assistive technology for behavioral interventions for persons with severe/profound multiple disabilities: a selective overview

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Persons with severe/profound multiple disabilities are often unable to interact with their immediate environment and control relevant stimuli. Some of these persons may also present behavioral problems (e.g., stereotypies) and inadequate postures (e.g., head forward tilting). The possibility of implementing successful behavioral programs with these persons may largely depend on the availability of assistive technology. The forms of assistive technology that may be particularly relevant for these persons include microswitches, voice output communication aids (VOCAs), and microswitch clusters. Microswitches are technical devices that a person can use to control relevant/pleasant environmental events on his or her own. VOCAs are devices set to translate simple non-verbal behaviors into synthesized or digitized verbal messages (e.g., attention requests). Microswitch clusters are combinations of microswitches that are used to increase the person’s adaptive responding and reduce problem behavior in an integrated approach. This paper presents a number of illustrative cases for the abovementioned forms of assistive technology in order to provide the reader a general picture of the evidence available and to discuss the implications of this evidence for education and rehabilitation programs.

Key words: multiple disabilities, microswitches, VOCAs, microswitch clusters, learning

Persons with severe/profound multiple disabilities (i.e., persons with intellectual and neuro-motor disabilities, possibly combined with sensory deficits or other impairments), regardless of whether these are congenital or acquired, are often unable to interact with their immediate environment and control relevant stimuli (Lancioni, O’Reilly, & Basili, 2001a, b; Lancioni et al., 2007a, b; Mechling, 2006; Shih & Shih, 2009). This inability (lack of response skills) has far-reaching implications, making them look passive or inadequate, reducing their opportunities of constructive engagement and environmental impact, and hindering their overall development or recovery.

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process, their social appearance, and, eventually, their quality of life (Lachapelle et al., 2005; Lancioni, O’Reilly, Oliva, & Coppa, 2001c, d; Schalock et al., 2003). Lack of constructive engagement with the outside world can be frequently combined in these persons with forms of problem behavior (stereotypies), such as eye poking and hand mouthing, or problem posture (inadequate and unhealthy body positions) such as head forward tilting. Those combinations make the persons’ overall situation even more complex, socially problematic, and more difficult to tackle (Kurtz et al., 2003; Lancioni, Singh, O’Reilly, & Oliva, 2003a, b; Lancioni, Singh, O’Reilly, & Sigafoos, 2009d; Matson, Minshawi, Gonzalez, & Mayville, 2006; Richman, 2008).

Intervention procedures based on environmental enrichment and direct stimulation provided by staff and parents would enhance the persons’ input level and might reduce problem behaviors (e.g., Lancioni et al., 2009d; Ringdahl, Vollmer, Marcus, & Roane, 1997). The same procedures would also present two main drawbacks. In fact, enrichment/stimulation conditions could easily make the persons simple recipients of external input rather than active agents who pursue such an input purposefully (Algozine, Browder, Karvonen, Test, & Wood, 2001). Moreover, those conditions would be unlikely to promote the development of specific response schemes by the persons (i.e., specific response skills that would be important education/rehabilitation targets and help the persons control stimulation in the surrounding context) (Glickman, Deitz, Anson, & Stewart, 1996).

A possible, alternative way to intervene with these persons with severe/profound multiple disabilities is to use microswitch technology or variations thereof such as Voice Output Communication Aids (VOCAs) and microswitch clusters (Lancioni et al., 2001a, 2008b; Leatherby, Gast, Wolery, & Collins, 1992; Sullivan, Laverick, & Lewis, 1995; Sullivan & Lewis, 1993). Microswitches are technical devices that a person with profound and multiple disabilities may learn to use as a means to control environmental events with simple/minimal responses (Crawford & Schuster 1993; Lancioni et al., 2001b; Lancioni, O’Reilly, Oliva, Singh, & Coppa, 2002a; Mechling, 2006). For example, a pressure microswitch fixed to the headrest of a person’s wheelchair and connected to a timer and a video display may enable the person to activate such a display for brief periods of time (i.e., as programmed in the timer) through small head-movement responses. Similarly, an optic microswitch fixed to an eyeglasses’ frame and connected to a timer and a music player may enable the person to activate brief periods of musical stimulation through repeated eyelid closures. An optic microswitch held in front of the person’s mouth and linked to massage vibrators may enable a person with pervasive motor disabilities to obtain brief periods of massage stimulation through simple mouth-opening or mouth-closing responses. None of the three persons involved in the aforementioned examples would have been able to access the stimulation events through a direct manipulation of the stimulation sources (i.e., video display, music player, or massage vibrators).

