would help in duplicating treatments for consistency, in providing justification for treatment, and in verifying progress in an objective way.

The research team decided to develop a robot system to aid the therapist in providing upper extremity reeducation for stroke patients. While the technical requirements to do so would be less complicated than, for example, writing a robot toothbrush program, it would put the applicability of robotics in rehabilitation therapy to an acid test. We wanted to demonstrate that stroke patients, even those with diminished cognitive competence and no familiarity with automated equipment, could be administered therapy safely and show patient acceptance of this technology; the results would encourage a variety of applications in occupational and physical therapy.

Design. The robot system and specialized hardware and software components were designed and developed by a research team consisting of occupational therapists at the Rehabilitation Institute of Michigan, Detroit, MI, and engineers at Metropolitan Center for High Technology, Detroit, MI. It was tested in the occupational therapy clinic of the Rehabilitation Institute of Michigan (2).

The system (**Figure 1**) consists of the UMI RTX robotic arm controlled from an IBM-PC personal computer. This arm has six degrees-of-freedom, or six axes of jointed movement. These joints duplicate the range of possible vertical and horizontal movements which a therapist would use with a patient within a 3-foot work envelope. The RTX arm has specific safety features which make it an ideal choice in personal robot applications—it moves slowly and can be stopped by a moderate touch.

Two sensor switches with indicator lights monitor the patient's movements. A "target" switch is mounted on the robot arm gripper or "hand." A "home" switch is placed either on the patient's lap or on a stool at the patient's side. A custom-built data acquisition board within the computer collects the switch sensor information. Computer programs were written to control the robotic arm exercise movements, collect the patient demographic and exercise data, and generate patient performance reports using the computer's printer.

The exercise procedure is available in two versions:

*Personal communication with K.G. Engelhardt, 1988.

