A Touch Pad and a Scanning Keyboard Emulator to facilitate writing by a woman with extensive motor disability

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Abstract

This study assessed the use of a touch-pad microswitch and a scanning keyboard emulator to facilitate the writing performance of a woman with extensive motor disability. The touch pad allowed the woman to select the letters and write them with a simple movement of her hand, as they were automatically scanned on the keyboard. The data showed that the woman learned to use this writing approach and her writing time improved (i.e., becoming similar to the time she needed with an adapted version of a regular keyboard). The new approach, contrary to the adapted keyboard, was not particularly tiring and the woman chose to use it at each of the 10 preference checks when she could decide which one to use. University psychology students also provided a positive evaluation of the new approach during a social validation assessment. Implications of the findings were discussed.

Keywords: Touch pad, Keyboard emulator, Extensive motor disability

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1. Introduction

Persons with extensive motor disabilities can have very serious difficulties using computers. In fact, their disabilities can prevent or make it particularly difficult for them to control the computer mouse and keyboard, that is, the two basic tools for computer access (Evans, Drew, & Blenkhorn, 2000; Betke, Gips, & Fleming, 2002; Turpin, Armstrong, Frost, Fine, Wards, & Pinnington, 2005; Borghetti, Bruni, Fabbrini, Murri, & Sartucci, 2007; Lancioni, Singh, O'Reilly, Sigafoos, Green, Chiapparino *et al.,* 2009). Given this condition, computer-mediated occupation and leisure perspectives and communication (e.g., writing) opportunities can be substantially reduced (Lau & O'Leary, 1993; Chen, 2001; Chen, Chen, Chen, Luh, & Lai, 2003a; Chen, Chen, Kuo, & Lai, 2003b). Various efforts have been made to develop technological support solutions that could alleviate the aforementioned difficulties and their consequences (Chen, 2001; Betke *et al.,* 2002; LoPresti, Brienza, & Angelo, 2002; Turpin *et al.,* 2005; Hori, Sakano, & Saitoh, 2006; Borghetti *et al.,* 2007; Lancioni, Singh, O'Reilly, Sigafoos, Chiapparono, Stasolla *et al.,* 2007).

For example, Evans *et al.* (2000) described the use of a special joystick, which could be operated through the participant's head movements. Essentially, these movements were translated into functional mouse signals through which computer operations could be managed. Similarly, Chen (2001) reported the use of tilt sensors fixed to the headset that the participant wore. The sensors detected the head movements and translated them into movements of the cursor. A further input through a face (cheek) sensor would be added to complete the mouse operations. Betke *et al.* (2002) described a camera mouse system, which was designed to use various forms of movement (and not only head movements) to produce movements of the mouse on the screen. Lancioni *et al.* (2007) introduced a system that relied on the use of a simple, minimal response of the participant (i.e., tongue protrusion or eye turning), a microswitch to monitor it, and a scanning keyboard emulator. The microswitch signal produced by the response could be used to control the key scanning process and ultimately the selection of the keys/letters.

The system developed by Lancioni *et al.* (2007) could be considered (a) fairly simple in terms of response requirements (thus easily used also with persons with pervasive motor disabilities and not likely to be tiring for them), and (b) rather non-invasive (i.e., participants would not be required to wear complex and intrusive materials such as an headset). The preliminary application of the aforementioned system for writing purposes seems to provide it an immediately relevant value. In fact, the perspective of a participant with extensive motor disabilities being able to engage in such an activity without adverse (tiring) effects for relatively long periods of time would be practically important and have wide-ranging implications (Borghetti et al., 2007; Lancioni, O'Reilly, Singh, Green, Chiapparino, De Pace *et al.,* 2010). Even so, caution may be obligatory until additional evidence is available (i.e., until several successful replications of the preliminary studies have been carried out with various participants). The present study was conceived as (a) a replication effort with a woman with extensive motor disabilities, and (b) a social validation assessment of the system involving university psychology students as social raters (Callahan, Henson, & Cowan, 2008).