VOCAs are technical devices that are set to translate into synthesized or digitized verbal messages simple non-verbal responses of the person with disabilities (Lancioni et al., 2007a; Schlosser & Sigafoos, 2006; Sigafoos et al., 2009). For example, the person may have a tilt device on his or her hand connected to an electronic control system equipped with a speech output instrument. Each time the person rotates the hand the tilt device sends a signal to the electronic control system. This in turn activates the speech output instrument, which emits a call to the person’s caregiver and asks for attention and stimulation or for mediation (e.g., help in obtaining specific environmental stimuli). The person is expected to learn the link between the hand response and the consequences of it and thus use it as a means to obtain those consequences.
Table 1. *Studies Using Assistive Technology for Persons with Severe/Profound Multiple Disabilities*

<table>
<thead>
<tr>
<th>Studies</th>
<th>Participants</th>
<th>Age</th>
<th>Response Types</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Microswitches for Small Responses</td>
</tr>
<tr>
<td>Lancioni and Lems (2001)</td>
<td>2</td>
<td>4, 18</td>
<td>Vocalization</td>
</tr>
<tr>
<td>Lancioni et al. (2001c)</td>
<td>2</td>
<td>7, 10</td>
<td>Vocalization</td>
</tr>
<tr>
<td>Lancioni et al. (2004a)</td>
<td>1</td>
<td>18</td>
<td>Chin movements (as in chewing)</td>
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<tr>
<td>Lancioni et al. (2004b)</td>
<td>1</td>
<td>6</td>
<td>Chin movements (as in mouth opening)</td>
</tr>
<tr>
<td>Lancioni et al. (2004d)</td>
<td>1</td>
<td>17</td>
<td>Chin movements (as in chewing)</td>
</tr>
<tr>
<td>Lancioni et al. (2005a)</td>
<td>1</td>
<td>9</td>
<td>Repeated eye-blink pattern</td>
</tr>
<tr>
<td>Lancioni et al. (2006c)</td>
<td>2</td>
<td>10, 12</td>
<td>Eyelid upward movement</td>
</tr>
<tr>
<td>Lancioni et al. (2007b)</td>
<td>2</td>
<td>6, 14</td>
<td>Forehead upward skin movements</td>
</tr>
<tr>
<td>Lancioni et al. (2007c)</td>
<td>2</td>
<td>5, 21</td>
<td>Hand-closure movements</td>
</tr>
<tr>
<td>Lancioni et al. (2009a)</td>
<td>1</td>
<td>68</td>
<td>Eyebrow lifting</td>
</tr>
<tr>
<td>Lancioni et al. (2010c)</td>
<td>1</td>
<td>41</td>
<td>Lip movements</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>Combinations of Microswitches</td>
</tr>
<tr>
<td>Crawford and Schuster (1993)</td>
<td>3</td>
<td>4</td>
<td>2 responses per participant: Hand, wrist or elbow movements</td>
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<tr>
<td>Sullivan et al. (1995)</td>
<td>1</td>
<td>3.5</td>
<td>2 responses: Head movements and hand movements</td>
</tr>
<tr>
<td>Lancioni et al. (2002a)</td>
<td>2</td>
<td>8, 12</td>
<td>3 responses per participant: Vocalization, head movements, and hand movements</td>
</tr>
<tr>
<td>Lancioni et al. (2002b)</td>
<td>2</td>
<td>8, 13</td>
<td>3 responses per participant: Vocalization, head movements, and hand movements</td>
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<tr>
<td>Lancioni et al. (2004c)</td>
<td>2</td>
<td>7, 17</td>
<td>3 or 4 responses per participant: Vocalization, head movements, and one or two hand movements</td>
</tr>
<tr>
<td>Lancioni et al. (2004c)</td>
<td>1</td>
<td>16</td>
<td>3 responses: Three different syllable-like sounds</td>
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<tr>
<td>Lancioni et al. (2006a)</td>
<td>3</td>
<td>7-16</td>
<td>2 responses per participant: Vocalization, chin and mouth movements, and hand movements</td>
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<tr>
<td>Lancioni et al. (2007e)</td>
<td>1</td>
<td>18</td>
<td>2 responses: Eyelid and mouth movements</td>
</tr>
<tr>
<td>Lancioni et al. (2010b)</td>
<td>2</td>
<td>53, 56</td>
<td>2 responses per participant: Finger or hand movements, eyelid movements, and head movements</td>
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Table 1. Continued

