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ABSTRACT

Recent efforts to develop Spanish-based adaptations for alternate computer input devices are considered, as are their implications for Hispanics with disabilities and for the development of language sensitive devices worldwide. Emphasis is placed on the particular need to develop low-cost high technology devices for Puerto Rico and Latin America as a way to increase accessibility to assistive technology (AT). Efforts of leaders in Puerto Rico to access AT for different age groups and disabilities are discussed, along with cultural, economic, and language barriers. Details are provided regarding redesigning the standard computer keyboard specifically for processing Spanish text. Specific programs that were developed for people with visual impairments are summarized, along with adapting a switching device to accommodate individuals with motor disabilities to allow playing video games, for example. Adaptations of electric cars to benefit the child with disabilities and development of voice input devices for assistance with typing are also described. Some accomplishments of the Puerto Rico Assistive Technology Project during the first year are discussed, along with difficulties that have been encountered previously and plans for the future. (SW)

Running head: AT DEVELOPMENTS IN PUERTO RICO

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Abstract

Recent efforts towards the development of Spanish based adaptations for alternate computer input devices are presented, as well as their implications for Hispanics with disabilities and for the development of language sensitive devices worldwide. Strong emphasis is given on the particular need to develop "low cost-high tech" for Puerto Rico and Latin America as a way of increasing accessibility to Assistive Technology. Local examples of inclusion through technology for different age groups and disabilities are presented. Cultural, economical and language barriers discussed through several cases. Finally, some of the accomplishments of the Puerto Rico Assistive Technology Project during its first year of operation are presented along with past difficulties and future plans.

Assistive Technology Developments in Puerto Rico

> It is possible that the time is not far away when pedagogy will be ashamed of the very notion of a "handicapped child", which signifies some unalterable defect in the child's nature.
> A blind person will remain blind and a deaf person deaf, but they will cease to be handicapped because a handicapped condition is only a social concept...
>
> L.S. Vygotsky (1924)[1]

The Puerto Rico Assistive Technology Project (PRATP) was created on December, 1993 through a grant from the National Institute of Disability and Rehabilitation Research (NIDRR). The Department of Education was selected as the lead agency and subcontracted the Medical Sciences Campus of the University of Puerto Rico (UPR) where the PRATP was finally established in the College of Health Related Professions, Department of Communication Disorders. The PRATP staff, headed by its Project Director, Dr. José Santana, has been continuously working to make the many benefits of assistive technology accessible to people with disabilities in Puerto Rico. At an early stage of the Project's development it became evident that the availability of AT equipment in Puerto Rico was quite limited and local AT developments were almost non existent; moreover, general knowledge about assistive technology among service providers and consumers was extremely low[2]. Working together with the Department of Education, and the University of Puerto Rico, the PRATP has been able to identify several barriers that severely limit the access to assistive technology on the Island:

- Unavailability of funds.
- High cost of AT devices.

- Scarcity of professionals properly trained to evaluate AT needs.
- Little knowledge about devices available for special populations.
- Language barriers; since most devices are not produced in Spanish. When available, prices for Spanish versions of hardware are generally much higher than their English counterparts (and usually the characteristics of the device itself do not satisfy the needs of the Hispanics with disabilities).
- Lack of professionals available to provide individual training to the user on the operation of complex devices.

Each of these barriers, which are further explored later in this paper, has contributed to make the history of assistive technology developments in Puerto Rico a very short one that may be easily traced back to its first important event in 1982[3]. In this year, Dr. Joseph Carroll, Professor of Psychology at the University of Puerto Rico, founded the N.M.J. Project, geared to help young adults with disabilities to succeed at high-school, university and work settings through the use of assistive technology devices and services (J.F. Carroll, personal communication, February 16, 1995). Throughout these years, Dr. Carroll has helped many people with disabilities as well as several agencies that provide services for this special population to gain access to assistive technology. At the Psychology Department of the University of Puerto Rico, Dr. Carroll has created the first assistive technology course on the Island, pursuing the development of a local psychology of the person with disabilities and the integration of psychological, physical and cultural aspects of AT in Puerto Rico. As a service provider, researcher, mentor or consultant, Dr. Carroll has been present in just about every AT development that has taken place in Puerto Rico.