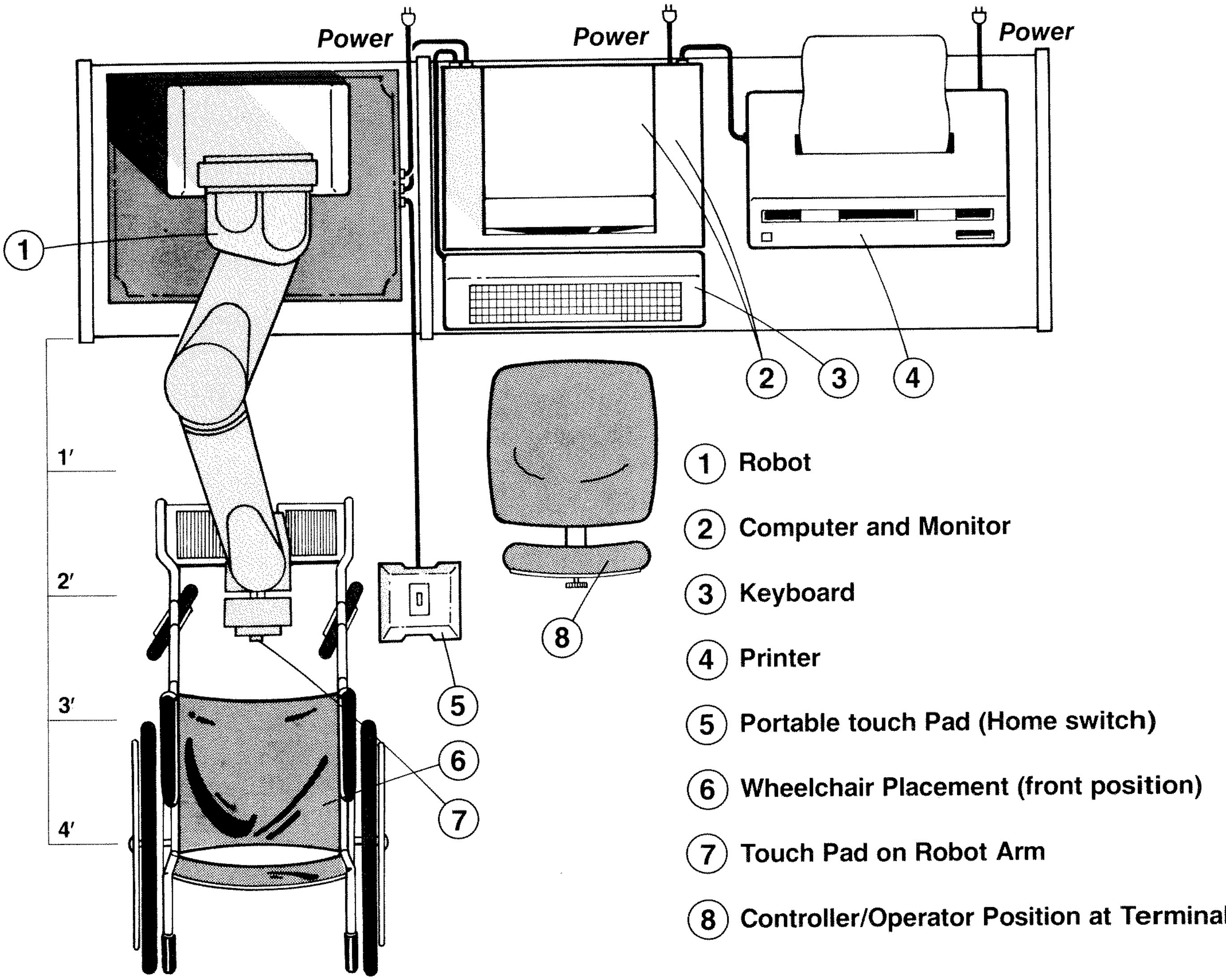

Figure 1.
Components of the robotic system.

the Pace mode and the Wait mode. The Pace mode requires the patient to work at one of four predetermined speeds, while the Wait mode allows him to work at his own rate. Five movement patterns, each consisting of eight points in space, are preprogrammed. These patterns have applications for various patient problems; they vary in difficulty, choice of points in space (left, right, low, high), and the sitting balance required. During a pattern run, each point is visited three times for a total of 24 exertions by the patient. An exercise routine with the patient seated in his wheelchair facing the robot arm (**Figure 2a** and **Figure 2b**) proceeds as follows:

- The indicator light on the "home" switch cues the patient to touch it. Once the patient has touched the switch, the light goes off.
- The robot arm moves to a point in space, then stops. The "target" switch light cues the patient to touch the robot arm gripper switch. (In the Wait mode the "target" switch light remains on until the patient touches it; in the Pace mode the light remains on for a predetermined amount of time depending on the speed chosen. If the patient fails to touch the target switch within that time, a "miss" is recorded and the home switch light goes on again).

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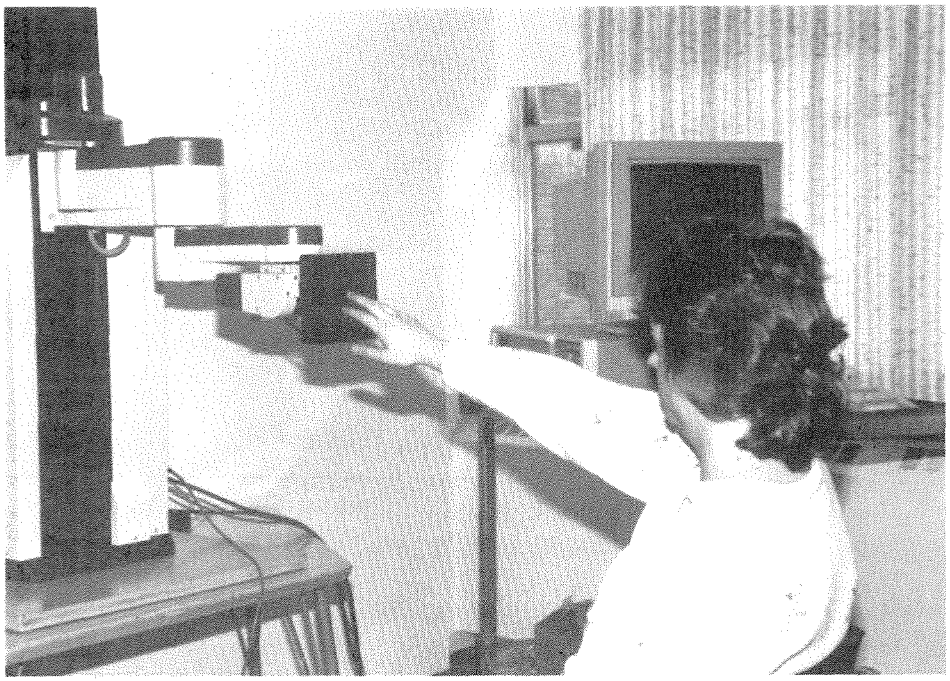