<table>
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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Combinations of Microswitches and VOCAs</strong></td>
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<tr>
<td>Lancioni et al. (2008a)</td>
<td>2</td>
<td>16, 18</td>
<td>3 responses per participant: Vocalization, head movements, and hand movements</td>
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<tr>
<td>Lancioni et al. (2008b)</td>
<td>3</td>
<td>10-15</td>
<td>3 responses per participant: Trunk movements, head movements, leg/foot movements, and one or two hand movements</td>
</tr>
<tr>
<td>Lancioni et al. (2009b)</td>
<td>1</td>
<td>52</td>
<td>2 responses: Head movements and arm/hand movements</td>
</tr>
<tr>
<td>Lancioni et al. (2009c)</td>
<td>11</td>
<td>5-18</td>
<td>2 responses per participant: Head, foot, and hand movements and vocalization</td>
</tr>
<tr>
<td>Lancioni et al. (2009b)</td>
<td>1</td>
<td>32</td>
<td>3 responses: Eyelid movements and two hand movements</td>
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<tr>
<td>Lancioni et al. (2010d)</td>
<td>1</td>
<td>20</td>
<td>4 responses: Two hand movements and two head movements</td>
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<td><strong>Microswitch Clusters</strong></td>
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<tr>
<td>Lancioni et al. (2007d)</td>
<td>1</td>
<td>13</td>
<td>3 responses: 1 adaptive foot response and 2 problem behaviors (hand mouthing and eye poking)</td>
</tr>
<tr>
<td>Lancioni et al. (2007f)</td>
<td>2</td>
<td>8, 12</td>
<td>2 responses per participant: 1 adaptive hand response and 1 problem behavior (hand or object mouthing)</td>
</tr>
<tr>
<td>Lancioni et al. (2007g)</td>
<td>1</td>
<td>41</td>
<td>2 responses: 1 adaptive hand response and 1 problem posture/behavior (face hiding)</td>
</tr>
<tr>
<td>Lancioni et al. (2008c)</td>
<td>1</td>
<td>12</td>
<td>2 responses: 1 adaptive hand response and 1 problem behavior (hand mouthing)</td>
</tr>
<tr>
<td>Lancioni et al. (2008d)</td>
<td>1</td>
<td>29</td>
<td>2 responses: 1 adaptive hand response and 1 problem behavior (arm/hand stereotypy)</td>
</tr>
<tr>
<td>Lancioni et al. (2008e)</td>
<td>3</td>
<td>8-17</td>
<td>2 responses per participant: 1 adaptive hand or foot response and 1 problem posture (head forward tilting)</td>
</tr>
<tr>
<td>Lancioni et al. (2009f)</td>
<td>2</td>
<td>4-13</td>
<td>2 responses per participant: 1 adaptive hand or trunk Response and 1 problem/ dystonic movement (body arching or leg stretching)</td>
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</tbody>
</table>
Microswitch clusters are combinations of microswitches that are used to monitor the person’s adaptive responding and problem behavior simultaneously (Lancioni et al., 2004f). For example, the person may have a touch/pressure microswitch on his or her wheelchair tray and a tilt microswitch fixed on a headband. The first microswitch would monitor the person’s adaptive response of manipulating/exploring an object; the second microswitch would monitor the problem behavior of bending the head forward. Another person may have optic microswitch devices linked to the objects of a box in front of him or her and optic microswitch devices at his or her chest. The former would monitor the person’s manipulation/exploration of the objects; the latter would monitor the person’s problem behavior of bringing his or her hand to the mouth. In both cases, the person could initially receive a brief period of positive stimulation in relation to the performance of the adaptive response, regardless of whether such a response is performed in the presence of the problem behavior. Subsequently, the performance of the adaptive response would be followed by positive stimulation only if it is not accompanied by the problem behavior (Lancioni et al., 2009d). The person is expected to link the adaptive response to the positive environmental events and curb the problem behavior so as to maintain the availability of those events.

The purpose of this paper is to provide a brief analysis of representative literature concerning the forms of technology mentioned above and the implications of the results obtained with their use for rehabilitation programs. Specifically, the first section of the paper will focus on studies of novel microswitches developed to monitor small, non-typical communication responses (to access stimulation), such as eyelid and lip movements, that suit persons with minimal motor repertoires. The second section will focus on studies assessing the combined use of two or more microswitches (for two or more typical or non-typical responses) to facilitate wider engagement and choice. The third section will analyze studies that have combined microswitches for direct access to stimulation with VOCAs for social attention and interaction. The fourth section will focus on the use of microswitch clusters to promote adaptive responses as well as self-control of problem behavior/posture. A final section will discuss the results obtained with the different forms of technology and their applicability and possible impact in daily education/rehabilitation programs. Table 1 lists relevant studies for each of the first four sections of the paper. Most of those studies are also summarized in the review sections that follow below.

**Microswitches for Small (Non-Typical) Responses**

Responses traditionally used within microswitch-based programs have involved head turning and hand pushing. The microswitches adopted for those responses generally consisted of pressure devices or similar kinds of instruments, which were commercially available. These response-microswitch combinations, albeit relatively practical, may not always be viable for persons possessing minimal motor behavior repertoires. For these persons, new (non-typical) responses and matching (generally experimental) microswitches may be needed. Table 1 provides a list of 11 studies focusing on the use of a single, nonypical response for microswitch activation (Lancioni & Lems, 2001; Lancioni et al., 2001c; 2004a, b, d; 2005a, 2006c, 2007b, c, 2009a, 2010c). The non-typical responses targeted in these studies included vocalization (i.e., a brief sound emission), chin movements (i.e., like those produced through mouth opening or chewing), lip movements, forehead skin movements, small hand-closure movements, and eyelid and eyebrow movements.

For example, Lancioni et al. (2001c) worked with two children of 7 and 10 years...
of age, who had pervasive multiple disabilities that made it difficult for them to produce reliable motor responses involving the use of the hands or specific movements of the head. Both participants, however, possessed small vocalization responses, which were viewed as a potential resource that could become an effective communication/access behavior through a new, specifically built microswitch. The new microswitch consisted of a battery-powered, sound-detecting device connected to a throat microphone (not influenced by environmental noise), which was kept at the participants’ larynx, using a simple neckband. During the intervention, the activation of the microswitch through the emission of a vocalization response led to the brief presentation of one or more preferred stimuli. Data showed that both children largely increased the frequencies of their vocalization responses during the intervention sessions, suggesting that they had learned to use these responses as means for stimulation access.