Computerized systems are possibly the most equalizing tools we currently have and the ones which can provide the widest variety of communication, productivity and independence alternatives to the user. Under the direction of Dr. Carroll, Lizama (1994) studied the particular characteristics of Spanish written language to redesign data input devices for computerized information systems. Over four million characters were analyzed through the use of three computer programs written to receive Spanish text files as input and compute character frequencies, di-gram (letter pair) frequencies and compare the amount of movements needed to actually write the text being analyzed using two different input layouts. The results were then used to redesign the alphabetic matrix of a commercially available computer program for single switch input so as to make automatic scanning most effective for the handling of text in Spanish. On initial comparisons of actual writing time, the redesigned matrix (DARE) allowed the user to spend 39% less time in writing tasks than the original matrix (Alpha1), this would mean a reduction of over 23 minutes for every hour spent working at the computer. This redesigned input system would undoubtedly be a convenience for any of us, but for people with disabilities it may signify a major increase in their productivity and a real opportunity to compete in the work force.

The standard keyboard layout (Qwerty) might be used quite well by people with conditions such as arthritis, carpal tunnel syndrome and muscular dystrophy, with the aid of a keyguard or a wrist support. For these people, the rate of typing is reduced by their condition which means an increased amount of time needed to complete writing tasks; also, in cases like carpal tunnel syndrome, there is a high probability of the condition becoming worse as a result of the longer lasting continuous exercise. A more effective keyboard layout may allow a user to spend less time, apply less effort, decrease the amount of fatigue and generally reduce the amount of movement required to write a text. Lizama (1994) redesigned the standard computer keyboard and created a keyboard specifically made for the processing of Spanish text (TEsL). A sample of over 660,000 words (22 files of text in Spanish) was used for the comparison of the two keyboard layouts on the writing of text using the standard touchtyping method. On writing Spanish text, TEsL proved to be far superior than QWERTY on every parameter identified in the literature as being characteristic of an effective keyboard (Table 1).

Table 1

Comparison of Qwerty and TEsL keyboards

Parameter	Qwerty vs. TEsL	Effect
Jumps outside home-row (resting position of fingers in touchtyping).	TEsL required an average of 61.41% less jumps outside home-row.	Less effort and finger coordination needed to complete the writing tasks.
Frequency of hand sequences.	Hand sequences that require less time to be written were increased in TEsL by 57%; those that require more time were reduced by 60 to 65%	For people with motor disabilities, this would allow to compensate typing speed that has been affected due to their condition.
Distribution of workload among hands	Workload in Qwerty is 61.61% for the left hand and 38.39% for the right hand. Balance among hands in TEsL is 50.46% (left) and 49.54% (right).	Qwerty places a much higher load on the generally less preferred left hand. In TEsL, a better balance among hands may allow a person to type for a longer time without the limit posed by one hand getting "fatigued" before the other due to a disproportionate workload.
Distance traveled by fingers (writing the text included in the sample)	User's fingers must travel a total of 68.44 miles on the Qwerty keyboard and 42.72 miles on the TEsL keyboard (37.56% less distance).	If less travel distance is required, the user's fingers are able to complete the tasks in less time, less effort is needed, and there is less probability of the user's disability to become worse due to long lasting typing tasks.

Knowing the characteristics of the Spanish language, it is now possible to develop and redesign effective computer access devices for a variety of needs and input methods. Layouts for special direct selection devices (one hand typing, infrared pointing, eye scanning, etc.) may be developed by studying the movements of a person with a particular motor difficulty to determine the areas of greatest control and ease of movement during typing. Preferred input method, reaction time measurements and distance to target keys from the most comfortable starting points may then be integrated with the movements identified as being the most effective and the characteristics of the language being used to layout an ideal configuration for productive access to computers. Small modifications of the programs written by Lizama (1994) would also allow the analysis of several other languages and the study of their individual characteristics so as to make possible the design and development of language-sensitive computer input devices.

José M. Alvarez, a student at the University of Puerto Rico, has designed and developed a variety of computer programs for people with disabilities and for the training of special education teachers at the UPR. Being part of the N.M.J. Project, Alvarez has contributed to the accessibility of computerized systems by developing Spanish based programs that are well suited to the particular needs of people with disabilities in Puerto Rico (see Table 2 for a description of some of these programs). With the aid of assistive devices to compensate for his low vision, José Alvarez currently works at the computer center of the University of Puerto Rico and has been about the only person in Puerto Rico to write programs for people with disabilities. José he is also a part of the PRATP staff and continues to volunteer his time at the N.M.J. Project.

Table 2

Summary of programs developed by José Alvarez.

