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Microswitch Technology for Enabling Self-Determined Responding in Children with Profound and Multiple Disabilities: A Systematic Review*

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Abstract
We reviewed 18 studies reporting on the use of microswitch technology to enable self-determined responding in children with profound and multiple disabilities. Identified studies that met pre-determined inclusion criteria were summarized in terms of (a) participants, (b) experimental design, (c) microswitches and procedures used, and (d) main results. The 18 studies formed three groups based on whether the microswitch technology was primarily intended to enable the child to (a) access preferred stimuli (7 studies), (b) choose between stimuli (6 studies), or (c) recruit attention/initiate social interaction (5 studies). The results of these studies were consistently positive and support the use of microswitch technology in educational programs for children with profound and multiple disabilities as a means to impact their environment and interact with others. Implications for delivery of augmentative and alternative communication intervention to children with profound and multiple disabilities are discussed.

Keywords: Augmentative and alternative communication; Choice making; Intervention research; Microswitch technology; Profound and multiple disabilities; Recruiting attention, Self-determination; Systematic review

Introduction
Educating children with profound and multiple disabilities (PMD) represents a significant challenge. The challenge arises, in part, from the complex nature of the associated impairments. Although there are varying definitions of PMD (cf. Bellamy, Croot, Bush, Berry, & Smith, 2010), the term generally refers to individuals with severe to profound intellectual disability and significant motor impairment, such as spastic quadriplegia or tetraparesis (Harding, Lindsay, O’Brien, Dipper, & Wright, 2011; Lancioni, Sigafoos, O’Reilly, & Singh, 2013). Many such children also have hearing impairment and/or vision impairment, and/or significant health issues, such as complex seizure disorders (Orelove, Sossey, & Silberman, 2004).

With respect to communication, children with profound and multiple disabilities typically present with little or no speech and rely primarily on “nonsymbolic modes of communication, such as gestures, vocalizations, facial expressions, and body language” (Beukelman & Mirenda, 2013, p. 225). Pre-symbolic or non-symbolic forms of communication are prone to frequent misunderstanding (Brady & Halle, 2002; Brady, McLean, & Johnston, 1995) and limiting in terms of the complexity of messages that can be communicated. Thus, these children are candidates for intervention to enable them to communicate using augmentative and alternative communication (AAC). However, researchers (e.g., Blain-Moraes & Chau, 2012; De Bortoli, Arthur-Kelly, Foreman, Balandin, & Mathisen, 2011; Harding et al., 2011) have noted several challenges with respect to the provision of AAC intervention to these children, who often have significant difficulty in initiating and maintaining social interaction. Additional challenges include pronounced learning difficulties, limited mobility, poor motor control, and fluctuating levels of alertness (Arthur, 2003; Blain-Moraes & Chau, 2012; Orelove, Sossey, & Silberman, 2004). All of these challenges seem to complicate the educational process, including provision of AAC intervention.

Over 30 years ago, Bailey (1981) argued that, in light of the significant challenges associated with PMD,
habilitation efforts should focus on enriching the environment through the provision of preferred stimulation and social interaction. This type of “stimulation programming” was considered more likely to be helpful to the child than systematic instruction to teach adaptive behaviors. This emphasis on stimulation programming remains prevalent today in the guise of intensive interaction (Berry, Firth, Leeming, & Sharma, 2014) and in the prevalent use of multisensory environments in educational programs for children with profound and multiple disabilities (Hogg, Cavet, Lambe, & Smeddle, 2001; Stephenson, 2002; Stephenson & Carter, 2011).

While stimulation programming, which involves exposure to preferred stimulation and social interaction, might be one way to enrich the environment and possibly increase a child’s enjoyment and quality of life, conceptual advances over the past 30 years have emphasized a more active approach to habilitation/educational programming for persons with developmental disabilities. Specifically, the self-determination principle highlights the importance of enhancing the autonomy of persons with disabilities (Singh et al., 2003; Wehmeyer, 1992; Wehmeyer & Abery, 2013). Enabling children with profound and multiple disabilities to exert a greater degree of control over the environment might be one way to enhance their self-determination. Specific types of self-determined responding might include (a) controlling access to preferred sources of stimulation, such as music and video, (b) choosing between two or more objects or activities, and (c) recruiting attention/initiating social interaction.