Lancioni et al. (2004b) implemented a program with a boy of 6 years of age, who usually sat in a reclined position and had his body largely static. The response that seemed most plausible for him to perform (and it was already present in his repertoire) was chin movements, specifically movements such as those involved in mouth opening. The microswitch arranged for this response consisted of (a) a small box containing a position sensor, which was fixed onto the side of a hat that the boy wore and (b) a light flexible band that connected the position sensor to the other side of the hat, and passed under the boy’s chin. Downward chin movements pulled the position sensor thus activating the microswitch and causing the occurrence of preferred environmental stimuli. The boy’s response led to preferred stimulation. The results showed a large response increase during the intervention periods.

Recently, a different microswitch was conceived to detect lip movements, that is, a response that can involve only the lips or can be similar to the chin movements mentioned above (Lancioni et al., 2006b). The microswitch employed for this boy consisted of an optic sensor held under his chin. The sensor was activated as its distance from the chin diminished below a preset level. Such a distance reduction occurred in connection with the boy opening his mouth. The boy’s response led to preferred stimulation. The results showed a large response increase during the intervention periods.

Lancioni et al. (2005a) carried out an intervention program with a boy of 9 years of age, who presented with profound developmental and physical disabilities and minimal motor behavior. The response selected for him (i.e., apparently the most plausible one given his condition) was eye blinking. A definite blinking pattern (i.e., two blinks performed within a 2-s interval) was identified as the target response, discriminable from the common blinking behavior.
The microswitch used for such a response was an optic sensor (consisting of an infrared light-emitting diode and a mini infrared light-detection unit) mounted on an eyeglasses frame that the boy wore during the sessions. This was linked to an electronic unit, which during the intervention allowed the activation of preferred stimuli in relation to the responses. The boy had a large increase in his response rates during the intervention periods.

Lancioni et al. (2006c) reported a study with two children of 10 and 12 years of age whose upward eyelid movements constituted the response that allowed them to produce environmental changes (i.e., the response through which they accessed brief periods of preferred stimulation). The microswitch technology involved optic sensors mounted on eyeglasses such as those described in the study by Lancioni et al. (2005a). However, the functioning of the technology was modified so that it could match the response selected. This consisted of raising one or both eyelids as in the case of somebody looking at something high up. In this study, the optic sensor was not directed at monitoring the blinks as in the Lancioni et al.’s (2005a) study, but rather the transition from the eyelid (which it normally pointed at) to the eye (which it would point at during the looking-up response). Both participants showed large response increases during the intervention periods (i.e., when the response was functional to access preferred stimuli).

Lancioni et al. (2007b) investigated the feasibility of using small upward or downward movements of the forehead skin as the target response for two participants of 6 and 14 years of age. The microswitch consisted of an optic sensor (barcode reader), which was supplemented with an electronic regulation unit and was employed in combination with a small tag with horizontal bars (kept on the participants’ forehead). The optic sensor was positioned in front of the tag. This position ensured that small movements of the tag (consequent to upward or downward movements of the forehead skin) would activate the microswitch system and in turn lead to brief periods of preferred stimulation during the intervention periods of the study. Data showed that both participants had clear response increases during intervention.

Lancioni et al. (2009a) resorted to the use of eyebrow lifting as the target response for a 68-year-old man who had a diagnosis of minimally conscious state and pervasive neuro-motor disabilities following traumatic brain injury and coma. The microswitch adopted for this response was a modified version of the optic sensor used for eyelid closures and eyelid upward movements (see above). Eyebrow lifting allowed the man to obtain brief exposures to preferred visual stimuli (i.e., video-clips with sport events and comic sketches). Data showed that the frequency of this response doubled during the intervention compared to the baseline.

**Combinations of Microswitches**

The use of a single microswitch is typically related to one specific response and a specific set of stimuli obtainable through the response during the sessions. The possibility of establishing two or more responses with multiple microswitches would allow the participant to widen and diversify his or her engagement, access different sets of stimuli, and eventually choose between them based on preferences and other practical conditions. Table 1 provides a list of nine studies assessing the combined use of two or more microswitches (Crawford & Schuster, 1993; Lancioni et al., 2002a, b, 2004c, e, 2006a, 2007e, 2010b; Sullivan et al., 1995). For example, Sullivan et al. (1995) worked with a girl who was 3.5 years of age. The two responses selected for the girl consisted of head backward movements and hand pushing/stroking movements. The microswitches used for the responses were commercially available pressure devices. They were simultaneously available and the activation of either one of them through the
aforementioned responses led to the occurrence of specific types of preferred stimuli. Data indicated that both responses increased during the intervention, as they allowed access to the preferred stimuli.

Lancioni et al. (2002a) conducted a study with two participants, who were 8 and 12 years of age. Three responses were targeted for each participant. Those responses included vocalization, hand movements (pushing/stroking), and head movements. For each response, a specific set of stimuli was available. The responses were introduced individually and each of them led to the occurrence of the set of stimuli selected for it throughout the intervention. Once the intervention had been implemented on all responses, the participants could use any of them at their will. This response freedom allowed the participants a wider and differentiated engagement and a continuous access to (an opportunity to choose among) all three sets of preferred stimuli. The results showed that both participants had an increased and consistent performance of all three responses.