Program	End users	Description
Teclado 1.5	Low vision or auditory impairments. Training of Special Ed teachers.	A tutorial program to learn the braille alphabet, american sign language (ASL) and braille keyboard. A person in the process of loosing vision may be taught the basics about reading and writing braille, and a person temporarily or permanently unable to speak may be introduced to fingerspelling.
Comuni-cación 1.O	Blind users.	A Spanish-based communication program. All graphic menus (confusing for voice synthesizers) were eliminated to make the screen reading program more effective and easier to use. Once the connection is made, the program automatically numbers each output line to allow for easier screen "navigation"; the program supports several file transfer protocols and features on-line help available at any time through a "hot-key". The blind person may enter any remote computer and be able to use all the features of a commercially available communication program.
Gran Calendario 1.O	People with low vision.	On-screen calendar that allows the user to set up appointments, organize daily tasks, arrange to-do lists, update class schedules, etc. The program reminds the user about each coming event at the appropriate date and time; it allows for the production of large print hard copies in order to maintain an updated schedule.
Calendario 1.O	Blind users.	Same characteristics as GRAN CALENDARIO but appointment reminders, on-screen text and keyboard input are "spoken" through a voice synthesizer and screen reader program.
Gran Teléfono 1.O	Low vision users.	Then user can maintain a data base of telephone numbers and access them through several field searches (last name, name, etc.). If a modem is connected to the computer the program itself can dial the desired number.
Teléfono 1.0	Blind users.	Same characteristics as GRAN TELEFONO 1.O but the user can hear the computer output through a voice synthesizer.
Horse Racing	Blind and low vision users.	A computer game based on the Kentucky Derby where the horse "Mr. Friski" of Puerto Rico participated. The program "narrates" a meter by meter account of a computer generated horse race where the winner is randomly selected.
Aprendiendo el Teclado	Low vision users.	Tutorial program to learn touchtyping in the standard keyboard layout (Qwerty).

Among assistive technology developments in Puerto Rico we may include several adaptations of study materials and evaluation instruments made under the supervision of UPR professors Dr. Carroll, Dr. Santana and Dr. Albarrán. In 1984, Ramírez developed study materials and a training program in Spanish for the use of the Kurzweil optical reading device. Existing module materials were translated, adapted and reorganized so as to facilitate independent learning for the improvement of reading skills on the Kurzweil machine. Guevara (1990) adapted and validated the Cirino Vocational Interests Inventory (CVII) for people with low vision using a ¼" letter size, commonly found in materials available for this population. The CVII is an instrument that was developed in Puerto Rico and it has proven itself to be a very useful tool for the vocational counseling and orientation of students and employees. Previously, people with visual impairments had access to the CVII trough the use of readers or magnifying glasses; however, both methods imply the participation of a cognitive, functional, motor and even an emotional context different from the one it was originally created for (Bauman & Hayes, 1951; Swallow, 1977). Reliability and validity measures were established for this adapted version of the CVII making it possible for the visually impaired population of Puerto Rico to benefit from it and allowing us to stand just one step closer to Guevara's vision: "...for the tests to be as useful for the person with disabilities as they are for the rest of the people" (1990).

Díaz Urbina (1993) adapted and standardized the instructions of the Bruininks-Oseretsky Test of Motor Proficiency, widely used by occupational therapists of the Puerto Rico Department of Education and the Adaptive Physical Education Lab of the Colegio Universitario Tecnológico de Bayamón. A statement is made about the need to adapt and standardize instructions to allow children with and without disabilities to approach a test situation under similar conditions so as to establish common grounds for comparing them. It has been a common practice in Puerto Rico to segregate deaf children from the regular physical education class on the basis of the inferior fine motor performance attributed to them in the literature (Díaz Urbina, 1993). A recommendation is made against this segregation since no significant differences were found in the test scores when the instructions were adapted so as to be well understood by both groups. It is not possible to state conclusively that the change in the instruction protocol was the variable responsible for the observed results, but we must recognize this research as an invitation to question the validity of testing special populations using instruments not developed nor adapted for them.

Development of Basic Assistive Technology Devices

At the PRATP we have tried, like many others before us, to increase accessibility of AT devices by designing some basic equipment that could easily be built by teachers and parents of children with disabilities. However, we have tried to push this endeavor just a little step further to the attainment of three primary goals: a) simplify the design of every self-made device so that we may increase the probability of people attempting to build them, b) lower the costs of self made devices to the minimum, and c) use readily available materials, specially "recycled" materials, that may be found everywhere and that require either little or no modifications to be useful. Many of the adaptations made at the PRATP are not original developments, they have just been "adopted" and "adapted" to fit our purposes and budgets. Here, we attempt to present a little of how they have helped us bring AT one step closer (at least in terms of cost and availability of materials) to people with disabilities in Puerto Rico.