Figure 2a.
Patient using the system by touching the pad on the end-effector.

Figure 2b.
Patient using the system by touching the pad placed on the floor.

- The patient then touches the "home" switch again.
- The robot arm moves to the next position.

This cyclic procedure is repeated until the exercise routine is completed. The indicator lights and beeper give the patient visual and auditory feedback. The repetitive reaching and touching results in the patient performing the same pattern movements traditionally performed with a therapist.

A typical session involves the therapist entering information on the stroke patient into the computer, such as name, ID number, and Brunnstrom stage of recovery of the arm (9). The therapist then selects the appropriate exercise pattern, mode, and speed. After the patient has completed the cycle for the selected pattern and rested as necessary, the pattern may be repeated (at the same or higher speed), or the patient can be switched to a more difficult one. This decision may be based on feedback on the patient's performance provided by the system. At the end of a session, the printer can produce a report with essentially the same performance information for future reference (**Figure 3**). The system documents what specific treatments the patient has received: patterns, repetitions, speeds, and "hits" and "misses" (successful and unsuccessful attempts to touch the switches within the specified time), and the points in space where these occurred.

OBJECTIVES AND METHODS

During a 5-month period, the system was used in the occupational therapy clinic of the Rehabilitation Institute of Michigan as part of a pilot study conducted according to a protocol approved by the Institute's Institutional Review Board. The objectives of the study were to: 1) determine safety of the system for the patients; 2) assess acceptance of the system by the patients and the therapists; and, 3) explore utility of the robotic system as perceived by the therapists.

During the study, 11 therapists used the system with 22 patients. All the therapists were female, with an average age of 30 years. They averaged 7 years of experience in OT (range 0 to 17); only one had previous experience with computers. The therapists received inservice training in small groups (5 to 8 people) in order to become familiar with the aims of the project, hardware and software, operational skills needed, and use of the log. After that, supervision and consultation were provided as needed by all members of the research team, especially the research occupational therapists.

The patient group consisted of 10 females and 12 males; the average age was 53 (range 15 to 80). Eight were outpatients and 14 were inpatients. Diagnoses were recent stroke with right hemiplegia (N=8) or left hemiplegia (N=9); Guillain-Barré syndrome (N=1), traumatic brain injury (N=1), multiple sclerosis (N=2), and amputation (old stroke) (N=1).* The Brunnstrom stage of the affected hand of the stroke patients ranged from 1 to 6; the stage of the arm ranged from 1 to 5.

These patients had a total of 46 sessions with the system (average of 2.2 per patient), during which 70 cycles were completed, 38 in wait mode and 32 in pace mode. All the patterns and speeds were used. All patients and therapists in the study were volunteers; they received information on the purpose and significance of the study, and signed an informed consent document.