Lancioni et al. (2004e) conducted a study involving a participant of 16 years of age who possessed three different vocal (syllable-like) utterances. The view was that those utterances could be used as relevant responses through which the person could bring about environmental changes and specifically produce different types of stimulation. To make the responses functional, a computer system was developed that worked as a combination of microswitches and could on the whole discriminate them. The software program for their discrimination was based on locally recurrent neural networks and time sequences of cepstral parameters. The participant increased the frequencies of his utterances during the intervention (i.e., when positive environmental stimuli followed those utterances). The system's percentages of correct utterance discrimination exceeded 70.

Lancioni et al. (2006a) worked with three participants who were between 7 and 16 years of age. Two simple responses were targeted for each participant. They consisted of vocalization and repeated chin movements, light knee movement and minimal swaying of a grid suspended slightly above the participant's face, and mouth closing and hand opening. The microswitches for vocalization and chin movements were as those previously described for the same responses (Lancioni & Lems, 2001; Lancioni et al., 2004a). The microswitches for mouth closing and hand opening were adaptations of the one used for chin movements. The microswitches used for knee movement and grid swaying consisted of combinations of tilt devices. The microswitches were introduced individually. Subsequently, they were simultaneously available and the participants could choose between them (between the two responses available and the related sets of stimuli). The last period of the study was aimed at assessing whether the participants' preference for one response or the other was due to a preference for the stimuli available for that response or simply to a preference for the response per se. All three participants succeeded in acquiring the responses selected for them and showed clear differences in the frequencies of those responses. Such differences seemed to be largely due to the stimuli available for the responses (i.e., to their levels of attractiveness) at least for two of the participants. For the third participant, response preference seemed also to play a role. More specifically, one of the responses seemed simpler than the other and this simplicity had an apparent impact on the participant's overall performance levels.

Lancioni et al. (2010b) worked with two post-coma adults of 56 and 53 years of age, who presented with a minimally conscious state and extensive neuro-motor disabilities. The responses targeted for them were finger and head movements and eyelid upward movements and hand stroking, respectively. The microswitches involved touch sensitive pads for the finger movements and hand stroking, an optic sensor for eyelid movements, and mini tilt devices for head movements. The microswitch responses were introduced individually.
Eventually, sessions with one microswitch/response were alternated with sessions with the other microswitch/response. Both participants increased their responding levels with both microswitches during the intervention periods.

**Combinations of Microswitches and VOCAs**

The successful use of single and multiple microswitches has strongly underlined the effectiveness of these technological resources to allow persons with severe/profound multiple disabilities opportunities of positive engagement, independent stimulation access, and choice. Microswitch-based programs may be seen as a necessary component of any rehabilitation context. In fact, they can be supplementary to the direct intervention of rehabilitation and care staff who cannot be expected to guarantee a consistent/continuous presence and contact (Lancioni et al., 2008b). The recognition of this extremely important function may not exclude a sense of caution about these programs due to the acknowledgement that they promote the person’s access to environmental (non-human) stimuli but neglect any possible desires of the person for contact with the caregiver. This caution may be more definite and justified when these programs involve relatively long sessions and/or sessions that are frequently repeated during the day. In such situations, one might curb concerns by supplementing conventional microswitch technology whereby the participant can access environmental stimuli independently with a VOCA. The VOCA would, in fact, enable the participant to ask for caregiver contact. Table 1 provides a list of six studies that have combined microswitch and VOCA devices to allow (a) the participants a wider range of opportunities (including contact with the caregivers) and (b) the caregivers a level of contact responsibility seemingly compatible with other work commitments (i.e., much lighter than direct interaction with the participant or consistent availability to him or her as it would have been the case with the use of VOCA devices only) (Lancioni et al., 2008a, b, 2009b, c, e, 2010d).