Mercury switches, or tip switches as they are commonly known, constitute quite versatile tools since a wide variety of particular motor behaviors may be accessed depending on their placement on the person's body. Of course, it is known that switches attached to the body are not as desirable as switches placed close to it, however, were we to choose the three most widely applicable switches, plate, wobble and mercury would probably be the ones. Mercury bulbs, which constitute the most important and most expensive part of the switch are sold in electronics stores at about $1.50; however, current prices for mercury switches in leading companies ranges from $46 to $60. To provide a more cost-effective alternative, we have gathered used up highlighters and markers from students at the University of Puerto Rico to build some very useful (and colorful) mercury switches. When properly assembled, the cap and a 2" piece sawed off from the highlighter tip, come together as an excellent enclosure for a mercury bulb. The space inside this enclosure is filled with silicon to make it shock resistant and therefore prevent the breakage and detain any spillage of the harmful mercury metal. Besides being colorful, highlighter caps were chosen because of the clip attached to them which becomes very useful when placing the switch on the person's sleeve, wristwatch, velcro bands, etc. For some children who could hold the switch with their hands, the whole highlighter was used in order to provide a bigger area for them to grasp. In this case, the device was built with the cap securely attached to the body of the highlighter to enclose the switch but it can also be taken off to flip the mercury bulb 180° and therefore select either an upward or a downward movement for the activation of the device. Total cost of materials involved in the making of these 50% recycled material mercury switches is $2.50, including the cable and the plug needed to attach the device to be activated. This obviously is a more accessible alternative for parents and teachers than the mercury switches currently available on the market which, by the way, do not include a clip.

The use of discarded watch boxes has allowed us to build momentary and latch plate switches, or "Seiko" switches as we call them (the first boxes we used were from Seiko watches), with sufficient contact area to be reliably used by persons with severe motor problems. Diskette, video cassette and Compact Disks boxes have also been used to build a variety of single switches of different sizes, contact area, resistance, color, tactile surface, etc. all of them between the $2-$4 range (market price $46-$70).

Battery adapters are, perhaps, one of the most versatile basic adaptations made for battery operated devices. The adaptor can be fitted in a wide variety of toys, radios, tape players, etc. and provides a way for the parent or teacher to quickly and inexpensibly change the device to be activated. One switch activated adaptor might be the only thing that a child needs to gain basic access to all of his/her battery operated toys. Thus, believing the battery adapters to be important AT tools, we attempted to develop very simple illustrated guides for parents and teachers to build them for a very low cost and, again, with 50% recycled material. The adaptor is made with two ½" metal squares cut off from the base of standard paper fasteners and separated by a slightly bigger plastic square cut off from the side of milk containers. The grooves already present in the paper fastener are excellent for soldering the adapters' cables. They also allow for good connection between the battery and the device's contact and prevent the battery and the adaptor from slipping due to the toy's movement. Commercial battery adapters are not too expensive (approx. $9-20) but they are often either too big or too thick to fit in the battery compartment. Our adaptor is quite thin, way smaller than the ones available on the market and it costs less than a dollar.

There are several public domain single switch programs available on the Internet as well as some low cost commercially available programs. However, the interfaces for using these programs with a single switch might be an expensive part of the package, specially for schools that need to use the programs on several computers and therefore need one interface per machine. Since most of these programs may be set to work with the mouse button, we have used the mouse as an interface and tapped the button circuit to install a 1/8" plug in which to connect the single switch. This simple adaptation has worked very well for us at the PRATP and at the UPR for students with severe motor disabilities to test several single switch program demos before purchasing them. Total cost of materials for these gadget was 75 cents, which has proved to be quite convenient as compared to the $20-$100 range for commercially available interfaces.

AT barriers in context

Teachers, parents and service providers have long understood the need to integrate special children with all other children as equal members of our society: "Any physical handicap, be it deafness, blindness or inherent mental retardation, not only changes a person's attitude towards the world, but first and foremost affects his relationships with people" (Vygotsky, cited in Rieber & Carton, 1993, p.76). Early exposure to a wide variety of shared learning experiences are not only crucial factors for an adequate cognitive development, but also for the inclusion of children with disabilities into their social context. Appropriate social interaction with similar aged children is facilitated when the special and the "regular" groups are able to share common interests and are able to engage in similar activities. Consequently, there is a need for our efforts to be directed towards the identification of what those preferred interests and activities are and to find viable ways of providing the special child with means to access them.

Among children, there are some easily identifiable factors that determine who is "in" and who is "out". For example, it is obvious that we are amidst the Nintendo revolution, video games are "in" and they provide a widely accepted common ground for social interaction which ranges from amicable group play to heated discussions about high scores, strategies and secrets to succeed in the latest title. Like most 8 year old children, Raúl Alexis enjoyed seeing his cousins play video games and they even tried several times to get him to play with them. However, cerebral palsy prevents Raúl Alexis from being able to use his hands or feet and therefore his cousins finally gave up in attempting to integrate him into their play. Even when he wasn't able to use it, Raúl Alexis requested a video game system for Christmas which his mother readily bought. He then asked his mother to play the games while he watched and he seemed to enjoy being an spectator; but seeing is only a part of experiencing.