While a case for the desirability of enhancing self-determination has been made in the literature (Singh et al., 2003; Wehmeyer, 1992; Wehmeyer & Abery, 2013), an important question is whether children with profound and multiple disabilities can learn to (a) control access to preferred stimuli, (b) make choices between stimuli, and (c) recruit attention/initiate social interaction. One potentially effective approach for increasing the impact of an individual on their environment would be to train their communication partners to better recognize and respond appropriately to the person’s existing prelinguistic communication behavior as suggested by Sigafoos, Arthur-Kelly, and Butterfield (2006). Along these lines, Tait, Sigafoos, Woodyatt, O’reilly, and Lancioni (2004) demonstrated that parents could be trained to enhance the prelinguistic behavior of their children with developmental and physical disabilities. The intervention was effective in enabling the children to, among other outcomes, more effectively access preferred stimuli (i.e., request preferred objects). However, as noted before, prelinguistic behavior is often prone to frequent communicative breakdowns (Brady & Halle, 2002; Brady et al., 1995). To counteract this possibility, it might be possible to enable children to independently control access to preferred stimulation using aided forms of AAC (Shodgrass, Stoner, & Angell, 2013) and related forms of assistive technology. A potential advantage of aided forms of AAC and related technology is that it consistently recognizes the child’s communicative attempts, unlike human mediators who often miss the child’s communicative attempts (Brady & Halle, 2002; Brady et al., 1995). To this end, various assistive technologies/AAC devices have been developed that might enable self-determination in children with PMD. Microswitches, for example, represent one type of assistive technology that would seem to have considerable potential for enabling self-determined responding in children with profound and multiple disabilities.

Lancioni et al. (2013) defined microswitches as a type of assistive technology that enables the person to perform adaptive behaviors (e.g., access preferred stimuli, choose between stimuli, and initiate social interaction) via some existing motor action, such as moving a finger or arm, head turning, touching/pushing, or chin movement. At present there are a growing number of individual studies examining the use of microswitches (Lancioni et al., 2013). However, these studies have typically involved a small number of participants using microswitches for a small number of tasks. What is needed is an integrated understanding of how past research can inform interventions to promote self-determination among children with profound and multiple disabilities using microswitch technology. For what types of tasks has microswitch technology been proven to be of benefit? For what children have these interventions been successful? What types of instruction was needed for these children to learn to use microswitches to make self-determined responses?

The aim of this review is to attempt to answer these questions by providing a systematic review of research that has evaluated the use of microswitch technology for enabling children with profound and multiple disabilities to make self-determined responses, specifically: (a) accessing preferred stimuli, (b) choosing between stimuli, and (c) recruiting attention/initiating social interaction. These types of responses could be considered important examples of self-determination and important educational goals for children with profound and multiple disabilities. Teaching these children to use microswitch technology to make these types of responses might represent a useful starting point for AAC intervention. Indeed, these types of responses could be conceptualized as beginning communication skills related to requesting objects and gaining attention. As Reichle, York, and Sigafoos (1991) argued, such beginning communication skills are important because they enable the child to access reinforcement and exert some degree of control over the environment, including control over the actions of other people in the environment.

The specific objectives of the present review were to (a) identity and summarize research studies that evaluated the use of microswitch-based interventions for enabling self-determined responding in children with profound and multiple disabilities, and (b) gain an overall picture of the success of these interventions. A review of this type could be helpful in advancing evidence-based practice. Advancing evidence-based practice is important...
because interventions based on high quality research are more likely to be effective (Cook, Tankersley, & Landrum, 2013). In addition, legislative mandates, such as the Individuals with Disabilities Education Act (IDEA, 2004) and No Child Left Behind Act of 2001, require the use of research evidence in educational programming (Yell & Rozalski, 2013). Thus a review of research in this area might help guide research-based-classroom interventions for children with PMD. A review of this type might also identify gaps in the existing evidence base and stimulate new research to fill those gaps.

**Method**

We systematically searched for intervention studies that evaluated the use of microswitch technology for enabling children with profound and multiple disabilities to (a) access preferred stimuli, (b) choose between stimuli, and/or (c) recruit attention/initiate social interaction. Identified studies that met pre-determined inclusion criteria were summarized in terms of (a) participants, (b) experimental design, (c) microswitches and procedures used, and (d) results.

**Search Procedures**

We searched the 56 electronic databases covered by ProQuest on 22 August 2014. The search terms were “microswitch” and “multiple disability” or “profound disability.” These search terms were entered into the Abstract field as free text. The search was restricted to English language articles in peer-reviewed scholarly journals. Limiting the search to peer-reviewed scholarly journals was intended to ensure that studies included met the peer-reviewed research requirement of IDEA 2004 (Yell & Rozalski, 2013). Two additional search strategies involved (a) reviewing the reference lists of articles identified from the electronic database to search for other relevant studies, and (b) searching for additional studies by the first author of each included study from the initial database search.

**Screening and Inclusion Criteria**

To be included in the review, the study had to meet three inclusion criteria. First, it had to focus on evaluating the use of microswitch technology with at least one participant who was 18 years of age or younger. Based on Lancioni et al. (2013), a microswitch was defined as any type of assistive technology that would enable the person to perform one of three self-determination responses: accessing preferred stimuli, choosing between stimuli, and/or recruiting attention/initiating social interaction. Microswitches were activated via some existing motor action that the child performed, such as moving a finger or arm, head turning, touching/pushing, or chin movement. PMD was defined as the presence of (a) severe/profound intellectual disability, (b) severe physical impairment (e.g., spastic quadriplegia or spastic tetruparesis), and (c) severe communication impairment/complex communication needs. Severe communication impairment referred to having little or no speech/spoken words based on the study’s description of participants. Second, the microswitch technology had to be primarily intended to provide the child with a way of (a) gaining access to preferred stimuli, (b) choosing between stimuli, or (c) recruiting attention/initiating social interaction. Third, the studies had to have an experimental design. Experimental designs included a range of single case experimental designs, such as ABAB, multiple baseline, and alternating treatments designs (Kennedy, 2005), but could have also included randomized control trials, although no studies using this latter design were identified. Including only experimental studies increases the certainty of evidence and is in line with the No Child Left Behind Act of 2001, which requires educational instruction to be based on scientific (i.e., experimental) research.