For example, Lancioni et al. (2008a) developed a program involving two microswitches and a VOCA with two participants of 16 and 18 years of age. The responses selected for one of the participants were head turning and hand stroking to activate two different microswitches, and vocalization to activate a VOCA. The responses for the other participant were left-hand movements and head upward to activate the microswitches and right-hand movements to activate the VOCA. The intervention started on one of the microswitches. When the participants had increased responding to it, the intervention focused on the second microswitch. Then, the two microswitches were made simultaneously available. Eventually, intervention focused on the VOCA and, as responding to it increased, the VOCA and microswitches were made simultaneously available. The stimuli available for the microswitches involved sets of musical items and of voices and noises for one of the participants and sets of visual and musical items or vibratory inputs for the other participant. The activation of a microswitch led to a brief presentation of the stimuli related to it. The activation of the VOCA led a vocal output apparatus to emit a short phrase that requested for the attention of the caregiver. The caregiver responded either verbally (i.e., with complimentary/support sentences) or verbally and physically (i.e., talking to and touching/caressing or kissing the participant briefly). For practical convenience, the verbal/physical consequence occurred for one-third of the requests and the verbal consequence for the other two-thirds. Data showed that during the last phase of the intervention (when both microswitches and the VOCA were available), the participants had fairly high and consistent levels of responding. Nearly three-fourths of the responses were performed via the microswitches and about one-fourth concerned the VOCA.
Lancioni et al. (2009c) conducted a study with 11 participants between 5 and 18 years of age. For each participant, one microswitch and one VOCA were used. The responses selected for activating these devices included, among others, head, foot and hand movements and vocalizations. For each participant, the intervention started on the microswitch, then focused on the VOCA, and eventually included both microswitch and VOCA. The activation of the microswitches led to brief periods of preferred stimulation, which varied across participants and included different combinations of items selected among vibratory inputs, music and songs, voices and noises, and light displays. The activation of the VOCA led to the emission of a short phrase that requested for the attention of the caregiver. The caregiver responded either verbally or verbally and physically (as in the study reported above; Lancioni et al., 2008a). Each participant learned to use his or her microswitch and VOCA successfully. The frequency of the microswitch responses was always higher than the VOCA responses. This outcome (similar to that previously reported by Lancioni et al., 2008a) was thought to indicate a lower impact of the VOCA consequences probably further weakened by the fact that only one-third of them included physical contact. The positive aspects of this outcome were that (a) the participants maintained interest for social contact without exceeding in the request of it and (b) this moderate (workable) interest level allowed the caregivers to comply with the attention requests without ignoring other environmental duties.

Lancioni et al. (2009b) carried out a program with a post-coma man of 52 years of age who had a diagnosis of minimally conscious state and extensive neuro-motor disabilities. A microswitch and a VOCA were used. The microswitch could be activated through head movement and led to a brief exposure to recordings of comic sketches. The VOCA could be activated with an arm movement and led to a verbal call for the caregiver who approached the man, talked to him, and engaged him in watching pictures, magazines or video-clips for brief periods of time. The intervention program started with the microswitch. Once the man had learned to use it successfully, the intervention focused on the VOCA. The last phase of the program alternated sessions with the microswitch and sessions with the VOCA. The man increased his responding in relation to the microswitch as well as to the VOCA and maintained it through the last phase of the program.

Lancioni et al. (2010d) worked with a man of 20 years of age who was taught to use single versus repeated performance of simple motor schemes as different responses. Initially, the intervention concentrated on a single and a double finger movement as two separate microswitch responses detected by a touch sensitive microswitch and leading to a variety of video-clips showing the participant during happy family events or video-clips of sport and music events. Then, the intervention focused on a single and a double head movement detected through a pressure-sensitive device placed on the participant’s headrest, which would activate different VOCA devices calling for different caregivers. One of them presented and talked about sport items; the other presented and talked about food and drink items. Eventually, the microswitch and VOCA systems were simultaneously available and the participant could perform any of the responses acquired. The participant was successful at each of the intervention phases. During the last phase, the microswitch responses represented more than 60% of the total number of responses.

**Microswitch Clusters**

Persons with severe/profound multiple disabilities are frequently characterized by (a) limited adaptive responding and (b) excessive inadequate behavior. The inadequate behavior may be represented by inadequate, unhealthy body postures or dystonic movements (Holburn, Nguyen,
& Vietze, 2004) or by stereotypies such as hand mouthing and eye poking (Lancioni et al., 2009d; Matson, Dempsey, & Rivet, 2009). Traditionally, intervention programs would be considered separately for the two (adaptive and inadequate) dimensions, that is, one intervention program for increasing adaptive behavior and one for reducing inadequate behavior (Kazdin, 2001). The use of microswitch clusters may allow one to consider an integrated approach to deal with the two dimensions within the same intervention program. Table 1 provides a list of seven studies that have pursued such an integrated approach (Lancioni et al., 2007d, f, g, 2008c, d, e, 2009f).

For example, Lancioni et al. (2007f) employed microswitch clusters with two participants of 8 and 12 years of age. The adaptive responses involved different forms of object manipulation. These responses were monitored through a wobble-like microswitch for one participant and a vibration microswitch for the second participant. The problem behavior consisted of hand mouthing and object mouthing for the two participants, respectively. Such behavior was monitored through optic microswitches, which were arranged (through special support frames) under the participant’s chin or to the side of the participant’s face. Initially, the participants obtained brief periods of preferred stimulation (e.g., vibratory inputs, video-clips, and songs) for object manipulation regardless of whether these responses occurred in the absence of the problem behavior. Subsequently, the same manipulation responses produced positive stimulation only if they occurred in the absence of the problem behavior. Moreover, the stimulation lasted the scheduled time period only if the problem behavior remained absent through that period. Otherwise, it was interrupted. The findings indicated that both participants learned to increase their adaptive manipulation responses and to control their problem behavior, which was reduced to negligible levels.