During their first visit to the PRATP Raúl Alexis' mother told us about the video game, and since we could easily see that Raúl Alexis would not be able to control any of the commercially available joysticks we started searching specialized catalogs for alternative control devices. The devices we found included either a multiple set of buttons which Raúl Alexis could not push or an impressive arrangement of individually activated switches that seem to complicate rather than ease the use of the system. Raúl Alexis seemed to have very good head control so we attempted to adapt the video game to be activated by head movements and do so at the lowest possible cost. Since we do not have engineers or electronics experts in our staff, we found this to be quite difficult, but finally, we came out with a prototype built on a bicycle helmet. Up, down, left, right and diagonal movements on screen are controlled by very slight corresponding movements of the head; fire buttons are controlled by two single switches or by a single switch activated device adapted to produce variable speed automatic-firing. The helmet was tested on young persons with cerebral palsy and muscular dystrophy and on several other "typical" adults and children. They all indicated that the device was quite effective and many of the "typical" individuals (specially children) even stated their preference for the head control over the joystick. Raúl Alexis could finally play on his video game system and the emotion and happiness of being able to do so was more than evident to all of us who were sharing this experience with him.

From a biopsychological perspective, access to video game systems may allow the child to develop and/or increase several important skills such as visual tracking, attention, signal/noise detection, fine motor head control, visual-motor coordination, background/foreground discrimination, and focusing, among others. Social interaction could definitely be facilitated by this head control device, since it is connected to only one of the game ports of the video game, leaving the other one free for a regular joystick and therefore allowing the child with disabilities to play together or against any other "regular" child. We recently managed to fit the circuitry of the head control device in a 3" x 3" x ½" box and place it on top of a baseball cap (from Raúl Alexis' personal collection) which is much more aesthetically appealing and proved to be much easier for him to control since it fits tighter on his head. We are currently half way into placing the video game controls on the frame of a pair of sunglasses; however, of all the characteristics of this device, probably the most outstanding is the total cost of the materials needed to build it: about $40[4].

In Puerto Rico, one of the common denominators over the last three Christmas seasons has been the "Power Wheel Fever". Boys and girls alike have turned their attention towards these little electric cars which they can ride and control. Bicycles have been put aside for a while and Bigfoot trucks, Wrangler Jeeps, Barbie cars and the timeless Volkswagen beetles, among many others, have taken up sidewalks and parks. However, lets not forget that toys are not only for "regular" children but for all children. Access to social experiences and inclusion are once again the important factors here since electric cars, like video games, constitute a widely accepted common ground for appropriate children interaction as well as a quite enjoyable and thrilling experience.

Like many mothers, last Christmas Iris wanted to buy a Barbie car for her 4 year old daughter, Patricia, who demonstrated a particular inclination towards this toy during a visit to a shopping mall. However, Patricia suffers from cerebral palsy and cannot move her legs to activate the gas/brake pedal nor use her hands or arms to control the steering wheel. Iris came to the PRATP two weeks before Christmas asking for the adapted electric Barbie car which she saw in a magazine for parents of children with disabilities. We could not contact the manufacturer through the only listed telephone number so we wrote a letter asking for information. A week before Christmas Iris decided that she wouldn't wait anymore and bought the $250 car asking us if we could make some kind of adaptation. Several days later we were loading the vehicle into Iris car and it was on its way to being wrapped up and given to Patricia as a Christmas present on the next morning.

Under the hood of the car we placed an electric distribution box containing a buffet of cables and electronic gadgets. Even though the car voltage is only 12 volt, the electric current passing through the circuitry is about 10 amperes and this may pose a danger to a child using a single switch for activation. Therefore, a single pole-double throw magnetic relay was used and a separate low current circuit was built inside the electric distribution box for its activation trough a self-made single pad switch located on top of the steering wheel and plugged into a phone jack inside the car's glove compartment. The car wheels may be fixed in any desired position since Patricia does not yet have the capability of steering it nor the cognitive ability to discriminate between switches to activate and turn the vehicle. A three position flip switch was installed inside the car; moving the switch to one side allows the child to activate the car by applying a very slight pressure over the plate switch; moving it to the other side activates the gas/brake pedal, deactivates the magnetic relay, allows for the single switch to be removed and for the front wheels to be unlocked so that any child could use the car in its original state; moving the switch to the center position deactivates all the electric system to prevent any unsupervised use of the vehicle.