The initial database search returned 261 results. The titles and abstracts of these 261 returns were given an initial screening by the first author, resulting in 23 studies for possible inclusion. The second author independently screened these 261 studies against the inclusion criteria and rated 18 as meeting the inclusion criteria. After discussion, six of the first author’s 23 studies were excluded because they were judged to be primarily focused on improving motor performance/control rather than on enabling participants to (a) access preferred stimuli, (b) choose between stimuli, and/or (c) recruit attention/initiate social interaction. In addition, one study nominated by the second author, but initially excluded by the first author, was subsequently deemed to meet the inclusion criteria, resulting in a total of 18 studies for inclusion in this review.

**Data Extraction and Coding**

The 18 studies were classified into three groups based on whether the microswitch technology was primarily intended to enable the child to (a) access preferred stimuli, (b) choose between stimuli, or (c) recruit attention/initiate social interaction. For each group of studies, we extracted data on the following variables: (a) participant numbers, gender, ages, and diagnoses, (b) experimental design, (c) microswitches and procedures used, and (d) results. Data extraction for all 18 studies was performed by the first author and checked for accuracy by the second author.

**Results**

**Accessing Preferred Stimuli**

Table I provides a summary of seven studies (Studies 1–7) that focused on enabling participants to access preferred stimuli via microswitch technology. A total of 12 participants received intervention in these seven studies. They ranged from 4–18 years of age (M = 9)
and included seven males and five females. Most were diagnosed with the following combination of conditions: (a) cerebropathy, (b) spastic tetraparesis, (c) epilepsy, (d) vision impairment, and (e) profound intellectual disability. Most participants were also described as having no speech and requiring wheelchairs for mobility.

The therapeutic aim of these studies was to enable participants to control access to preferred stimulation (e.g., music, songs, vibration, and/or lights) via microswitch activation. Four microswitch response combinations were evaluated: (a) microphone switches activated by vocalizations, (b) vibration switches activated by 70 dB or higher vocalizations. Baseline activations had no consequences. For intervention, activations triggered 5–7 s of preferred stimulation (e.g., songs, bells, clapping).
vated by tapping/hitting the table surface on which the switch had been placed, (c) lever switches activated by chin movement, and (d) optic microswitches activated by forehead movements. Switch activations produced different outcomes/consequences depending on the phase of the study. Specifically, switch activations that occurred during the baseline phase did not produce any stimulation, whereas switch activations that occurred during the intervention phase produced 4–10 s of access to preferred stimulation (i.e., 4–10 s of music, songs, vibration, and/or lights).

During the baseline phases, children were given access to the microswitch technology (e.g., the lever switch was positioned next to their chin), but switch activations produced no consequences. After baseline, a few practice sessions were provided, during which children were assisted to activate the switch four to six times (with consequent brief access to stimulation). After these practice sessions, the children had intervention sessions during which independent activation of the microswitch resulted in varying durations (4–10 s) of preferred stimulation. Thus the instructional procedures involved initial practice sessions using graduated guidance and the subsequent contingent reinforcement sessions that were conducted within a free-operant paradigm (Duker, Didden, & Sigafoos, 2004). The paradigm was free operant in the sense that the child could access preferred stimulation, via switch activation, at any time during the session. This free-operant paradigm could be seen as an especially powerful approach for evaluating whether the intervention did in fact produce self-determined responding. The power comes from the fact that after the practice sessions, the children were never prompted, instructed, or in any way cued by others to activate the switch. Thus it was the children themselves who determined when and how often to make the switch activating response so as to gain stimulation. Indeed, the intervention sessions differed from baseline sessions only by virtue of the fact that each switch activation resulted in contingent reinforcement in the form of 4–10 s of preferred stimulation. In line with this free-operant arrangement, the main dependent variable was the number (frequency) of switch activations per session, which was sometimes converted into a rate per minute measure.

To evaluate the intervention, five studies used ABAB reversal designs and two studies used the non-concurrent multiple baseline across participants design (Kennedy, 2005). Five studies included from 6 weeks to 3 months of follow-up. In the reversal designs, the return to baseline conditions meant that switch activations no longer produced contingent stimulation. That is, responses that were reinforced in the previous intervention phase were now placed on an extinction schedule. The change from the extinction schedule (in effect during the baseline phases) to the continuous reinforcement schedule (in effect during the intervention phases) was not signalled to the children in any way. Any change in responding from baseline to intervention could therefore be attributed to the change in the contingencies (i.e., the change from no reinforcement to contingent reinforcement) rather than to any antecedent instruction or cueing. In addition, any increase in responding with intervention would provide evidence of cause-effect learning; that is, the children had learned that activating the switch caused the stimulation (Calculator & Jorgensen, 1991).

