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Intervention Programs Based on Microswitch Technology for Persons with Multiple Disabilities: An Overview

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Abstract This paper provides an overview of microswitch-based programs for persons with multiple disabilities. Three types of programs are included in the overview: Firstly, programs involving only one microswitch, aimed at promoting specific response engagement in relation to contingent environmental stimulation; secondly, programs involving one or two microswitches, directed at promoting response engagement and choice; thirdly, programs typically involving a combination of two microswitches, aimed at promoting response engagement as well as reducing problem posture or problem behavior. This paper also provides general considerations about the programs reviewed (i.e., in terms of applicability, potential benefits, and costs), and suggests several issues for new research in the area.

Keywords Microswitches · Contingent stimulation · Technology · Microswitch cluster · Hand responses · Head responses · Vocal emissions · Tongue protrusion · Forehead skin movement · Head forward tilting

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Introduction

Microswitches are assistive technology devices that can be activated with small or minimal responses (e.g., head turning, finger movement, and eyelid closure) and are normally used in combination with an electronic control system (computer), and basic software [1, 2, 3•, 4, 5]. The control system can contain a variety of stimulus files (e.g., music and videos) and can also be linked to external stimulus sources (e.g., light and vibration devices). Intervention programs involving the use of microswitches for persons with multiple disabilities (e.g., neuro-motor and intellectual disabilities) have one major objective in common. The objective is to help the person acquire an active role, and develop and strengthen some form of constructive/functional response in order to access relevant (reinforcing) stimulation events in an independent manner [3•, 6]. The programs' extension and scope can, however, vary quite substantially in light of the participants' characteristics as well as procedural or environmental considerations. Based on these differences, at least three groups of microswitch-aided programs can be identified: Programs aimed at promoting specific response engagement in relation to contingent environmental stimulation; programs directed at promoting response engagement and choice; programs aimed at promoting response engagement as well as reducing problem posture or problem behavior [3•, 7–10].

The purpose of this paper is to provide an overview of studies carried out to assess the three types of programs mentioned above. In particular, the paper presents detailed summaries of a few studies for each of the three types of program, clarifying which of the various microswitch solutions (and technology packages) were adopted; responses targeted, procedural conditions implemented, and results obtained. Considerations regarding the programs' general applicability, benefits, and costs are also presented. Finally, some new technology developments as well as other possible issues for future research are discussed.

Programs Aimed at Promoting Specific Response Engagement

Most of the early studies evaluating microswitch-aided programs to promote specific response engagement focused on the strengthening of a hand or head response and predominantly used pressure microswitches [5, 7, 9–18]. Another group of studies investigated a variety of small responses (e.g., vocal emissions, eyelid closures, mouth opening or closing) and the new microswitch technology developed to monitor those responses [19•, 20–22, 23•, 24•, 25•]. The possibility of monitoring small responses is critical to allow the application of microswitch-aided programs for persons with pervasive motor impairment who only have a minimal response repertoire, which would be inadequate for conventional pressure microswitches [3•, 23•].

Studies Targeting Hand and Head Responses

One of the studies involving these responses was carried out by Gutowski [12]. The study involved two participants of 39 and 46 years of age, who presented with extensive motor impairment; unspecified (probably profound) intellectual disabilities, and no recognizable forms of communication. The microswitches used for one of the participants consisted of pressure devices strapped on each armrest of her wheelchair. A response on either of the two devices produced a brief music episode. This was considered to be motivating (reinforcing) for the participant, and thus capable of increasing her response level. The microswitches used for the second participant consisted of the same type of pressure devices, adapted into the palms of the participant's hands. Pressure on either device led to the presentation of a small quantity of beverage. Both participants were reported to have quickly increased their responses and also maintained such a level of responses when the stimuli were made available intermittently.

Holburn et al. [13] included five participants whose ages varied from 23 to 40 years. All participants required wheelchairs, were rated in the profound intellectual disability range, and were not capable of any recognizable communication. The microswitches employed consisted of pressure devices activated through responses varying from hand/finger movements, (such as pushing/moving flexible spring-like devices), to head turning actions aimed at pushing on pressure devices. Microswitch activation allowed the participants access to visual stimuli presented on a computer screen. The stimuli consisted of a series of 50 images that were available for each intervention session. The results indicated that two of the participants had substantial response increase during the intervention program, one had a moderate response increase, and two had only limited or doubtful increases.