2. Method

2.1 Participant

The participant (Beth) was 27 years old, and was considered to be within the typical range of intellectual functioning although no formal testing had been carried out and no IQ scores were available. Due to perinatal hypoxia, she presented with spastic tetraparesis and dysarthria. This condition reduced her motor independence and also interfered with her verbal communication (which was quite tiring for her to produce and very difficult for the listeners to understand). She could easily follow spoken language (i.e., conversations) produced around her and was interested in intervening with her feedback. She could read written text and enjoyed doing so. She was very interested in writing, but the use of a slightly modified keyboard (i.e., a keyboard with a special perimeter to prevent her hand from touching/pressing the keys during its movements) was quite laborious and tiring for her. She had asked for a simpler solution and was eager to use the system available within this study. Her parents provided informed consent for this study, which had also been approved by a scientific and ethics committee.

2.2 Technology and Response

The technology used for the study included a touch pad microswitch, a scanning keyboard emulator (QualiKey by QualiLife UK, Kent TN15 7DA), and a personal computer (PC). The touch pad microswitch could be activated with a small hand stroking response (i.e., a response considered to suitable for Beth because she could perform it fairly quickly, reliably, and without much effort). The touch pad microswitch was adopted because it appeared very practical, simple, and economical.

The keyboard emulator appeared in the lower half of the computer screen. The composition and functioning of the keyboard were adapted to Beth's condition. That is, the keyboard included only the letter keys, which were arranged in three rows. The automatic scanning (i.e., illumination) of the letter rows and of the single keys (letters) of the rows was set at 2 seconds (see below). In practice, the first response (i.e., microswitch activation) led to the scanning of the first row of letters for 2 seconds. If none of the letters of that row served for the word to be written, Beth refrained from responding and the scanning automatically moved to the next row at the end of the 2 seconds. If Beth responded during the scanning of a row, the scanning process moved immediately to the single keys/letters of that row (2 seconds per key). Responding during the scanning (illumination) of a letter wrote that letter on the upper half of the computer screen. This was followed by the re-illumination of the row and a continuation of the process as described above.

The technology used before the study (i.e., adapted keyboard connected to a computer and related screen) served as a control condition during the study. Specifically, it served for the initial sessions of the study and for the alternating treatments period of the study (see Experimental Conditions).

2.3 Sessions and Data Collection

Sessions involved the writing of six to eight familiar words, which were presented individually by a research assistant. Sessions were followed by brief conversations which the research assistant, on Beth's favorite topics, such as television programs and perfumes (i.e., by events that could be pleasing for Beth and motivating for her efforts). Data collection consisted of recording (a) the time required for writing each word, (b) Beth's responses to 10 preference checks (i.e., Beth's choices of the new technology or of the old technology at the start of preference-evaluation sessions), and (c) the scores provided by the psychology students involved in the social validation process on a 4-item questionnaire (see below). Interrater agreement was assessed over about 20% of the words written during the study and on all preference checks. No agreement was assessed on the students' scores, as they were permanent data. The percentages of agreement were above 95 (allowing a discrepancy of 5 seconds between raters) on the words, and 100% on the preference checks.

2.4 Experimental Conditions

The study included four procedural phases followed by the social validation assessment. During the first procedural phase, Beth was provided with her conventional technology. The second phase involved the use of the new technology system. The third phase compared the two (old and new) systems according to an alternating treatments design (Barlow, Nock, & Hersen, 2009). The fourth phase served for the preference checks.

First phase (traditional technology). This phase included 12 sessions reproducing Beth's normal writing conditions.

Second phase (new technology). This phase included 37 sessions, which differed from those used in the first phase in that they (a) included the new technology and (b) were introduced by practice sessions on the use of this technology. The practice sessions consisted of four periods of about 30 minutes each, during which the research assistant provided any help that Beth would require to use the technology.