Patricia will now be able to interact with other to-be-licensed car owners or, being hers a two passenger vehicle, she may be able to take a friend for a ride or, with the flip of a switch, she can be taken for a ride by any one of her friends. Social interaction could undoubtedly be facilitated by this device but also, in Patricia's case, it could help her to acquire the basics of switch detection, cause and effect association, acting over the environment and acting over herself as part of the environment (besides providing her with visual, auditory, sensory and vestibular stimuli). Deitz, J. (Personal letter to Jim Steinke, July 27, 1994) informally reported some initial evidence on the benefits of using electric powered cars for rehabilitation purposes as reflected in children's response to training, following instructions and rate of self-initiated movements; an increase in all these factors is also evident in Patricia's case. As with the video game system, probably the most outstanding characteristic of the adapted Barbie car was the total cost of the materials used in the adaptation: about $35.

At the beginning of February, the information about the adapted toy cars arrived; the very same Barbie car that Patricia has, specially adapted by this company, had a list price of $3,550 not including the adapted seat (shipping and handling is $165 extra). It is obvious that this car has several more electronic gadgets and functions than the one we adapted, such as servo motor and plates, proportional remote and a proportional joystick. However, as indicated before, Patricia like many other children cannot use a joystick and does not yet have the cognitive nor motor ability to use an arrangement of switches intended for activating and turning the vehicle. From a purely pragmatical perspective, we know that a regular family in Puerto Rico can make a little effort and buy a $300 adapted car, but a $3,550 toy is definitely out of their reach no matter how many extra gadgets it may have. For our social and economical context, it is completely irrelevant how many functions and electronic pieces a device may have, Patricia can either enjoy our adapted car or not have any car at all.

Patricia's car has still to undergo some adjustments for proper seating and posture to be achieved, therefore her therapists are exploring the alternative of a self-made adapted seat or, if not viable, the purchase of an adjustable padded seat with harness for about $180. It must be noted that only the cost of shipping and handling the factory-adapted car to Puerto Rico would cover the purchase of this new adapted seat & harness for Patricia's vehicle.

Like Patricia, a group of 4-6 year old children with severe disabilities at the school of the Pediatric Hospital were in need of equipment to start a microswitch training program geared to develop some basic cognitive, social and communication skills. The school was visited, the children were observed, several options were explored, the basic equipment was identified and a proposal was written; however, the funds did not arrive. As always, there was still the possibility of the funds being awarded some months later, but the education and development of these children cannot wait for bureaucracy so we decided to start working with some of them. Ramón, like some of his classmates, is non-verbal, cannot use his hands or legs and spends most of the time on his wheelchair. After trying several options we built a mercury switch for him to use with an upward arm movement and adapted a toy train with light, sound and movement which was used to train Ramón in cause and effect and in the proper motor behavior for switch activation. It was then decided that Ramón needed a device that may allow him to call the attention of the teacher since he didn't have the means to indicate when he needed or wanted something. The price for beepers with sound and light available in catalogs was about $49 each (batteries not included) and, since the school didn't have the money, we bought materials and build a beeper for about $7, including batteries. The low cost of this device now allowed us to build three more beeper units and a plate "Seiko" switch.

Ramón was instructed by Gloria Vélez (from the PRATP staff) to activate the device to call her when she left the room, after a little while he readily did so. Trial after trial he reliably used the beeper to summon Gloria and later to call one of his teachers and even one of his classmates; by then, several people had gathered to watch Ramón. Apparently, every time Gloria was called into the room she emphasized so much the sentence "What is it Ramón, do you want me to be here?", that Ramón suddenly made a big effort and repeated the word "here" (aquí) even though he was considered to be completely non-verbal. The concept of calling for social attention was obviously learned and Ramón clearly understood that his behavior not only had a real purpose but also some real consequences. After responding the way he did it was obvious that for his parents, teachers and even for himself, Ramón was not the same child that afternoon than the one who came to school that morning, and he never again would be. The main reason for bringing up this story is that it raises once again the issue of the importance of low cost technology for Puerto Rico; either Ramón could be provided with a $7 gadget for basic communication or he would still not have the means to demonstrate that he could understand, follow instructions, engage in social interaction and even develop some verbal communication (and would therefore be treated accordingly). Even the best intentioned parents and teachers treat the child according to what they believe his or her capabilities to be, and this poses a serious danger if we are not able to provide a way for the child to demonstrate what he is really capable of doing. In a recent article, Bob Williams (1994) supports this view from his own experience:

> ...I learned that at that time my teacher did not believe I would ever learn to read. In fact, I am convinced that if I had not been given the typewriter, that teacher's perception would have become a self-fulfilling prophesy (p. 31).
>
> ...[Writing about a friend] The greatest crippler she faces is not her disabilities, but others' severe ignorance and profound underestimation of her abilities (p. 31).