Information was collected from four sources: 1) a log located next to the computer in which therapists recorded comments, suggestions, and system problems; 2) the system database; 3) patient feedback forms, completed with help from the therapist (aphasic patients answered with nods) (**Appendix A**); and, 4) a comprehensive therapist questionnaire, completed at the end of the pilot study (**Appendix B**). Because of the small number of patient and therapist participants and the nature of the data, the presentation of results that follows is qualitative rather than quantitative.

*While the system was designed for use with stroke patients, therapists were free to explore its potential uses with other diagnostic groups. The therapists' opinions on safety, utility, etc. of the system reported here are based on use with *all* patients, whatever their diagnosis.

RESULTS

Safety

The safety of patients and therapist was an overriding concern of the research team. We used markers on the floor to indicate exactly where the wheelchair was to be placed in front of the arm for safety and maximum effectiveness. In performing the movement patterns, the patient's arms or hands were never within the area of space *actually used* by the robot: the sensor was mounted on the most distal point of the arm and needed touching only. No safety problems were mentioned in the data sources available.

Being safe is different from feeling safe: if a patient felt threatened in any way by the robot arm, it would have resulted in a refusal to use the system, or less-than-optimal cooperation. All 20 patients completing the form answered affirmatively to our question whether they felt safe (**Appendix B**, Q 4).

Staff were asked whether at any time they felt that their patient was at risk of being hit by the robot arm (**Appendix B**, Q 10). The answers indicate that such fears existed prior to the therapists becoming familiar with the system, or in the case of a patient who was very slow in moving back into his chair after touching the target switch. They also stated that they would have no problems letting cognitively intact patients work alone, but many specified that some form of supervision is needed for patients with decreased mentation or those who get easily confused. Three therapists thought that it was necessary that for these patients the therapist or a therapy aide should be at their side, but three others thought it sufficient to keep the patient in one's visual field.

Patient acceptance

The patients' acceptance of the robotic aide is summarized in **Table 1**. All therapists indicated that overall the patients' responses to the robot were positive. In their comments, they added that some patients thought it boring, but others thought it interesting. Many answers suggested that patients appreciated how the system gave them a "real workout."

System utility

Several questions on the therapists' questionnaire addressed issues of system utility. While therapists were

Table 1.
Patient Feedback: Acceptance*

Question	Answer yes	no
Did you like this treatment?	19	1
Do you feel it was helpful?	19	1
Was this boring?	4	16
Was it confusing to use?	4	16

*Based on answers by 20 patients: 18 first-time users, plus two who completed the feedback form at their last session.

learning the system, setting up a patient (including positioning the patient, turning on the equipment, identifying the patient and selecting pattern and speed) might take quite some time. Almost all became more adept. The information in **Table 2** on the therapists' estimate of the set-up time needed (after they had become familiar with the system), and their satisfaction with that time suggests that the maximum time set-up should take is 5 minutes. Reasons as to what took the longest in setting-up varied. Two therapists indicated that positioning the patient, explaining to the patient or turning on the equipment was the most difficult or time consuming, and seven named entering of the necessary information on themselves and their patients. Two people stated that both were time-consuming. The set-up process was judged not difficult by five therapists.

While data input may have been time consuming, most of the therapists had no particular problem. Ten stated that the instructions on the screen were easy to follow, and only three recommended specific changes that would make use of the system easier. Six therapists reported problems with the computer program and six reported malfunctioning of the robot arm.

Table 2.
Therapists' estimate of the time needed to set up, and their satisfaction with that time.

Estimated set-up time needed (minutes)	Satisfactory yes	no	total
10.15	2	1	3
5-10		2	2
5 or less	4		4
2-3	1		1
Not given		1	1
Total	7	4	11

Only four therapists reported that they actually used the performance information for making a decision as to what pattern and/or speed to select for the next cycle or session, or for reporting patient progress in chart rounds. Those who did not use the information gave various reasons, including: lack of understanding of what the data meant, loss of data due to computer (program) malfunction, and lack of applicability of the data to the problem of their particular patient.