Third phase (alternating conditions). This phase included 20 sessions. Ten of them corresponded to those of the first phase and the other 10 corresponded to those of the second phase. The two types of sessions were alternated regularly.

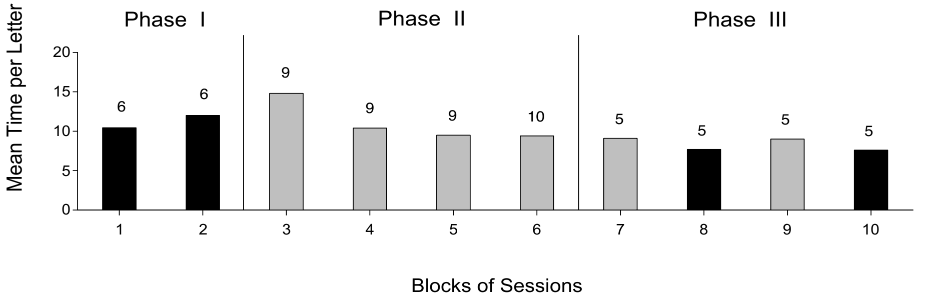
Fourth phase (preference checks). This phase included 10 sessions. Prior to each of them, Beth was asked to indicate which system she wanted to use for the session. The session was then carried out with the system that Beth chose.

Social validation assessment. This assessment involved the participation of 42 psychology university students ranging in age between 21 and 46 (M = 24) years. The students watched two 4-minute video clips in groups of two to five members. For one-half of the students, the two video clips concerned Beth's performance in sessions with the traditional technology and in sessions with the new technology, respectively. For the other half of the students, the order of the video clips was reversed. The clips had been selected by two research assistants out of a pool available for the two types of sessions occurred during the alternating conditions phase. The selection was based on the view that they were most representative of Beth's performance during those sessions. After watching the clips, the students were to score the two writing conditions on their presumed suitableness and effectiveness for Beth, on Beth's enjoyment of them, and on the students' personal liking of them. For each item, scores of 1 to 5 were available with 1 being the least positive and 5 the most positive.

3. Results

Figure 1 summarizes Beth's writing data during the first three procedural phases of the study. The sessions are grouped into two blocks for the first phase, four blocks for the second phase, and four blocks (two per technology condition) for the third phase. The number of sessions included in each block (bar) is indicated by the numeral above it. Each bar represents the mean writing time per letter over a block of sessions (i.e., computed over all the words of the sessions included in the block). The writing time per letter of the single words was computed by dividing the number of seconds needed for writing the word by the number of letters written correctly.

Figure 1 - *Each bar represents the mean writing time (in seconds) per letter computed over all the words of a block of sessions with the old technology (black bar) or with the new technology (gray bar). The numbers of sessions included in the bars/blocks are indicated by the numerals above them*



The mean writing time per letter over the two blocks of the first phase exceeded 11 seconds (with a range of 4 to 29 seconds per letter across the single words). The mean writing time per letter over the first block of sessions of the second phase (i.e., immediately after the introduction of the new technology) was about 15 seconds. The range per letter of the single words was 7 to 36 seconds. The mean writing time per letter over the next three blocks of the phase was about 10 seconds (with a range of 5 to 20 seconds per letter across the single words). The mean writing time over the two blocks of sessions of the third phase concerning the new system was about 9 seconds. The mean writing time over the two blocks of sessions concerning the old system was below 8 seconds. During the fourth phase of the study, Beth chose the new system at each of the 10 preference checks. Her writing performance (not reported in Figure 1) was comparable to that observed during the third phase.

The social validation data are summarized in Table 1. The scores of the 42 students had mean values of about 4 and about 2 at each item of the questionnaire for the new and the old technology systems, respectively. Post-hoc paired t tests indicated that the score differences were statistically significant on each of the items. The t (41) values were between 10.1 and 14.2 ($p < 0.01$) (Bourke, Daly, & McGilvray, 1985).