Mechling [16] implemented a microswitch-aided program with three participants of 6 to 19 years of age, who presented with profound intellectual disabilities and motor impairment. The microswitches used were pressure devices activated through hand/arm movements and head turning. Each main session was divided into three sub-sessions of 3 minutes, within which responding led to different types of stimulation (i.e., adapted toys, a commercial stimulation package, and instructor-made videos). All participants had a clear response increase during the sub-sessions in which instructor-made video clips were available. This type of stimulation continued to be motivating (and the participants had satisfactory response levels) during an intervention supplement.

Studies Targeting Small Responses with Experimental Microswitches

As stated above, the use of hand and head responses in combination with pressure microswitches is not suitable for persons with pervasive motor impairment [3•, 23•]. For these participants, very small responses have been assessed with the help of new (experimental) microswitches. The responses included, among others, vocal emissions, prolonged or repeated eyelid closure, chin movements, and mouth opening or closing [3•, 19•, 20–22, 23•, 24•, 25•, 26]. Some of the microswitches developed for these responses avoid contact with the person's body and rely instead on camera technology connected to electronic control systems [19•, 20, 22, 24•, 25•]. The results of the studies in general were largely encouraging as to the applicability of the new microswitches and the possible benefits for the participants.

Lancioni et al. [21] assessed the possibility of using a vocal-emission response with a dual-microphone microswitch for a girl of 8 years of age with intellectual, motor and visual disabilities. The combination of a throat and an airborne microphone virtually eliminated the risk of false positive responses. In fact, microswitch activation occurred only if both microphones were triggered simultaneously. The girl showed substantial increases in response frequency during the intervention phases of the study, when each response allowed her access to brief stimulation events.

Leung and Chau [22] focused their work on the development of new camera-based microswitch technology for monitoring tongue protrusion. Specifically, they developed a multiple-camera microswitch for monitoring the tongue-protrusion response in a boy of 8 years of age with spastic quadriplegic cerebral palsy. His limbs and head were often affected by protracted bouts of spasticity with totally unreliable movements. The same spasticity could also affect the boy's facial expressions, making them unreliable. In spite of the above, he seemed able to control tongue protrusion. The microswitch set up for monitoring this response consisted of three connected cameras. One observed the frontal view of the boy, while the other two were used as peripheral cameras and offered a view of the child when his head turned 45 degrees, or more, to the left or to the right. This type of microswitch arrangement was then tested over five sessions each lasting about 1 hour. The results indicated that the microswitch was a plausible device for detecting the tongue protrusion response in a fairly reliable manner. Memarian, Venetsanopoulos, and Chau [24•] extended the research in this area by successfully evaluating an infrared thermal microswitch for detecting mouth opening and mouth closing with a man of 26 years of age who presented with pervasive motor impairment and communication disabilities. In practice, they successfully used an infrared thermal camera to detect local temperature changes connected with the opening and closing of the mouth.

Lancioni et al. [27•] carried out a study with two participants of 21 and 26 years of age who presented with extensive motor impairment and were rated in the profound intellectual disability range. The response selected for them was an upward movement of the forehead skin of 2 mm or greater. The microswitch was an optic sensor, which was positioned above the participants' left or right eyebrow and kept in place with medical tape. A black mini sticker was attached about 2 mm below the microswitch. When the participants displayed the response the microswitch pointing shifted from the forehead skin to the black sticker. This led to microswitch activation and brief stimulation periods during the intervention phases of the study. Both participants showed clear response increases during these phases.

Programs Aimed at Promoting Response Engagement and Choice

Two types of programs were carried out for promoting response engagement and choice. One program involved the use of two or more microswitches, which were introduced sequentially and then made available simultaneously. Each microswitch was linked to specific stimuli and the participant could choose which response to perform and which stimuli to pursue [3•]. The second program involved only one microswitch that the participant could use to select among environmental stimuli presented through a computer system. In practice, brief samples of the stimuli were automatically presented through the system and the participant could choose whether to have longer exposure to those stimuli or to bypass them (i.e., by activating the microswitch or abstaining from doing so, respectively). In some studies, the participant was also allowed to extend exposure to any particular stimulus by activating the microswitch at the end of the stimulation period [28•].