Positive results were reported in all seven studies and for all 12 children. Visual inspection of the graphed data in these studies showed that switch activations were very low during baseline phases, but increased to much higher and steady levels with intervention. Switch activations also remained higher during follow-up than during baseline. A calculation of response frequencies indicated that across these seven studies, switch activations during baseline averaged approximately six responses per session, whereas during intervention and follow-up, switch activations averaged approximately 18 responses per session. These approximations were based on calculations made by the second author, which were then independently checked for accuracy by the last author. Thus, switch activations were roughly three times higher during intervention and follow-up sessions than during baseline sessions. The results suggest that the microswitch technology and the intervention procedures employed enabled the children to independently control (i.e., self-determine) access to preferred stimuli. The higher levels of independent switch activations during intervention and follow-up also provide clear evidence of cause-effect learning (Calculator & Jorgensen, 1991).

Making Choices

Table II provides a summary of six studies (Study 8–13) focused on enabling participants to make choices using microswitch technology. A total of 11 participants received intervention in these six studies. They ranged from 6–17 years of age ($M = 11$ years) and included four males and seven females. Participants were diagnosed with the following combination of conditions: (a) cerebropathy, (b) spastic tetraparesis, (c) epilepsy, (d) vision impairment, and (e) severe to profound intellectual disability. Six participants were described as having some spoken words or recognizable vocalizations.

The therapeutic aim of these studies was to enable participants to experience a brief sample of various stimuli and then choose the stimulus that they wanted to access. The study by Lancioni et al. (2006c; Study 11), will serve as an illustrative example of the studies in this group. In this study, the participant had only one microswitch and a computer system, which presented him with brief stimulus samples. After each sample, he was to decide/choose whether he wanted to access that stimulus or not. In the first case, he was expected to activate his microswitch. In the second case, he was expected to abstain from activating the microswitch. In the other studies, participants were taught to use two or more microswitches. In three of those studies (Studies
### Table II. Summary of Six Studies Focused on Evaluating Microswitch Technology for Enabling Children to Make Choices.

<table>
<thead>
<tr>
<th>Study</th>
<th>Participants</th>
<th>Design</th>
<th>Microswitch intervention</th>
<th>Results</th>
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<tbody>
<tr>
<td>8. Lancioni, Singh, O’Reilly, and Oliva (2003)</td>
<td>This study included two participants, but only one was less than 18 years old. The (17-year-old) girl had cerebropathy, spastic tetraparesis, vision impairment, epilepsy, spastic tetraparesis, vision impairment, and severe intellectual disability. The child could speak some words.</td>
<td>Multiple probe across behaviors design with 2-month follow-up. The separate behaviors were use of different microswitches.</td>
<td>A mercury switch for head raising, a right-hand push button switch, and a left-hand press bar switch were used to request stimuli and a microphone switch, activated by saying <em>yes</em> was used to choose presented stimuli. Baseline activations had no consequence. For intervention and follow-up, activations were used to present a stimulus offer, which could then be chosen by the microphone switch. At the start of intervention, the child was initially prompted to activate each microswitch. Activations of each microswitch increased only when intervention was applied to that microswitch.</td>
<td></td>
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<tr>
<td>9. Lancioni Singh, O’Reilly, and Oliva (2004)</td>
<td>One girl (17 years old) and one boy (6 years old) with cerebropathy, spastic tetraparesis vision impairment, severe intellectual disability and some speech/recognizable vocalizations.</td>
<td>Multiple probe across behaviors design with 14 follow-up sessions. The separate behaviors were use of different microswitches.</td>
<td>Each child used 2 or 3 microswitches (e.g., mercury switch, optic sensor, and/or pressure switch) to request stimuli and then used a microphone switch, activated by vocalizations, to choose presented stimuli. Baseline activations had no consequence. For intervention, activations resulted in stimulus presentations, which could then be chosen by activating the microphone switch. At the start of intervention, the children were initially prompted to activate each microswitch. Activations of each microswitch increased only when intervention was applied to that microswitch.</td>
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<tr>
<td>10. Lancioni et al. (2006b)</td>
<td>Three girls (7, 9, and 15 years old) with cerebropathy, vision impairment, epilepsy, severe to profound intellectual disability, and no speech.</td>
<td>Multiple probe design across two behaviors. The two behaviors were use of two different microswitches. A final phase assessed use of both switches to make choices.</td>
<td>Contact microphone switch affixed to one of the girl’s throats was activated by vocalizations. A position sensor attached to the chin of one of the girls was activated by downward chin movements. Multiple mercury switches were activated by body and knee movements, and an adapted position microswitch was activated by hand opening. Each MS activation triggered a specific preferred stimulus. Each participant had two microswitches to make choices between two types of stimuli. Baseline activations had no consequence. For intervention, activations enabled the child to choose among different stimuli. Activations of each microswitch increased only when intervention was applied to that microswitch. The final phase indicated that all three children used both of their acquired microswitch responses to make choices.</td>
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<tr>
<td>11. Lancioni et al. (2006c)</td>
<td>One boy (9 years old) with cerebropathy, vision impairment and intellectual disability. He had previous experience using chin movements to activate microswitches to request preferred stimuli.</td>
<td>ABAB design with 6- and 10-week follow-ups.</td>
<td>A sensor switch attached to the boy’s face was activated by an upward eyebrow movement. Samples of preferred and non-preferred stimuli were presented via a computer and could be chosen by switch activations. Baseline activations had no consequence. For intervention, activations enabled the child to choose the presented stimulus. Switch activations were low during baseline phases. With intervention, switch activations for preferred stimuli increased while switch activations for non-preferred stimuli remained low. This differential pattern was maintained during follow-up.</td>
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(Continued)
Microswitch activations were low during baseline and increased with intervention. With intervention, the children consistently used the yes microswitch to request preferred stimuli and used the microswitch to reject non-preferred stimuli. Performance remained high during follow-up.