The report format itself was called "clear" by seven subjects. One therapist suggested that exact range-of-motion be included. Eight therapists had produced the print report (**Figure 3**), and did not experience any problems. Printouts were made not just to have a permanent record allowing comparison over time; several therapists indicated that they showed the printout to the patients because they were most interested in their scores.

All 11 therapists stated that the five preprogrammed patterns were adequate for their needs, although three qualified that by stating that more complex patterns would be welcome. All stated that they were able to obtain therapeutic movements from the established patterns. Seven therapists expressed a preference for an option allowing programming of patterns by the therapist because custom-made patterns would better serve the patients' needs.

All therapists stated that the system was a valuable treatment modality for motor relearning. Reasons given included: 1) provided the repetition and consistency needed for relearning; 2) elicited patient cooperation; 3) delivered exactly the prescribed patterns every time; 4) provided therapeutic motions uni- and bilaterally; and, 5) helped with motor planning, praxis, and spontaneity of movement. They suggested that the system needed further development for use by patients with higher Brunnstrom levels. Others suggested developments that included functions for relearning fine motor aspects of hand function and for advanced coordination or more distal gross motor movements.

Even though the pattern program was designed specifically for stroke patients, the therapists saw applicability to a number of other diagnoses and used it with other diagnostic groups. Suggestions for potential users included traumatic brain injury patients who need upper extremity reeducation, patients with burns or peripheral neuropathy, multiple sclerosis, systemic lupus erythematosus, or arthritis, and patients with quadriplegia or polyneuropathy. The purpose of using the pattern program with these patients was not necessarily for motor relearning; therapeutic exercise for improving range of motion,