Table 1 - *Means (M) and Standard Deviations (SD) of the Students' Scores on the two Technology Conditions across the four Questionnaire Items*

Items	Old Technology		New Technology	
	M	SD	M	SD
1	2.00	0.73	4.26	0.59
2	1.90	0.76	4.19	0.55
3	2.31	1.09	4.12	0.61
4	2.12	1.02	4.14	0.56

4. Discussion

The data of this study indicate that the new system involving the touch pad microswitch and the scanning keyboard emulator allowed Beth to write with a speed similar to that she could manage with the old system. The new system, however, appeared much less demanding for her, and indeed she chose to use it at each of the preference checks. The university psychology students involved in the social validation assessment indicated a clear difference between the systems and attributed much higher (more positive) scores to the new one.

The availability of a writing system that is simple and non-tiring is essential if one has to establish writing as a communication activity or as an instrument to access Internet and engage in information-gathering or leisure activities (Davies, Mudge, Ameratunga, & Stott, 2010). For Beth, the new system may be an important step in this direction (i.e., an opportunity to develop writing along the aforementioned lines with wide-ranging implications for an overall improvement in her condition (Moisey & van de Keere, 2007; Kehoe, Neff, & Pitt, 2009; Lathouwers, de Moor, & Didden, 2009).

The writing speed reported for Beth seems quite modest, and efforts would be needed to improve it. A first effort could concern the adoption of a new response and microswitch that might allow some advantage over the response and microswitch used. For example, one might think of (a) vocalization as a response that can be fast and non-tiring and thus potentially advantageous, and (b) a voice detecting device with a throat and an airborne microphone (Lancioni, Singh, O'Reilly, & Oliva, 2005). A second effort might concern the grouping of two or three letters within each keyboard key (Bache & Derwent, 2008; Lancioni *et al.,* 2010). The person could stop the key when this is scanned and then choose one of the letters included in it with one or more (hand or vocal) responses.

In conclusion, this study provides additional positive evidence as to the possibility of using a simple response and microswitch combined with a scanning keyboard emulator to allow persons with pervasive motor disabilities to write without particular efforts (i.e., without getting tired). These findings support the view that writing may eventually be used for long periods of time, as a tool for elaborate communication and Internet access (Dobransky & Hargittai, 2006; Weber, 2006; Lathouwers *et al.,* 2009). The relative slowness of the writing process, however, calls for new research efforts to find ways of improving this aspect. The aforementioned suggestions of trying new responses and grouping letters within the single keyboard keys could be taken as immediate targets of new research.

References

Bache, J., & Derwent, G. (2008). Access to computer-based leisure for individuals with profound disabilities. *NeuroRehabilitation, 23*, 343-350.

Barlow, D. H., Nock, M., & Hersen, M. (2009). *Single-case experimental designs: Strategies for studying behavior change* (3rd ed.). New York: Allyn & Bacon.

Betke, M., Gips, J., & Fleming, P. (2002). The camera mouse: Visual tracking of body features to provide computer access for people with severe disabilities. *IEEE Transactions on Rehabilitation Engineering, 10,* 1-10.

Borghetti, D., Bruni, A., Fabbrini, M., Murri, L., & Sartucci, F. (2007). A low-cost interface for control of computer functions by means of eye movements. *Computers in Biology and Medicine, 37*, 1765-1770.

Bourke, G. J., Daly, L. E., & McGilvray, J. (1985). *Interpretations and uses of medical statistics* (3rd ed.). London: Blackwell.

Callahan, K., Henson, R. K., & Cowan, A. K. (2008). Social validation of evidence-based practices in autism by parents, teachers, and administrators. *Journal of Autism and Developmental Disorders, 38*, 678-692.

Chen, Y. L. (2001). Application of tilt sensors in human-computer mouse interface for people with disabilities. *IEEE Transactions on Rehabilitation Engineering, 9,* 289-294.