Both participants had two microswitches. One switch was either a pressure switch or a mercury switch to trigger a computer system to present samples of preferred and non-preferred stimuli. Microswitch responses were evaluated by activation of a computer system to present samples of preferred and non-preferred stimuli. Positive results were reported in all six studies and for all 11 children. Generally, switch activations were low during baseline phases, increased to higher and steady levels with intervention, and remained high and steady during follow-up. When choices for preferred versus non-preferred stimuli were compared (e.g., Studies 11 and 13 in Table II), correct use of the switch activation sequence to make choices for preferred stimuli averaged approximately 5% during baseline, but increased to above 70% during intervention and follow-up. Choices for non-preferred stimuli remained low (5% or less). The results suggest that the microswitch technology, and the intervention procedures employed, enabled the children to access a list of stimulus options and then choose whether or not to experience each specific option. The higher levels of independent switch activa-
tions for both microswitches during intervention and follow-up, compared to baseline, provide convincing evidence that the children had learned a rather complex behavioral chain consisting of two sequential microswitch responses.

**Recruiting Attention/Social Interaction**

Table III provides a summary of five studies (Study 14–18) that focused on enabling participants to recruit attention and initiate social interaction via the use of microswitch technology. A total of 22 participants received intervention in these five studies. They ranged from 5–18 years of age \( (M = 11) \) and included 12 males and 10 females. The diagnostic descriptions of the children in these studies varied. Sobsey and Reichle (1989; Study 14), for example, described their six participants as “multiply handicapped” (p. 48). These children appeared to have at least severe intellectual disability and motor impairments. Most were also described as producing either only vocalizations or a few words of speech. The 16 children in the other studies generally had two or more of the following conditions: (a) cerebral palsy, (b) spastic tetraparesis, (c) epilepsy, (d) vision impairment, and (e) severe to profound intellectual disability.

There were two main therapeutic aims addressed in these five studies. The first aim, addressed in Sobsey and Reichle (1989; Study 14), was to determine what type of consequence maintained the children’s use of a call buzzer; specifically, whether the maintaining consequence was the resulting attention from an adult or simply the noise of the call buzzer. In this study, the six children were taught to activate a call buzzer. The call buzzer could be activated by touching, hitting, or pushing a pressure microswitch. Under some conditions activation of the switch was followed by having an adult approach and speak to the child (e.g., Hello [child’s name]. Did you call me?), while in other conditions switch activations only produced a buzzer noise.

In the other four studies, the main therapeutic aim was to enable participants to recruit attention/initiate a social interaction. In these four studies, microswitch activations triggered digitized or synthesized output from a speech-generating device (SGD). Kennedy and Haring (1993; Study 15), for example, taught participants to activate a toggle switch, which triggered a recorded message (e.g., “Can we do something else?”) and a relevant social response from a peer (e.g., talking to the child and engaging the child in a new activity). Four types of microswitches were evaluated in these five studies: (a) pressure and toggle switches activated by touching, hitting, or pushing the switch with head or hands, (b) tilt switches activated by body (e.g., wrist) movements, (c) microphone switches activated by vocalizations, and (d) optic microswitches activated by eye, mouth, or head-turning movements.

To evaluate the effects of different consequences on the frequency of microswitch activations, Sobsey and Reichle (1989, Study 14) used an alternating-treatments design with four different conditions compared. The other studies used a multiple-probe across participants design (Study 15), or multiple-probe across behaviors design (Studies 16–18). In the Sobsey and Reichle study, children were first taught to use the microswitch to recruit attention using verbal, gesture, and physical prompts (Duker et al., 2004) and were then exposed to the four conditions in an alternating treatments design. In the other studies, children had the microswitch technology during both baseline and intervention sessions. In baseline, switch activations produced no consequences, whereas during intervention each switch activation triggered speech output, which was then followed by receiving attention/social interaction. In addition to these differential consequences, Kennedy and Haring (1993; Study 15) also used physical prompting to assist the children in making the response.