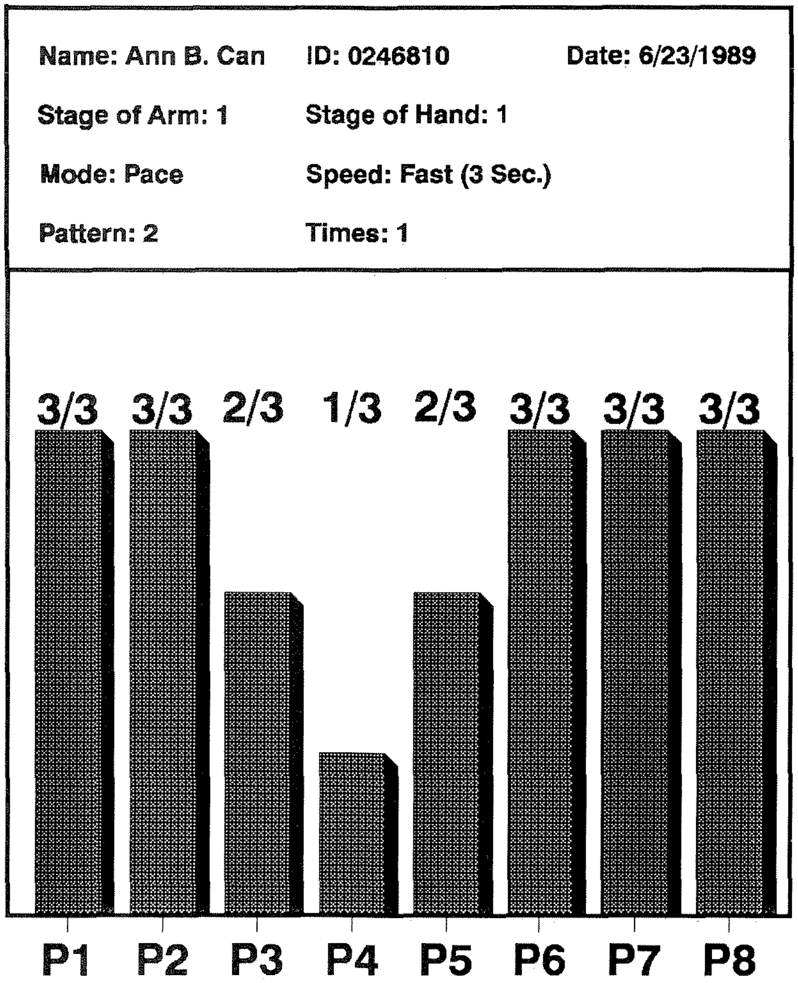

Figure 3.
Example of Pace Mode Report. Pl through P8 refer to the 8 points in space that make up the pattern. Each point is visited 3 times during each pattern run. The bar graph gives a visual report of the number of hits (0, 1, 2, or 3) for each point. The report also contains patient identifiers and information on the nature of the session: mode, speed, pattern, repetition of pattern. The (hypothetical) patient shown failed 2 out of 3 for point 4, and 1 out of 3 for points 3 and 5; the therapist may guess that the nature of the patient's motor problems underlies the lack of success for these points which are adjacent in space.

dynamic balance, attention, organizational skills, and ability to follow directions were suggested.

Some of these purposes would be better served by a modified or expanded robotic system. The staff made a number of specific suggestions in answer to a question (**Appendix B**, Q 27) on how they would like to see the system further developed (including a capability to program custom patterns, a module for using the gripper for fine prehension skills, and modules for cognitive training and auditory feedback).

Therapist acceptance

Seven therapists indicated that at first they were hesitant to use the robot aide due to a lack of familiarity with computers and robots, but that they felt more comfortable with time. Three never were hesitant to use the system. One therapist indicated that she never felt comfortable using the system because she could not adapt the program to obtain the patterns and speeds needed by her patient.

Ten of the therapists indicated that their *overall* response to the technology was positive. A list of the pros and cons they mentioned is contained in **Table 3.** It appears that most of the negative items on this list are due to the

Table 3.
Pros and cons of the robotic aide as reported by staff occupational therapists who used the system.*

Pros	Frequency
Robot maintains patient's attention/is interesting (in doing repetitive exercises)	6
Robot provides good exercise/patients work harder and reach further	4
Appropriate for high and low stages of recovery; various patterns; easily graded	2
Provides (over-time, comparative) performance date	3
Provides an addition to treatment	1
New and interesting concept	1
Predictable and controllable patterns are provided	2
Patients feel it's good for their arm	1
Cons	**Frequency**
Robot exercises are boring	2
AROM only — no weights for resistance	1
Easy for the patient to cheat	1
Robot frightening/intimidating to patient	1
Cannot use system with low-level patients	1
Set-up takes too long (cuts into therapy time)	2
Proper use hard to remember	1
Not challenging for high level patients	1
Limited in present stage — may not be cost efficient	1
Not enough therapist control over pattern selection	1

*Based on response by 11 therapists

fact that the therapist wanted to use the system for patient problems for which it was not designed. This and other problems can be solved by further system development.

When asked if they would have one of these robot aide systems in their occupational therapy clinic if they were a director, one therapist answered with an unqualified "yes." All others specified that they would need to see proof of cost-effectiveness, or that the system ought to be further developed to include exercise programs for patients with other diagnoses in order to make it worth the price. Because a price and cost-effectiveness study is not yet available, the answers cannot be more than a rough indication of the perceived value of the system.

DISCUSSION

The purpose of our study was to determine whether the robot system was safe for patient and therapist, and acceptable to both of them. The data presented suggest that the system was considered safe. We did not experience a single safety incident, nor did therapists or patients express fears of accidents. Even though many of the patients were elderly, with limited education and cognitively compromised, they seemed intrigued by the system. Many expressed enjoyment working with it, and made other comments indicating that they accepted receiving treatment from a machine. Because this was an early test, the therapist was at the patient's side at all times; it may be that patients will feel less safe or interested if they work by themselves with the therapist nearby in the clinic area. Research on a larger number of patients is needed to explore this issue. Additional research is also needed to determine which patients can work with the system independently and for how long, thus allowing therapists to do other work.