Tam, Phillips, and Mudford [29] carried out a program of the first type with six adults of 38 to 48 years of age who lived in a residential care facility. The participants presented with a combination of extensive motor impairment, profound intellectual disability and visual or auditory disability; and a lack of recognizable forms of communication. The two microswitches used with each participant were pressure devices that could be activated by left- and right-hand pressure responses or combinations of head and arm or head and hand responses. The microswitches were linked to different sets of stimuli, and the participants received stimulation throughout the time that a microswitch was activated. Results showed that all participants learned to activate the available microswitches. When the two microswitches were simultaneously present and one allowed access to highly preferred stimuli while the other led to supposedly low preference stimuli, three participants had greater choice levels for the highly preferred stimuli, two participants seemed equally determined to pursue both sets of stimuli, and the last participant seemed to be more inclined to pursue the supposedly low preference stimuli.

Lancioni et al. [30] carried out a study of the second type with two participants of 20 and 14 years of age, who presented with extensive motor impairment, profound intellectual disability, and minimal visual residuals. A camera-based microswitch was used for both participants with the aim of recording smile expressions, the response that the participants were to perform in order to choose among stimulus options. Within every session, the participants were presented with 23 choice/response opportunities. Any such opportunity consisted of the presentation of a stimulus sample for 4 or 5 seconds. Eighteen of the samples concerned stimuli considered preferred while five represented stimuli considered non-preferred. A smile response (microswitch activation) during the last 2 seconds of the sample, or the 4 seconds that followed it, led to a 20 second exposure to the stimulus matching the sample. A pause interval of about 15 seconds was programmed between the end of the stimulus episode, or the end of a sample with no responding, and the presentation of the following sample. A computer system was used for recording microswitch activations and regulating all stimulus presentations. The participants had minimal response levels during the baseline phase and a control phase (when the camera-based microswitch was not available and a vocal response was required for operating the choices). However, they had mean frequencies of about 13 and 14 responses per session during the intervention phase with the camera-based microswitch. During the intervention phase, the participants responded to approximately 70% of the samples representing preferred stimuli, and less than 10% of the samples representing non-preferred stimuli.

Programs Aimed at Promoting Response Engagement and Reducing Problem Posture/Behavior

Persons with multiple disabilities may be characterized by a lack or low level, of adaptive responding, and the presence of problem postures or behaviors (e.g., head forward tilting and hand mouthing). The presence of inappropriate postures/behaviors may further complicate their physical situation, interfere with their adaptive responding and possibly hamper their social image, as well as their overall acceptance within their daily context [31, 32]. Given this situation, it is widely agreed that intervention programs need to tackle both aspects of the situation to have any real impact [33]. In practice, intervention programs would have to pursue the dual goal of promoting constructive responding and reducing negative postures/behaviors [34]. One type of program that can combine these two goals is based on the use of microswitch clusters, combinations of microswitches to simultaneously monitor adaptive responding and problem posture/behavior; and trigger the automatic delivery of preferred stimuli contingent on adaptive responses performed in the absence of the problem posture/behavior [35].

For example, Lancioni et al. [36•] assessed the use of microswitch clusters with two participants, a boy and a woman of 10 and 64 years of age, respectively. The boy had congenital encephalopathy and presented with spastic tetraparesis that confined him to a wheelchair, severe visual impairment, and reportedly profound intellectual disability. He was generally passive without interaction with objects, did not possess any recognizable form of communication, and tended to have his head tilting forward. The woman presented with a neurodegenerative condition with decline in all aspects of life. She had minimal, confused, and difficult to understand speech, was non-ambulatory, and appeared largely passive. She spent her time sitting with her head and trunk leaning on the table in front of her. Staff and families were interested in intervention programs that could help the participants become more active and reduce their problem postures.

The microswitch cluster introduced for the boy consisted of: tilt and optic microswitches attached to objects in front of him, activated when he manipulated those objects (i.e., when he displayed an adaptive response); and an optic microswitch attached to the wheelchair headrest, activated when the boy's head was less than 10 cm from it (when he kept his head upward).

The microswitch cluster used for the woman included: a vibration microswitch that was activated when she moved objects on the table (i.e., when she displayed adaptive responding); an optic microswitch on the wheelchair back that was activated when her trunk was raised and moved close to it; and a tilt microswitch connected to her ear that would be activated when her head was raised.