Chen, Y. L., Chen, S. C., Chen, W. L., Luh, J. J., & Lai, J. S. (2003a). Application of SEMG in computer mouse access for the disabilities. *Disability and Rehabilitation, 25,* 218-223.

Chen, Y. L., Chen, W. L., Kuo, T. S., & Lai, J. S. (2003b). A head movement image (HMI)-controlled computer mouse for people: Analysis of a time-out protocol and its applications in a single server environment. *Disability and Rehabilitation, 25,* 163-167.

Davies, T. C., Mudge, S., Ameratunga, S., & Stott, N. S. (2010). Enabling self-directed computer use for individuals with cerebral palsy: A systematic review of assistive devices and technologies. *Developmental Medicine and Child Neurology, 52*, 510-516.

Dobransky, K., & Hargittai, E. (2006). The disability divide in internet access and use. *Information, Communication and Society, 9,* 313-334.

Evans, D. G., Drew, R., & Blenkhorn, P. (2000). Controlling mouse pointer position using an infrared head-operated joystick. *IEEE Transactions on Rehabilitation Engineering, 8,* 107-117.

Hori, J., Sakano, K., & Saitoh, Y. (2006). Development of a communication support device controlled by eye movements and voluntary eye blink. *IEICE Transactions on Information and Systems*, E89D, 1790-1797.

Kehoe, A., Neff, F., & Pitt, I. (2009). Use of voice input to enhance cursor control in mainstream gaming applications. *Universal Access in the Information Society, 8*, 89-96.

Lancioni, G. E., Singh, N. N., O'Reilly, M. F., & Oliva, D. (2005). Microswitch programs for persons with multiple disabilities: An overview of the responses adopted for microswitch activation. *Cognitive Processing, 6,* 177-188.

Lancioni, G. E., O'Reilly, M. F., Singh, N. N., Green, V., Chiapparino, C., De Pace, C., Alberti, G., & Stasolla, F. (2010). Use of microswitch technology and a keyboard emulator to support literacy performance of persons with extensive neuro-motor disabilities. *Developmental Neurorehabilitation, 13*, 248-257.

Lancioni, G. E., Singh, N. N., O'Reilly, M. F., Sigafoos, J., Chiapparino, C., Stasolla, F., Oliva, D. (2007). Using an optic sensor and a scanning keyboard emulator to facilitate writing by persons with pervasive motor disabilities. *Journal of Developmental and Physical Disabilities, 19*, 593-603.

Lancioni, G. E., Singh, N. N., O'Reilly, M. F., Sigafoos, J., Green, V., Chiapparino, C., Stasolla, F., & Oliva, D. (2009). A voice-detecting sensor and a scanning keyboard emulator to support word writing by two boys with extensive motor disabilities. *Research in Developmental Disabilities, 30*, 203-209.

Lathouwers, K., de Moor, J., & Didden, R. (2009). Access to and use of internet by adolescents who have a physical disability: A comparative study. *Research in Developmental Disabilities, 30*, 702-711.

Lau, C., & O'Leary, S. (1993). Comparison of computer interface devices for persons with severe physical disabilities. *American Journal of Occupational Therapy, 47,* 1022-1030.

LoPresti, E. F., Brienza, D. M., & Angelo, J. (2002). Head-operated computer controls: Effect of controlmethod on performance for subjects with and without disability. *Interacting with Computers, 14,* 359-377.

Moisey, S., & van de Keere, R. (2007). Inclusion and the Internet: Teaching adults with developmental disabilities to use information and communication technology. *Developmental Disabilities Bulletin, 35*, 72-102.

Turpin, G., Armstrong, J., Frost, P., Fine, B., Wards, C. D., & Pinnington, L. L. (2005). Evaluation of alternative computer input devices used by people with disabilities. *Journal of Medical Engineering and Technology, 29,* 119-129.

Weber, H. (2006). Providing access to the Internet for people with disabilities: Short and medium term research demands. *Theoretical Issues in Ergonomics Science*, *7*, 491-498.