Lancioni et al. (2008c) carried out another study to promote object manipulation and reduce hand mouthing with a participant of 12 years of age. Optic sensors and mini-tilt devices constituted the microswitch to monitor the adaptive responses, which consisted of manipulating/moving objects within a box. An array of optic sensors at the participant’s chest constituted the microswitch to monitor the problem behavior of bringing the hand to the mouth. The intervention procedure differed from the one mentioned for the previous study (Lancioni et al., 2007). In fact, the intervention started directly with the availability of positive stimulation for the manipulation responses occurring in the absence of the problem behavior. The stimulation continued for the scheduled time if the problem behavior did not appear during that period. The frequency of adaptive responses increased rapidly, and the presence of the problem behavior was largely reduced. The participant also seemed to have a positive mood during the intervention sessions.

Lancioni et al. (2008e) resorted to microswitch clusters for promoting adaptive responding and reducing inappropriate (unhealthy) head forward tilting in three participants of 8 to 17 years of age. The adaptive responses for the three participants consisted of hand or foot movements. The microswitches for monitoring them were tilt devices or pressure sensors. The head posture was monitored through a tilt microswitch attached to a headband that the participants wore during the sessions. The intervention was initially directed at the adaptive responses. Their occurrence led to a brief period of preferred stimulation regardless of the head posture. Subsequently, the adaptive responses were followed by positive stimulation only if emitted with the head upright (rather than forward tilting). Moreover, the stimulation lasted the scheduled time only if the head remained upright during that time. All three participants had a drastic increase in the frequency of adaptive responses, learned to emit them with the
head upright, and maintained such a posture for most of the session time.

Lancioni et al. (2009f) conducted a study with two participants of 4 and 13 years of age. The adaptive responses were hand or trunk movements directed at contacting objects. The microswitches were pressure sensors attached to the objects that the participants reached with their hand/trunk movements. The problem behavior consisted of dystonic movements (i.e., body arching and leg stretching). The microswitches used for these movements were pressure and tilt devices. Initially, both participants received preferred stimulation when they performed the adaptive responses. Subsequently, this stimulation followed the adaptive responses, which were not accompanied by dystonic movements. As in the studies summarized above, this stimulation lasted the scheduled time only if the dystonic movements did not appear during that time interval. Both participants were successful in increasing the frequency of the adaptive responses and learning to control the dystonic movements through the sessions.

Discussion

Outcome of the Studies

The positive results of the studies listed in Table 1 and of most of the studies using microswitches and related forms of technology such as VOCAs and microswitch clusters, in general, emphasize the relevance of these forms of assistive technology for persons with severe/profound multiple disabilities (Lancioni et al., 2009a, b, c; Shih, Chang, & Shih, 2010; Sigafoos et al., 2009). The chances of success of an intervention program such as those reported in this overview are definitely higher when (a) the response requirement is not excessive (i.e., when the response is in the person’s repertoire and requires a fairly low level of effort to be performed), (b) the stimulus events that the person accesses through the responses are powerful (i.e., highly effective reinforcing events), and their positive value exceeds the efforts required for performing the response, and (c) the intervention time is carefully programmed and sufficiently protracted to meet the person’s learning conditions (Kazdin, 2001; Lancioni et al., 2001a; 2009a; Saunders et al., 2003).

Selecting a suitable response may entail different things for different persons. For some persons, one may successfully identify fairly simple (typical) movements that do not need to be particularly precise spatially, do not involve any remarkable physical effort, and can provide some obvious types of feedback (e.g., swaying a grid above one’s face with small hand movements). For other persons, one may need to resort to less conventional forms of behavior (as pointed out in the first section of this paper). These forms of behavior may be fairly minimal and include, among other things, vocalizations, eyelid movements, or chin and lip movements (Lancioni et al., 2001c, 2004b, 2005a, 2010c).

Selecting the stimulus events that the person can access directly through his or her microswitch responses and the VOCA-mediated events is a critical process. The selection can be performed through indirect and direct strategies, such as observations of the persons within their regular environment, interviews with staff and caregivers, and stimulus preference screening procedures (Crawford & Schuster, 2003; Horrocks & Morgan, 2009). Two cautionary measures that could help maximize the possibility of success (i.e., the effectiveness of the stimulus events) are represented by (a) the selection and use of more than one event so as to avoid satiation risks, and (b) repetitions of the selection procedures over time to ensure that the events used are those that attract the person’s current interest and thus those potentially more effective (Kazdin, 2001; Lancioni et al., 2009d; Saunders et al., 2003).

Implications of the Studies and Practical Perspectives

The aforementioned overview and comments emphasize first of all the importance
of targeting single, non-typical responses for successful microswitch-based programs. The studies adopting those responses have provided a new level of evidence that is quite encouraging as to the possibility of helping persons with very minimal motor behavior learn to control their immediate environment. These persons would be most unlikely to benefit from intervention programs involving typical motor responses and traditional microswitches (Lancioni et al., 2004b, d, 2005a, 2007a, b, g). Providing these persons the chance to be active and to decide about their environmental stimulation effectively and independently can be viewed as highly relevant, in terms of the individuals’ quality of life as well as from a technical standpoint (Lachapelle et al., 2005; Petry, Maes, & Vlaskamp, 2005). Indeed, the possibility of being constructively engaged and of determining independently the level of stimulation may increase the person’s overall satisfaction, improve his or her general mood, and enhance his or her social image (Browder, Wood, Test, Karvonen, & Algozine, 2001; Karvonen, Test, Wood, Browder, & Algozine, 2004; Petry et al., 2005; Wehmeyer & Schwartz, 1998; Zekovic & Renwick, 2003).

