Gaming in Physical Liberation: Three Case Studies

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Abstract

This paper looks at three nonspeaking individuals who are using games to develop skills needed for the operation of augmentative communication devices. Each person has severe physical and/or cognitive limitations which have restricted the mode of input which he or she has been able to use in a practical way. The therapy team for each person has introduced a game that challenges that user to use a hitherto untapped input modality. In the first case study, a game with stimulating reinforcement serves to awaken a minimal response in the user that may lead to a practical scanning device. In the second case, a person already using a scanning system is now mastering direct selection techniques using movements he never before tapped in a systematic way for communication. The third individual has been restricted to single-switch scanning for over a decade. He is now playing a game using his foot and toe movement to create coded patterns. This is seen as leading to a more efficient way for him to operate systems for communication and environmental control. In all three cases, gaming is called upon to facilitate a transition toward more efficient control and greater personal freedom.

Keywords: Rehabilitation, Triaxial Accelerometer, Augmentative Communication, Paralyzed, Cerebral Palsy, Head Injury, Communication Disorders

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Introduction

For persons who are profoundly physically limited and unable to speak, life options are highly restricted. Fortunately, the last four decades have seen the advent of computer-based systems for *augmentative and alternative communication* (AAC), also referred to as *augmentative communication*. Using a variety of input sensing techniques and portable voice synthesis, Voice-Output Communication Aids (VOCAs) have revolutionized the rehabilitation options for persons paralyzed by stroke, cerebral palsy, traumatic brain injury, and progressive neurological disorders. For insurance purposes, such devices are also called Speech Generating Devices (SGDs) (Aetna, Inc., 2010).

To be able to benefit from this technology, the user must be able to produce some purposive signal that can be interpreted as a communicative act. A wide range of input technology has been developed and is now commercially available. This includes single switches, keyboards, joysticks, touch panels, and a range of other sensing devices. Some commercial communication devices are designed to be mounted on wheelchairs. Others may be carried or worn by an ambulatory user. There has been no end to the search for better input technology for augmentative communication (Eulenberg & Blosser, 1996; Eulenberg & Blosser, 2004; Eulenberg, Currier & Blosser, 2010; Eulenberg, King, & Patterson, 1985; Eulenberg & Rahimi, 1977).

The historical development of commercial electronic gaming technology has run parallel to that of AAC technology. The evolution of joysticks and game controllers into wireless sensors of the gamer’s movements, together with an ever richer audio and visual display capability, has helped to bring us myriad virtual worlds in which to play our games.

The aim of augmentative communication technology, however, is not to create a virtual world, but to permit the user to function well in the real world. Nevertheless, the world of gaming and the world of rehabilitation do have a significant intersection. They intersect not only in their tools and techniques, but also in their transformative nature. In this paper, we explore this nexus of tools and transformation in three case studies.

The Transformative Nature of Games

In all the case studies discussed here, games are used as the means of training individuals in skills that they can transfer to the successful operation of a communication aid system. In each case, we are testing the hypothesis that if the cognitive and physical requirements of a communication system sufficiently match those of a game, then that game can be used as a means to develop those same skills.

Our underlying theoretical model of skill transferability from game to communication system does not require that all aspects of the game and the target communication system be identical for the gaming experience to be of value. Rather, the transfer of skills will be considered successful if the individual can operate the communication device to purposely produce spoken or written utterances. Other communication skills, such as grammatical correctness, turn-taking, and appropriate choice of vocabulary, are important for separate consideration in a therapeutic or academic framework.

One major element that the rehabilitation context contributes to game design is the input technology. Mainstream commercial games are based on typical human abilities. The joysticks and controllers for hand action and the dance mats and gym mats for foot sensing are designed for persons within the conventional spectrum of capability. When used in rehabilitation, the physical input for communication devices and games alike must often tap an unconventional locus of control.

The augmented communicator may be seen as a dyad of a human and a device or system that serves as a prosthesis. This AAC user controls his or her system to produce utterances that other people can understand, whether written or spoken. The device presents the user with a set of linguistic units from which the user chooses in sequence to construct utterances. The linguistic units are arranged in what is termed a "language space." A language space is defined as "a structured representation of linguistic elements and their relationships." (Eulenberg, Rahimi, & Reid, 1977). An example of a representation of language space would be a computer keyboard, where the elements are alphanumeric characters, punctuation, and control functions. These elements of the language space are called a "selection set" (Beukelman & Mirenda, 2005).

A commonly used representation of language space in augmentative communication is a word board or letter board, where the selection set are letters, words, and phrases. The nonspeaking person uses such a board by pointing successively to individual items in order to construct an utterance. The prevailing model of augmentative communication, as described by Dowden and Cook (2002), uses a hierarchical taxonomy of input modalities based on how many symbols a person can point to in a given language space. This taxonomy is divided into two major categories: (1) *direct selection*; and (2) *indirect selection*. The latter category is further differentiated into two subcategories: *scanning* and *encoding*. Dowden and Cook (2002) describe each of these input modalities as follows (original emphasis retained):

Direct selection: A method of communication in which the individual specifically indicates the desired item in the selection set **without any intermediary steps**.