The microswitch clusters were connected to a computer system that recorded the participants' responses and postures and regulated the presentation of stimulation events. Initially, the participants accessed brief periods of preferred stimulation for each adaptive response regardless of whether their posture was correct or not. Subsequently, the adaptive responses led to positive stimulation only if their occurrence did not coincide with the presence of the problem postures. Moreover, the stimulation available for those responses lasted the full, programmed period only if the problem posture did not appear throughout that period. In case it appeared, the stimulation was interrupted. Data showed that, during the first intervention phase, both participants had a large increase in the frequency of adaptive responding. During the second intervention phase, they maintained their high levels of adaptive responding and reduced their problem posture throughout the sessions.

Considerations on the Practical Implications of Microswitch Technology

The microswitch technology can vary extensively across different participants, based on their motor repertoire (i.e., the responses available/suitable for microswitch use) and their level of functioning and overall performance [3•]. The relevance of helping a person with minimal response potential and total isolation/passivity to develop responding and acquire control over environmental stimulation can never be overemphasized. In essence, such a person, who did not have a chance to take the initiative, could become active, exercise self-determination, and regulate his or her stimulation input through the use of a conventional or an experimental microswitch based on the response available [3•, 29, 37–39]. This achievement would have important positive implications in terms of individual growth and social status, and would not require large economical or time investments [40]. In fact, microswitches *per se* can often be bought or put together (experimentally) with costs ranging from less than US$100 to about US$300. Obviously, an interface and a portable computer with simple software also need to be available for making the microswitches usable within an intervention program [41–43].

Programs aimed at promoting response engagement and choice can be relatively straightforward in their overall arrangement, allowing the participants to control (choose between) two sets of stimuli through different responses; or more elaborate, allowing the participants to access multiple stimuli among which to choose [28•, 29, 30]. The first type of program may be highly suitable for participants with a lower level of functioning. They can start with a single microswitch (leading to one set of stimuli) and, if successful, can proceed to a second microswitch (leading to a different set of stimuli), and eventually have both microswitches simultaneously available [29]. The second type of program may require a relatively high level of attention from the participant so as to ensure that he or she may keep track of the stimulus samples presented and then produce the choice response or abstain from it depending upon the level of interest available for each of them [30]. The first type of program may be realized with costs only slightly higher than those required for the programs involving a single microswitch. The second type of program may have higher economical costs (e.g., about US$2000).

Programs using microswitch-cluster technology for promoting engagement and reducing problem posture/behavior may be considered a great resource in most contexts for persons with multiple disabilities. They are first directed at establishing a constructive response through the availability of strong, contingent stimulation. Once the participants have become accustomed to receiving such stimulation and benefiting from the enjoyment it provides, they may not want to miss it and thus may correct their problem posture/behavior for that purpose. In other words, the use of microswitch-cluster technology may help the participants in achieving forms of self-control that enable them to maintain their general response engagement largely free from their problem posture/behavior. In light of the above, the use of such technology could be considered the most constructive approach to deal with problem posture/behavior (and also most respectful for the participants) [35, 36•, 44, 45]. The cost of a program involving microswitch-cluster technology may range between US$1000 and US$2000 [41, 43].

Conclusions

Microswitch-based intervention programs may be of critical importance for helping persons with multiple disabilities (e.g., extensive motor, intellectual, and communication disabilities). These programs may differ considerably from one another in their attempts to help persons with different levels of disabilities achieve relevant goals in a direct way and, with affordably modest levels of staff involvement and supervision [3•]. Two lines of research may be considered critical for the future. The first line might be aimed at developing new types of microswitches or upgrading those available for monitoring minimal responses (e.g., lip movements involved in opening the mouth wider or in making a smile) without being invasive, and thus helping persons with pervasive motor disabilities [46]. These types of microswitches may involve camera-based microswitches with one or multiple cameras, or infrared thermal imaging technology employed in monitoring the responses [19•, 22, 24•, 25•]. The second line of research might focus on the program contents. For example, one could envisage a choice-based program in which other sets of stimuli are made available in addition to music and video-clips. The new stimuli could involve different forms of caregiver attention/intervention. This would allow sessions to be relatively long and guarantee a social dimension [30, 40, 45]. One could also expand the research concerning the microswitch-cluster programs with: assessment of their effectiveness with additional combinations of adaptive responses and problem posture/behavior; comparisons of their effects with those of alternative intervention strategies (e.g., differential reinforcement for alternative behavior); and social validation studies involving staff and service providers as social raters [35, 47–52].

Compliance with Ethics Guidelines

Conflict of Interest Giulio E. Lancioni, Nirbhay N. Singh, Mark F. O'Reilly, Jeff Sigafoos, and Doretta Oliva declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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