In the Sobsey and Reichle (1989, Study 14) study, acquisition training appeared to be effective, as evidenced by a gradual increase in independent switch activations as training progressed. When the four conditions were then alternated, participants showed more responding during the buzzer plus attention condition, followed by the attention only, buzzer only, and no attention/no buzzer conditions. These data suggest that the children had learned to use the microswitch to recruit attention, but that some level of responding also seemed to be maintained by the sound of the buzzer. However, responses that occurred in the buzzer only and no attention/no buzzer conditions might have stemmed from resistance to extinction given that attention was no longer forthcoming for switch activations during these latter two conditions.

The other four studies (Studies 15–18) reported positive intervention effects for all 16 participants. This is evidenced by visual inspection of the graphed data, which showed that switch activations to initiate social interactions were low during baseline phases and increased to higher and steady levels with intervention. Responding was also generally maintained at levels comparable to those of intervention during follow-up (Studies 16 and 17). For example, during baseline, the three children in the Kennedy and Haring study (1993, Study 15) had a mean response frequency of less than one response per session. With intervention, the children were routinely making 4–16 responses per session. The results from Studies 15–18 suggest that the microswitch technology and the intervention procedures employed enabled the children to activate an SGD so as to recruit attention/initiate social interaction. The higher levels of independent switch activations under conditions when switch activations resulted in social interaction suggests that the children had learned to operate the switch as a means of recruiting attention/social interaction.
Table III. Summary of Five Studies Focused on Evaluating Microswitch Technology for Enabling Children to Recruit Attention/Initiate Social Interaction.

<table>
<thead>
<tr>
<th>Study</th>
<th>Participants</th>
<th>Design</th>
<th>Microswitch intervention</th>
<th>Results</th>
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<tbody>
<tr>
<td>14. Sobsey and Reichle (1989)</td>
<td>Six children (3 boys and 3 girls) ranging from 6-16 years of age. All were described as having multiple handicaps.</td>
<td>Alternating treatments design with an initial acquisition-training phase. After children had acquired the microswitch response, four conditions were alternated to determine if responding was maintained by attention and/or buzzer sound from the microswitch. The conditions were: (a) buzzer only (buzz sound of the switch), (b) attention only; (c) attention plus buzzer, and (d) no attention plus no buzzer.</td>
<td>A pressure switch connected to a call buzzer was activated by a touching response. Acquisition training involved verbal, gesture, and physical prompts until children independently activated the switch. In the buzzer-only condition, switch presses resulted in the buzzer noise. In the attention-only condition, switch presses produced attention from an adult, but not the buzzer. In the attention plus buzzer condition, switch activations resulted in attention and the buzzer. In the final condition, switch pressing produced neither the buzzer nor attention.</td>
<td>Each child learned to activate the switch independently with acquisition training. In the subsequent alternating treatments phase, switch activation frequencies were highest in buzzer plus attention condition, followed by attention only, and then the buzzer-only condition. Frequencies of switch activations were lowest under the no-attention plus no-buzzer condition.</td>
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<td>15. Kennedy and Haring (1993)</td>
<td>The study included four participants, but only three were children. The children were one girl (5 years old) and two boys (6 and 18 years of age) with microcephaly, spastic tetraparesis, epilepsy, and &quot;no formal means of communication&quot; (p. 64).</td>
<td>Three studies were conducted; Study 1 involved a preference assessment, which identified 12 low and 14 high preference items for each participant. Study 2 followed a multiple probe across students with an alternating treatments design to train microswitch activation. Study 3 involved a stimulus generalization baseline phase (from instructor to peer) followed by an alternating treatments design with three treatment conditions to control social interaction with non-disabled peers.</td>
<td>The microswitches included a contact switch and a toggle switch. Switch activation triggered digitized (recorded) output (i.e., &quot;Can we do something else?&quot; or &quot;Let's try something new&quot;). The three alternating treatment conditions were (a) participant in control of stimuli, (b) non-disabled peer in control of stimuli, or (c) stimuli duration and sequence matched that of the peer-control condition and the microswitch was not available.</td>
<td>During Study 2, switch activations increased during intervention from baseline when preferred stimuli were present. When preferred stimuli were absent, switch activations were low. Additionally, the length of time participants engaged with highly preferred stimuli increased during intervention. During Study 3, switch activation generalized to non-disabled peers.</td>
</tr>
<tr>
<td>16. Lancioni et al. (2008a)</td>
<td>One boy (16 years old) and one female (18 years old) with cerebropathy, spastic tetraparesis, vision impairment, profound intellectual disability, and no speech</td>
<td>Multiple probe across three behaviors with 1.5 month follow-up. The behaviors were use of two different microswitches and operation of a speech-generating device via a microphone switch.</td>
<td>Children were taught to use tilt, pressure, and microphone switches to (a) access preferred stimuli, and (b) trigger a speech-generating device to initiate social interaction (i.e., &quot;Could somebody talk to me&quot;). In baseline, switch activations had no consequence. For intervention, different switches produced preferred stimuli or the speech output, which then resulted in an interaction with a caregiver.</td>
<td>Microswitch activations were low during baseline and increased with intervention. Within the third intervention tier, the children consistently used all three microswitches to access preferred stimuli and initiate social interaction. Performance remained high during follow-up.</td>
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<tr>
<td>17. Lancioni et al. (2008b)</td>
<td>Two boys 10 and 11 years old) and one girl (15 years old) with spastic tetraparesis, encephalopathy, vision impairment, severe to profound intellectual disability and no speech. All had previous experience in using microswitches.</td>
<td>Multiple probe across three behaviors with 1.5- to 3-month follow-up. The behaviors were use of three different microswitches.</td>
<td>Children were taught to use pressure and tilt microswitches to (a) access preferred stimuli, and (b) trigger a speech-generating device to initiate social interaction (i.e., &quot;Can somebody play with me&quot;). In baseline, switch activations had no consequence. For intervention, different switches produced preferred stimuli or the speech output, which then resulted in an interaction with a caregiver.</td>
<td>Microswitch activations were low during baseline and increased with intervention. Within the third intervention tier, the children consistently used all three microswitches to access preferred stimuli and initiate social interaction. Performance remained high during follow-up.</td>
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We identified 18 studies reporting on the use of microswitch technology to enable three types of self-determined responding in children with profound and multiple disabilities. The results of these studies were consistently positive. Indeed, each study provided convincing experimental data that every participant learned to activate one or more microswitches to (a) access preferred stimuli, (b) choose between stimuli, or (c) recruit attention/initiate social interaction. The positive results from these 18 experimental studies, involving 45 participants, would seem to provide sufficient empirical evidence to support and justify the use of microswitch technology in educational programs for these children.