Encoding: A rate enhancement technique in which the user selects a predetermined sequence of items to retrieve a complete word, phrase or sentence. Codes can be based on icons (symbols), alphabet letters, letters and numbers combined ("alphanumeric codes") or numbers alone. A sequence of symbols from the selection set calls up the desired word or phrase..

Scanning: An "indirect selection" technique in which items are presented sequentially one at a time and the individual activates a switch or otherwise signals to accept one of the items when presented. Scanning is only intended for individuals who do not have sufficient motor control for direct selection techniques. (chap. 12)

It is apparent that scanning is generally for persons with the lowest level of physical ability, while direct selection is for persons with relatively good physical ability. Encoding is intermediate between the two, requiring greater ability than needed for scanning, but less than is needed to use direct selection. Over the years, as new input technology has been introduced into the field of augmentative communication, the taxonomy of direct selection, encoding, and scanning has had to be extended to a more complex analysis to take into account systems which use combinations of these basic categories. Nevertheless, for our present purposes, this taxonomy can still be used to illumine the case studies here presented.

Three Case Studies

Each of the case studies reported here involves an individual using gaming as a way to move upward within this hierarchy of access modalities. The individuals are all severely physically limited, but each has his or her own unique set of abilities and requirements. In each case, a person has been using one means of augmentative communication, but now, through gaming, is learning to use his or her physical body in a new way to attain a newer, more effective level of communication.

Study 1: MH, Finding a Pathway to Single-Switch Scanning

In this first game-based intervention, the individual is a candidate for a single-switch scanning system because of her limited range of motion and variability in her observed level of consciousness.

MH, now 31, experienced brain damage on her eighteenth birthday, the result of an apparent anaphylactic reaction. She cannot walk or otherwise control her extremities. She is not able to hold up her head without a head restraint. Her condition at times resembles a coma, with eyes sometimes closed as if in sleep. At other times, her eyes are wide open and she seems to be taking in the scene around her. She does not speak. She does, on occasions, produce vocalizations indicative of pleasure or pain. We have set up a game for MH, *JOng*, which she operates with slight sideward movements of her head, detected by an infrared SCATIR switch mounted on a metal gooseneck on MH's wheelchair. The game's display screen shows a maze of six vertical halls separated by narrow walls of randomly varying colors (see Figure 1).

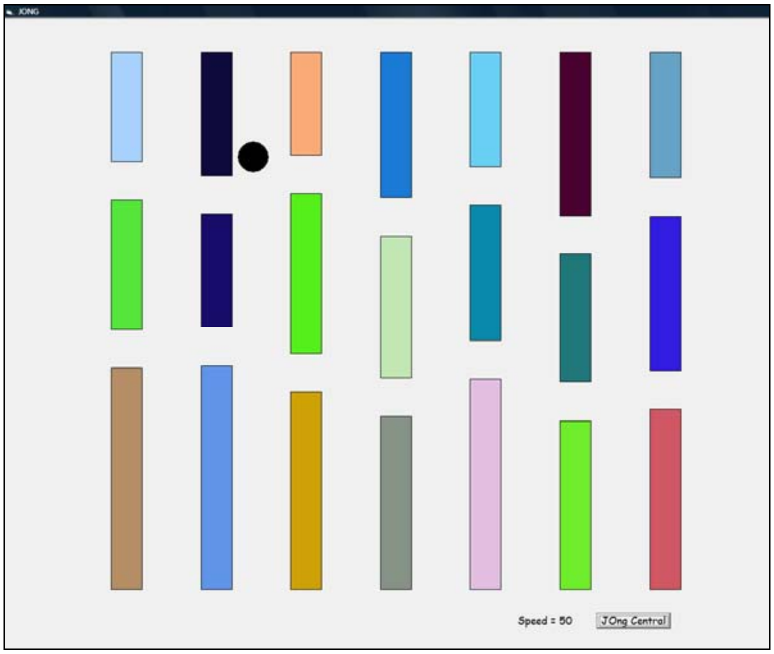

Figure 1. Screenshot of *JOng* in mid-game play.

A ball moves within the leftmost section, bouncing from bottom to top with audible "boing" sounds at the extremes. Each of the vertical dividing walls has two gaps in it. Each gap is therefore a passageway between two halls. If the user activates a switch while the moving ball is passing by a gap, the ball moves through that gap and into the next hall to the right. When the ball has moved out of the rightmost hall, the game is over. At that point, the player is rewarded with a short music video, randomly selected from a repertoire of about a dozen videos. One of the music videos is an animated GIF of MH herself dancing in her wheelchair to a Motown tune (see Figure 2).