While indicating their receptiveness to this innovative addition to occupational therapy practice, the therapists maintained a critical stance. Their reservations had their origin in two sets of factors: problems with the equipment (especially initially, when the research team was still finding and fixing bugs, and the therapists were not yet familiar with the system), and the shortcomings of the system (in its current version) as a therapy aide. To a degree, they forgot that the project was to provide proof-of-concept of

robot-assisted therapy, and immediately focused upon things the system could **not** do. The system that was tested was very basic; it did not offer the full range of movement patterns, nor full options for the therapists in order to select speeds, repetitions, and variations. We are working on new versions that will offer more choices for the therapist.

The therapists' critical stance is justified for other reasons. At this time there is no evidence to justify jumping headlong into therapeutic robotics. We do not yet know whether a robot can deliver therapy semi-independently, thus freeing the therapist to work in other areas. More importantly, we do not yet have information about the *outcomes* of robot-assisted therapy: is it as effective as traditional methods? Nor is detailed, objective time-trend documentation of patient performance at the current time perceived as an advantage by all therapists. This probably is due to the fact that occupational therapists have relied more on qualitative rather than quantitative data to assess their patients and monitor their progress.

A recent survey of 51 hospital-based occupational therapists without hands-on robotics experience found that they considered robots (in a PCA, workstation, etc., application) valuable, obedient, fun, and intelligent; however, they remained leery because robots are mysterious, difficult, and unfriendly (4). Our data suggest that occupational therapists can adjust quickly to working effectively with this type of sophisticated equipment.

The effectiveness and efficiency of equipment is a critical issue. We should not adopt new technology just because it is "high-tech," but because it is effective in treating patients or will save resources as compared to our current methods of treatment. Any equipment that is complicated, difficult to set up, quick to break down, or provides feedback that cannot be understood, is not likely to be in use for long, even though it may have been accepted initially because of the glamour of high technology.

Many therapeutic techniques provided by occupational and physical therapists consist of showing patients movements, guiding them through these, providing feedback on adequacy of performance, and then encouraging the patients to repeat the movement or task until it has been mastered or the therapeutic effect has been accomplished. (For many of these tasks, licensed therapists use assistants). These are things that a robot can do, relieving the therapists of tasks which can lead to boredom and burnout, and freeing up their time for more creative and satisfying aspects of their job. In principle, a robot system has many advantages when used in the routine aspects of therapy. It never tires, and is available 24 hours a day, 7 days a week. It never gets bored and will repeat the same activities with equanimity and without burnout. It has no negative emotional reactions towards the patients. It is never distracted and will maintain its level of concentration and diligence continuously.

These advantages are still to be realized, and most therapists will focus on the obvious disadvantages. Even the most advanced robot cannot offer solutions to unique patient or situational problems, and is unable to observe the patient's quality of movement, pain, refusal to cooperate, or other problems, and act accordingly. Thus, for patients with compromised competence (e.g., after stroke or traumatic brain injury), a therapist should be at hand. However, if the robotic system is designed in such a way that it cannot harm the patient, it appears possible for one therapist to monitor three or four robots, each administering therapy to one patient.

Usefulness and cost-effectiveness of a multiple-robot system will likely depend on the variety of applications available, so that the system can be used for the assessment and/or treatment of a number of patient problems. We already are using the hardware described above for two additional applications: "tracking," in which the patient is required to follow the robot end-effector and touch it within a specified time whenever the light goes on; and, "tapping," a test of the speed of tapping either one end-effector or alternating between the two. We have completed a prototype of a shape manipulating system that we expect to be useful for stroke patients who receive treatment for more advanced hand function. A project has just begun exploring the creation of modules for assessment and treatment of upper extremity coordination problems. These examples certainly do not exhaust the potential of treatment using robotics—modules for the assessment of hemineglect for example, or the treatment of problems involving strength or endurance, as well as many others are possible.