From a technical standpoint, one can emphasize the importance of having isolated and successfully targeted small, non-typical responses and having developed viable interfaces (microswitch devices) to allow those responses to control relevant environmental events. The non-typical responses so far used in the studies include vocalization, chin and lip movements, eyelid and eyebrow movements, small hand-closure movements, and forehead skin movements. Additional responses or response variations should be investigated to provide practical alternatives to those mentioned above and thus allow a wider applicability of this approach (i.e., make it suitable to a larger number of individuals). For example, one could assess the usability of full/protracted eyelid closures as target responses for participants for whom such behaviors may be more affordable than double blinks or upward looking. Such closures could be monitored with simple adaptations of the optic-microswitch technology previously used for eyelid responses. Similarly, one could target small hand opening movements for participants, who tend to have their hands closed (i.e., keeping the fingers against the palms of their hands). Technically, one could resort to a modified version of the microswitch now available for the hand-closure responses. The new microswitch version would be activated as the person decreases the pressure applied on it or ends the contact with it.

The use of multiple responses through multiple microswitches constitutes an important perspective in the application of microswitch-based programs. Multiple responses/microswitches allow a person to increase the range of his or her engagement and the variety of sensory input (preferred stimulation) that he or she can access. Different responses are typically related to different sets of stimuli, and this stimulus variation is a useful condition to limit the risks of satiation. In addition to enjoying the variation of stimuli, the person may also gratify his or her possible preferences for some of the stimuli available by performing the response(s) instrumental to access them more frequently than the other responses (Cannella, O’Reilly, & Lancioni, 2005; Stafford, Alberto, Fredrick, Heflin, & Heller, 2002). Choice opportunities and self-determined access to the most preferred stimuli may promote a sense of personal fulfillment, pleasure (expressed in indices of happiness), and strong engagement motivation (Dillon & Carr, 2007; Green & Reid, 1999; Hoch, McComas, Johnson, Faranda, & Guenther, 2002; Kazdin, 2001; Lancioni et al., 2003c, 2006a; Ross & Oliver 2003).

Despite the great potential of programs involving multiple responses with multiple microswitches, one may object that they do not pay direct attention to a person’s possible desires for contact with the caregiver.
With regard to this point, two considerations seem in order. First, the objection might be realistic when the program includes (a) participants who are used to and obviously enjoy social contact and (b) caregivers who are able to integrate the provision of social contact within their daily work schedule. Second, whenever the aforementioned conditions (for participants and caregivers) apply, programs with multiple microswitches may be modified into programs with combinations of microswitches and VOCAs (cf. Lancioni et al., 2008b; Schlosser & Sigafoos, 2006; Sigafoos et al., 2009). Combining a VOCA, for the request of caregiver attention or mediation, with regular microswitches that consent direct access to environmental stimuli, may be conceived as a fairly straightforward strategy as indicated by the studies reviewed earlier (e.g., Lancioni et al., 2008b, 2009b, 2010d). Programs allowing the participant the possibility of asking for caregiver attention/mediation parallel to the independent access to preferred stimuli could also justify longer occupational sessions as compared to programs involving only the use of microswitches (and thus excluding contact with the caregiver).

With regard to the microswitch clusters, one may argue that they represent a most constructive and positive approach to help persons with severe/profound multiple disabilities advance in their development. In fact, the use of microswitch clusters serves to integrate the intervention conditions for increasing adaptive responding and for reducing problem behavior/posture within the same program. The technology to realize such an approach may be considered reasonably accessible both in terms of complexity and costs. The studies summarized earlier in this paper and reported in Table 1 were concerned with basic adaptive responses and specific forms of problem behavior or inadequate posture (e.g., hand mouthing, eye poking, and head forward tilting). Other adaptive responses and other problem behaviors/postures may also be targeted to extend the applicability and relevance of the approach. More extensive forms of program may also be contemplated. For example, one may envisage a situation in which the cluster involves two or more microswitches linked to different adaptive responses and one microswitch linked to a problem behavior/posture.

In conclusion, this brief/selective overview indicates that forms of assistive technology such as microswitches, VOCAs, and microswitch clusters may represent critical resources for the implementation of behavioral programs with persons with severe/profound multiple disabilities. The various applications of the aforementioned forms of technology, while already practical and beneficial, could be advanced profitably. For example, one may envisage research initiatives to extend and upgrade the microswitches for monitoring minimal, non-typical responses, namely, to adapt such microswitches to various response situations and make them work with minimal invasion/contact (i.e., realizing devices that do not need to be fixed onto the person’s body; see Lancioni et al., 2010a; Leung & Chau, 2010). Similarly, one could develop microswitch-cluster programs suitable to help reduce posture problems and physical deterioration of persons with extensive motor disabilities. These programs could become an effective supplement to physiotherapy and ergonomics (Begnoche & Pitetti, 2007; Leyshon & Shaw, 2008).

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