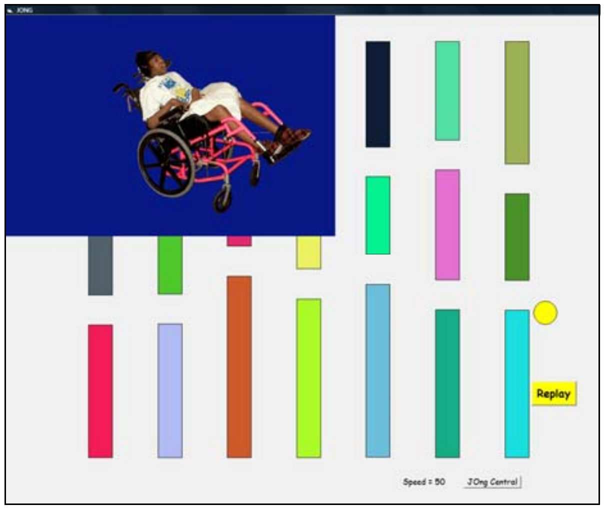

Figure 2. Screenshot of *JOng* showing music video reward.

After the music video is finished, play resumes with a new randomly drawn maze. The time that the player takes to go through the maze is recorded in a data file. A record of short times indicates that the player is a good candidate for a communication system based on single-switch scanning.

MH has played this game dozens of times in the past year. Given enough time, she usually does get through the maze, but it usually takes her on the order of thirty minutes to do so. This compares to a typical game time of one minute or less for other quadriplegic players with whom we work. It is not always evident whether MH is activating the switch on purpose or by accident, but she shows from her affective responses -- her smile and her vocalization -- that she enjoys the experience. Her main problem seems to stem from her apraxia: her inability to plan and execute purposive movements in an acceptable time frame. Her ultra-slow game time would seem to exclude her from candidacy for a scanning-based communication system. We speculate that she does purposefully activate her switch, but that her apraxia prevents her from doing so consistently. We think that those moments when control is possible are meaningful to her because they prove to her that she is not completely isolated from the world. We are continuing to work with her therapy team to find signals that MH can reliably produce. In the meantime, she continues to enjoy *JOng*.

Study 2: KJ, Advancing Towards Direct Selection

In this second intervention, the individual has for years used a single-switch scanning system. His communication, however, is at a low level of efficiency due to his limited range of control. He has recently begun to have success using a new access mode which may enable him to use a system based on direct selection. He is developing his skills using this new access mode through game-based practice.

KJ, 45-years old, has athetoid hypertonic cerebral palsy. He has no understandable speech, but he can produce several distinct vowel sounds as well as the voiced velar consonant (/g/). He has limited control of his extremities and is unable to walk or stand up. His limbs tend to move uncontrollably, often in reflexive opposition to one another, causing his arms or legs to lock up. He has never been able to use a keyboard or other direct-selection input system. He has used a proprietary infrared head-position sensor (U.S. Patent No. 7369951, 2008) to operate a single-switch scanning device with digital voice output. This scanning system is very slow because of his relatively slow head movement. The inefficiency of scanning led KJ's therapy team to search for a body movement that would allow KJ to use direct selection. The team solicited KJ's own suggestions for the locus of control that he thought could be his best. KJ indicated that he wanted to try to use his left leg. He was insistent on this, despite the significant problems of spasticity and athetosis (involuntary movements) that he experienced with both lower extremities. When given the opportunity to use his leg with a Freescale™ Semiconductor ZSTAR wireless triaxial accelerometer (Lajsner & Kozub, 2007), KJ showed his team that he actually could point to different places on a video display. He was using his left leg to perform direct selection for the first time in his life. (Eulenberg, 2010)

Based on this initial breakthrough, we designed for KJ a video game, *Ivory*, that he controls with movements of his left leg via the ZSTAR triaxial accelerometer, mounted on his shoe (see Figure 3).

Figure 3: Accelerometer mounted on KJ's athletic shoe.

The *Ivory* game video display shows a set of lines demarcating horizontal levels and a blue ball which moves in two dimensions in accordance with the tilt of KJ's leg (see Figure 3). A cartoon elephant points with its trunk to indicate a target level where KJ is supposed to position the ball (see Figure 4).