The more treatment applications are available using a robot system, the more there is a need for creative use of the system by the occupational therapist, who understands the patient's problem, as well as all treatment modalities and approaches. The robot will provide the repetition necessary for relearning and mastery; the therapist will assess, monitor, select modalities, and make decisions on how and how long to use them.

We consider the patients' response to the system positive (**Table 1**). It is surprising that so few called the treatment boring. One may doubt that patients will be inclined to do these exercises if they are administered as part of

routine treatment in rehabilitation, rather than in an experimental project for which the patient was invited and for which explicit written consent was given. It is certainly possible that the "Hawthorne effect" explains part of the patients' interest, acceptance, and willingness to work with the system. The interest in the system by the occupational therapy staff assigned to other patients, and other hospital staff and visitors was likely to stimulate the subjects in our study. However, in most cases the novelty wore off rather quickly, especially for those who had multiple sessions, and was replaced by the hard work of therapy. Research is needed to determine whether compliance is as good in routine use of the system as in an experiment.

Similarly, research is needed to demonstrate the efficiencies that can be attained with the system. A basic question is how much human attendance is necessary (e.g., can one therapist with one certified OT assistant "run" five or six systems?). Even if further field trials indicate that it is necessary for the therapist to work one-on-one with the patient, thus generating no cost savings, it may be that the ability of the robot aide to deliver standard movement patterns in a standard manner in the exact sequence and repetition seen as necessary, and generate objective, quantitative reports on the patient's performance, will enhance the occupational therapist's effectiveness enough so it is worth the price tag.

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APPENDIX A
Robotic Evaluation: Patient Feedback

Primary therapist to fill out with patient:

Check one:
First experience ☐
Week of discharge ☐

1. Did you like this treatment?	Yes _____	No _____
2. Do you feel it was helpful?	Yes _____	No _____
3. Was this boring?	Yes _____	No _____
4. Did you feel safe?	Yes _____	No _____
5. Was if confusing to use?	Yes _____	No _____

Additional comments which would be helpful:

Patient name: ______________
R.I. # ______________
Age: ______________
Sex: ______________
Date: ______________

APPENDIX B:
ROBOTICS STUDY FOLLOW-UP QUESTIONNAIRE

1. How long did it take to set up your patients?
2. What took the longest in setting them up?
3. Was this time satisfactory to you?
4. Was setting up your patients complicated? If so, explain.
5. Were the markers on the floor helpful in set up? If not, explain.
6. Were the directions on the computer screen easy to follow? If not, explain.
7. What would you change on the screen to make it easier to follow?
8. Did the computer program work consistently upon your command? If not, explain problem.

9. Did the robot arm (not the computer) malfunction at any time? Please describe incidents.
10. Did you feel at any time that your patient was at risk of being hit by the robot arm? If so, what could be done to prevent this?
11. Would you feel comfortable leaving your patient alone to work? If not, what type of supervision would be needed?
12. Did you feel hesitant to use this system initially due to a lack of computer or robotic knowledge/experience? If yes, do you still feel the same since using it?
13. Did you ever use the data collected? Please explain your answer in detail.
14. Was the data confusing? If so, explain.
15. Would any other data have been more useful? Explain.
16. How often did you generate a printed copy of this data?
17. Was it easy to generate a report from the printer?
18. Overall, would you say the patients' responses to the robot were positive or negative?
19. Please list memorable patient responses both pro and con.
20. Overall, was your response to this positive or negative? Please list your pros and cons.
21. Were the available patterns adequate to meet your needs? If not, explain.
22. Were you able to obtain therapeutic movements from the established patterns?
23. Would you have preferred to program your own patterns?
24. Do you feel this was a valuable treatment modality for motor relearning? Why or why not is it valuable?
25. What do you see as its limitations at this point?
26. What type of patients would benefit from this modality in its current stage?
27. How would you like to see it further developed?
28. If you were an OT director would you want to order one of these systems for your clinic? Why or why not?