The studies included in this review were scientific (i.e., involved experimental designs) and peer reviewed, thus meeting the requirements of NCLB and IDEA. Each study also was judged by the first and last authors to have provided sufficiently detailed intervention protocols to enable replication in applied settings, such as classrooms. Indeed, these studies could be seen as technological and analytic (Baer, Wolf, & Risley, 1987). The studies were technological in the sense of providing an objective description of the procedures and analytic in the sense of providing a convincing demonstration of a positive intervention effect. In addition, the findings would appear to have considerable external validity given that the main findings of any given study were often reproduced across several additional, yet independent studies (Sidman, 1960/1988). For example, the seven studies evaluating microswitch technology to enable children to access preferred stimulation (see Table I) could be viewed as systematic replications in the sense that all of these studies used the same basic arrangement and all of them reported similarly positive findings. The same could be said for most of the studies summarized in Tables II and III.

## Discussion

### Table III. (Continued)

<table>
<thead>
<tr>
<th>Study</th>
<th>Participants</th>
<th>Design</th>
<th>Microswitch intervention</th>
<th>Results</th>
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<tr>
<td>18. Lancioni et al. (2009)</td>
<td>Four boys and four girls ranging from 5–17 years of age with encephalopathy, vision impairment, and severe to profound intellectual disability.</td>
<td>Multiple probe across behaviors design. The behaviors were use of two different microswitches.</td>
<td>Children were taught to use optic, pressure, and/or tilt microswitches to (a) access preferred stimuli, and (b) trigger a speech-generating device to initiate social interaction (e.g., &quot;Can you play with me?&quot;). In baseline, switch activations had no consequence. For intervention, different switches produced preferred stimuli or the speech output, which then resulted in an interaction with a caregiver.</td>
<td>Microswitch activations were low during baseline and increased with intervention. Within the third intervention tier, the children consistently used their microswitches to (a) access preferred stimuli, and (b) initiate social interaction. Performance remained high during follow-up.</td>
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</tbody>
</table>
and that they were also able to self-determine the onset and offset of preferred stimuli, make choices among available stimuli, and initiate social interaction. The microswitch technology could be seen as enabling them to overcome the handicap imposed by motor impairments. Given the positive results reported in the present set of studies, the creative skills of interventionists in configuring such technology might be the only real limit to what children with profound and multiple disabilities could achieve. While accessing preferred stimuli, choosing between stimuli, and recruiting attention/initiating social interaction are important, microswitch-based interventions might also enable such children to perform more communication, academic, community living, and vocational skills.