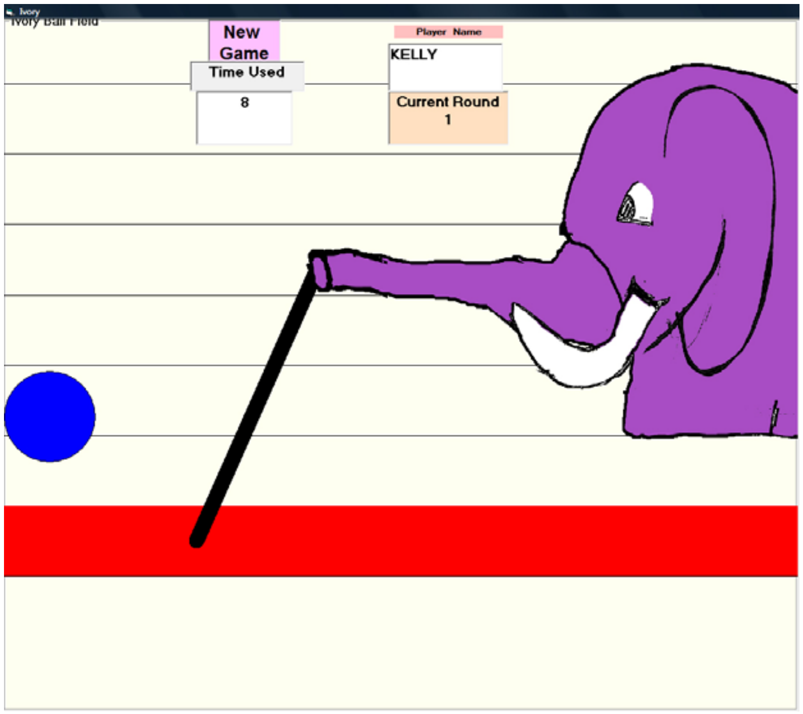

Figure 4: The *Ivory* game graphic display.

If he is able to maintain the ball on the target level for a predetermined length of time, there is an auditory reward (a musical whistle) and the elephant then points to the next target level.

KJ's performance is logged to a data file that his therapist uses to record his progress. After three months of playing "Ivory", KJ is now able to operate a voice-output communication system that he controls in the same way: using his leg to point to a word or phrase on a visual display and then activating that utterance by dwelling there for a preset length of time. He has made the transition from single-switch scanning to a limited vocabulary direct selection system, using skills he developed playing *Ivory*.

Study 3: BM, Learning to Encode Leg Movements

In this final intervention, the individual has for years successfully used a scanning system for communication and environmental control. He has recently shown aptitude for using an encoding-based night-call communication system that involves rudimentary pattern recognition, for which he uses a game to hone his skill.

BM, now 49, was 35 when he sustained catastrophic injuries in a snowmobile accident. He has paralysis in all four extremities and has no speech. He does have the ability to elevate his right foot and can squeeze his right thumb against the palm. We fitted him with a squeeze-bulb switch, which he operates successfully. For the past eight years, he has used this squeeze switch with a single-switch scanning system for voice output communication and for environmental control. He lives in a residential rehabilitation facility where he has his own private room. The facility wanted to provide him with a night-alarm system that would allow him to call a nurse or attendant if he should awaken during the night and need assistance. Use of his squeeze-bulb switch in such a situation was precluded because he cannot hold onto it while sleeping. After assessing his ability to move his right leg, we proposed that he could be fitted with a small wireless triaxial accelerometer. Worn over his night foot bindings, the accelerometer senses his movements in 3D space and transmits these on a continuing basis to a computer-based receiver at the night nurse's station. To send a signal to the nurse, BM must move his foot purposively in a pre-set manner, such as three "up-downs" in a period of two seconds, followed by a two-second pause, and then two more "up-down" movements.

In order to determine whether BM could produce such foot-movement encodings, we asked him to reproduce various movement patterns on command. He was happy to show us that he could accurately make these patterns. This has led us to collaborate with BM and his therapy team in designing a video game, “B’s Snow Race,” that rewards him for producing various foot gestures. Based on a snowmobile race theme, BM advances a snowmobile through a snowy terrain by accurately moving his foot according to a displayed target pattern. At this time, his night alarm system is being evaluated for safety and reliability. His game is providing him with both recreation and beneficial exercise.

Discussion

All 3 of the individuals described here continue to experience profound physical limitations. Each has been advancing, through gaming, toward greater ability to communicate with others and with the environment.

MH is in the process of emerging from a closed inner world. Gaming presents her with feedback for her slightest movement and therefore gives her a pathway to self awareness as well as a means of outward expression. KJ's game playing has led him to a new means of control that allows him to point directly at places in a visual presentation of a set of symbols rather than depending on a much slower scanning system. BM Has used gaming to develop a new modality of night signaling using encoded leg movements. He retains his functional squeeze-switch scanning system for daytime use. The possibility exists that these two modes may in the future be combined into a functional dual input system.

Computer based gaming has many technological similarities to augmentative communication. Gaming can play an important part in helping persons with profound physical restrictions to advance toward higher levels of communication and control.

Game designers can make meaningful contributions to rehabilitative intervention by providing a platform for fostering skills and self awareness.

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