A week later, Ramón was using his beeper not only to call for attention, but also to answer questions from his teachers about object and color recognition. Did this seemingly retarded child suddenly become far more intelligent than he was before, or did we just provided ourselves with a way to access the cognitive capabilities he had all along?

Social interaction in the class setting constitutes an important part of a child's experience but, when these peers are all children with severe disabilities, interaction might prove to be quite a difficult goal to accomplish. This need was detected at the school of the

Pediatric Hospital and, as an initial response to it, we recently built a cooperation/contingency box to provide the children with some shared group experiences. To use the box, a preferred activity of the group is chosen, listening to a tape for example, and the adapted device is plugged into the box; next, three single switches are plugged in the box and each one is assigned to a child according to his/her particular activation behavior. In order for the tape player to work, all three switches must be activated at the same time. Individual activation of a switch would yield no response since the functioning of the tape player is contingent upon the cooperation of all three children to exert their particular activation behavior simultaneously and for a similar period of time. According to the number of children and the intended complexity of the activity, the use of two or three activation devices can be selected through a flip switch installed in the box. Through this $6 cooperation/contingency box children may learn that their individual behavior affects and is affected by others; moreover, children can learn that together they may all affect and be affected by their environment, which becomes a very crucial concept for higher level social interaction[5].

Correct body posture is a prerequisite for almost any kind of intervention to be effective, therefore, proper positioning is a major concern for teachers, therapists and parents of children with severe disabilities. For a special child, a correct body posture is quite often very difficult to achieve and to maintain not only because of physical limitations but also due to a lack of attention or interest in the task being performed or to the absence of consistent feedback on the correctness of the posture. For children who face this situation, we looked for devices that would encourage proper posture and/or discourage incorrect body posture. We found three available devices, all mounted in head bands and placed on the side of the child's head. The first one is a box which plays music when the correct body position is achieved; however, although most children enjoy music, the box continuously plays the same song over and over. The second device was a buzzer with an annoying sound that turned on at an incorrect body position but nothing at all happened when the correct behavior was exhibited (behaviorists have already warned us against punishment conditioning in humans). The third device was a tilt switch that activated a device when the head was tilted and this, of course, was the exact opposite to what we wanted to accomplish[6].

We believed these devices to be inappropriate for the achievement of our goal not only because of their mechanical functioning but also because a) they ignore the child's personal significance system (what is of interest to the particular child) and b) it is somebody else, not the child, the one who decides about the correctness of the given behavior. That is, not all children like the same song or feel motivated to act because of a particular melody; as for point "b", incorrect body positioning might certainly be the correct behavior if the child has grown tired of listening to the same song over and over or if he enjoys the sound of the buzzer. Lacking options, we built a small device that may be placed on a headband on the side of the child's head. When the body posture is correct, the device activates any adapted equipment of their preference such as a toy, a radio tuned at their favorite station or a tape player with songs they enjoy; incorrect posture results in the immediate deactivation of the device being used. We believed this device to have very much potential for working with children positioning, mainly because of four reasons: a) the child is encouraged to behave in a certain way that brings something meaningful to him/her, b) the child determines the correctness of the answer since it is his/her desire to activate the toy, c) if the child gets tired of using a particular toy it may be replaced by another toy of her preference at her request and d) the price of the materials needed to build the device is about $4.00.

Used together with the cooperation/contingency box, the head positioning device may allow a single switch activation of an adapted equipment to be contingent to proper body posture. Patricia, for example exhibits a very frequent backward tension of her body which difficult her learning, therapy sessions and general performance. Once Patricia's cognitive abilities develop enough, we can make the activation of her Barbie car contingent to her body posture (the plate switch would only work if her positioning is correct). Currently, we are developing a low cost device that would allow the head position switch to be connected to the remote control of a television or video cassette recorder, so that it turns the equipment on when adequate body posture is maintained and turns it off when it is not[7].