While it is perhaps not surprising that well-established instructional procedures and the free-operant/contingent reinforcement paradigm, can be successfully applied to enable self-determined responding in children with profound and multiple disabilities, it must be remembered that 30 years ago, such direct instructional approaches were often considered inappropriate, due to their serious neurological impairments. Instead, passive stimulation programming was recommended (Bailey, 1981). Even today, various stimulation programs (e.g., intensive interaction and multisensory environments) appear to be widely used for these children, despite having limited empirical support (Berry et al., 2014; Hogg et al., 2001; Stephenson, 2002; Stephenson & Carter, 2011).

Of course, it is not necessarily the case that one must choose between promoting self-directed versus merely providing stimulation and/or social interaction to the child. Instead, it is possible that these two approaches could be usefully integrated. That is, microswitch-based interventions, aimed at enabling self-determined responding, might be successfully combined with intervention efforts aimed at training communication partners to recognize and respond appropriately to the child’s desire for preferred stimulation and social interaction. For example, communication partners might be taught how to effectively present an array of choices that the child could then choose/request using a microswitch-based SGD.

The present set of studies offers an empirically validated alternative, or supplement, to stimulation programming; an alternative or supplement that is seemingly more consistent with the contemporary philosophy of self-determination (Singh et al., 2003; Wehmeyer, 1992; Wehmeyer & Abery, 2013). By combining microswitch technology with systematic instruction and the free-operant/contingent reinforcement paradigm, the participating children appeared to have learned the cause-effect relations arranged via the microswitch program. They also appeared to have demonstrated self-determination in the sense of choosing when to access preferred stimulation, what type of stimulation to access, and when to initiate a social interaction. While self-determination encompasses more than just these three types of responses (Singh et al., 2003; Wehmeyer, 1992; Wehmeyer & Abery, 2013), enabling children with profound and multiple disabilities to independently perform such responses would nonetheless seem to be highly functional and potentially quite empowering.

The three types of responses that were the focus of this review could be seen as important early communication skills and thus this review has implications for children with PMD who require AAC and who are at the beginning stages of AAC intervention. The five studies that focused on enabling participants to recruit attention/initiate social interaction, for example, provided successful examples of how educators could use microswitch technology to enable children to communicate with an SGD. The manner in which participants accessed preferred stimuli and made choices in some of these studies did not involve message exchange with a communication partner, but it might be possible to arrange a situation whereby accessing preferred stimuli and making choices via a microswitch set-up occurs within the context of a communication interaction with a listener. In either case, using microswitch technology to access preferred stimuli and make choices could be considered a type of early requesting behavior that could be targeted in the beginning stages of an AAC intervention.

In addition to making use of well-established instructional procedures, a critical factor for success in any such intervention would seem to be the employment of microswitches suited to the child’s motor abilities. In the present set of 18 studies, a range of microswitch-response combinations were used, including (a) pressure switches activated by touching/hitting or pushing the switch, (b) toggle switches activated by bumping, hitting, or swiping, (c) microphone switches activated by vocalizations, (d) vibration switches activated by tapping/hitting the table surface on which the switch had been placed (e) lever switches, activated by chin movement and (f) optic microswitches activated by forehead movements. Such a range of microswitch-response combinations is likely to be necessary because children with profound and multiple disabilities present with varying degrees and types of motor abilities and impairments. Lancioni et al. (2013) noted three factors that appear to be related to the success of microswitch-based programs for these individuals: (a) ensuring the microswitch is easy for the person to activate given the person’s existing motor abilities, (b) ensuring that each switch activation produces a meaningful (i.e., reinforcing) outcome, and (c) ensuring the person receives sufficient support and practice (i.e., systematic instruction) to gain independence and fluency with the technology.

One limitation of this set of studies is that the participating children were taught to use only one or two microswitches for a limited number of functions/purposes. The extent to which children with PMD could learn to manage such technology for accomplishing other functions/purposes is an empirical question that
could be addressed in future research. One limitation of the present set of 18 studies is that Lancioni and colleagues published most of them. Confidence in the reliability of the findings from these studies would be enhanced by replications by other research teams. Another potentially useful direction for future research would be to ascertain whether children with profound and multiple disabilities could learn to use emerging new technologies (e.g., eye gaze control of computers) to exercise control over the environment and interact with others. Answering these questions might not be immediately easy. Still, the results of the present review provide empirically validated examples of how micro-switch technology can be applied to promote three types of self-determined responses in these children.

Surely, AAC professionals can build on this existing research by developing new communication technologies and demonstrating their successful and creative application to promote even greater self-determination among children with profound multiple disabilities. The gains over the past 30 years have been impressive. The field has moved from a view that such children were incapable of learning and needed others to stimulate them, to a view that such children should be enabled to self-determine when, how much, and what type of stimulation they want to receive. Thirty years from now, such children should be able to accomplish so much more using technology more sophisticated than can yet be imagined. AAC researchers and practitioners should be at the forefront of developing and applying existing and future such technologies. Mirenda’s (2014) call to arms is worth repeating: “If we do this, the lives of children . . . will be changed again . . . We can do this; we must do this” (p. 7).


**References**

*Studies included in the review

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No Child Left Behind, 20 U.S.C. § 16301 et seq.