Low cost devices are a undoubtedly a good solution for funding problems; however, as noted before, funding is neither the only nor the worse barrier that Puerto Rico has for the accessibility to AT devices. Clemente Fernández, a young lawyer suffering from Friedreich's Ataxia needed professional help in the purchase of an equipment that would allow him to write all the legal documents that his job required. Clemente wanted an adapted computer and he had the money to buy it, but he was not able to find anybody who could tell him exactly which computer and what kind of adaptation he needed. In Puerto Rico there is a lack of professionals properly trained, experienced and with enough knowledge of AT devices available so as to provide an accurate evaluation and recommendation of high tech equipment. After meetings with Clemente and Dr. Joseph Carroll, we realized that the the equipment needed would include a 486 computer with a fax/modem/voice card, spanish word predictor and a keyguard. The equipment was purchased, taken to his home and we even volunteered to install it, but training was not available for him to learn how to use it. When it comes to training the end user and adjusting the fit of the human-computer interaction, there is a major lack of professionals in Puerto Rico who can integrate knowledge about high tech equipment, specialized software programs, human-machine systems, training methods and techniques and about the special needs of the person in order to provide adequate short and long term support. Clemente was finally trained by the PRATP staff on the use of his computer and was guided and encouraged to learn more on his own; as for adjustments, the keyboard had to be changed, several pointing devices were evaluated, the computer was connected to the Internet and legal databases in order for him to access materials related to his job.

For people with severe motor impairments, like Clemente, voice input devices appear to be an excellent alternative since the user can type faster by using this device than almost any other alternate input system (except maybe morse code). Despite the potential benefits that this type of equipment may have on our disabled population it still doesn't exist any effective voice input device in Spanish and the company that is expected to come up with the first version has not being able to produce it in the time frame it was supposed to reach the computer market[8]. Voice recognition programs may help cognitively challenged children to acquire vocabulary and learn the correct spelling of words by speaking into the microphone and seeing the corresponding characters appear on screen. It may also be specially useful when working with children whose learning is highly visual, as is the case with many children with Down Syndrome. However, once again, the Hispanic community must wait for the availability of an assistive device instead of being able to develop its own technology through the use of the human resources available in major research centers (universities for example). Professionals in Puerto Rico do have the necessary knowledge to develop high technology devices, but they have not been properly oriented nor motivated towards applying their skills to the creation of assistive equipment for people with special needs. With this in mind, the PRATP has already established contacts with the engineering departments of the UPR, Mayaguez campus, to design and develop AT equipment according to the particular needs of the hispanic community.

Héctor Román is a blind law student at the University of Puerto Rico and a part of the PRATP staff. With the help of Dr. Carroll, Héctor became the first blind person on the Island to use an adapted computer with a voice synthesizer and access the Internet through it. Together with David Cruz, current Ombudsman for People with Disabilities, Héctor was one of the first blind persons in Puerto Rico to gain access to high tech assistive devices. One of the deciding factors on Héctor's success story was his early introduction to AT devices, which is generally not the case for children with disabilities. To attempt to remedy this situation, the PRATP has offered several conferences throughout the Island to increase awareness on the need of AT equipment in school settings and to train service providers on the effective use of assistive devices on children with special needs.

In one way or another, the PRATP has cracked and debilitated each one of the factors identified as barriers to the access of assistive technology devices and services[9], but there is undoubtedly much more work to be done. During the first 12 months of operation, the PRATP achieved a most significant progress in every goal and objective set for the program year and, from our current standpoint, we can anticipate that the assistive technology impact in Puerto Rico is not a small one.

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Footnotes

[1] Cited in Rieber & Carton, 1993, p.83.

[2] Results of a needs assesement study carried out by the PRATP (1994) revealed very little knowledge about assistive technology devices and services among service providers (2.13 average on a 1-5 scale).

[3] Although the use of AT devices in Puerto Rico has a longer history, local development and adaptation of technology is quite recent.

[4] As far our research has gone, we have found no comparable device currently in the market.

[5] The cooperation/contingency box may also be used for shaping particular sequences or instances of motor behaviors identified by the therapist as being desirable for the child. For training and practice on coordination skills, a musical lantern may be set to turn on when two switches mounted on a wheelchair tray are simultaneously activated one with each hand. The two switches may be placed on the tray so as to be simultaneously activated with the elbow and the hand of the same arm, and therefore approach the correct arm position required for writing and coloring. If the child reaches from above to touch one switch the device is not activated since the elbow is not supported on the tray and the second switch is not pressed.

[6] This switch may be repositioned to turn on a device when the correct posture is achieved and to turn it off when the head tilts to one preset direction. However, if the switch is set to turn off the device when the head tilts to the front, it will still be activated even when the head falls backwards or sideways.

[7] The importance of this device lies in the fact that the television seems to be a very motivating, attention keeping and generally significant stimulus for children and these factors may well be put to good use by parents, teachers and therapists.

[8] The Spanish version of the program is now expected to be released sometime this summer (1995).

[9] General knowledge about assistive technology on service providers that participated in the PRATP training sessions was significantly increased from a 2.13 to a 3.28 on a 1-5 scale.