Successful Voluntary Grasp and Release Using the Cookie Crusher Myoelectric Hand in 2-Year-Olds

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We examined the ability of two 2-year-old children with limb deficiency to demonstrate grasp and release while using the cable-operated voluntary opening book-band and the externally powered single-site myoelectric Cookie Crusher system. The Cookie Crusher circuit is an electronic package that causes the prosthetic hand to open in response to muscle contraction and closes (as if crushing a cookie) when the muscle is relaxed. Both children were consistently good prosthetic wearers, beginning with their initial passive devices and progressing through their cable-operated books and bands. However, before they began to use the Cookie Crusher (Subject 1 at 25 months, Subject 2 at 30 months), neither had developed voluntary grasp or release in spite of 3 to 12 months' use of cable-operated voluntary opening prehensors. Both children developed a voluntary grasp and release for the first time within minutes of starting to use the Cookie Crusher. The more adept of the two children, a girl with a traumatic above-elbow amputation, showed prehensile function with the Cookie Crusher during play. The spontaneous use of the Cookie Crusher may be related to the predominance of associated reactions in young children. As children play bimanually, associated movements of the nondominant extremity often occur and, in the case of children with limb deficiencies fitted with Cookie Crusher prehensors, these associated reactions result in successful grasp and release. We will continue to follow the choice of effective control schemes in these children as they mature.

It is common practice in the United States to defer myoelectric fitting for a child with limb deficiency until the child has proved that he or she can operate a cable-driven prehensor. Thus a young child with limb deficiency will routinely experience several prehensor control schemes as he or she matures. Studies comparing rejection rates for children using myoelectric prehensors report widely varying rejection rates ranging from 10% to 40% (Glynn, Galway, Hunter, & Sauter, 1986; Hubbard, Bush, Kurtz, & Naumann, 1991; Kruger & Fishman, 1993). Factors influencing acceptance of myoelectric control schemes in children include parental support, weight of prehensor, age at first fitting of passive prehensor, cosmesis, absence of harness, comfort, age and developmental level at time of fitting with myoelectric control scheme, length of residual limb, maintenance demands, social acceptance correlation with better integration into body scheme, and stronger grip (Baron, Clarke, & Solomon, 1984; Berke & Nielsen, 1991; Brooks & Shaperman, 1965; Celikyol, 1987; Childress, 1973; Glynn et al., 1986; Kruger & Fishman, 1993; Scandlon & Galway, 1983; Sorbye, 1980; Trost, 1983; Weaver, Lange, & Vogts, 1988).

After recent technological advances in the circuitry of myoelectric devices, that is, the development of the
Cookie Crusher scheme (Williams, 1990), we fitted two 2-year-old children with limb deficiencies with this new device. In this paper, we report that these children were able to operate the Cookie Crusher control scheme intuitively, without needing a drill to learn how to open the cable-operated terminal device. Our findings suggest that this type of myoelectric device may be suitable as a first prehensor for young children with limb deficiency.

Study Purpose
Professionals working with upper extremity amputations and limb deficiencies must often assess the relative merits of two prehensor control schemes, the externally powered myoelectric control scheme and the cable-operated mechanical system. The Cookie Crusher circuit (Williams, 1990) is an externally powered myoelectric control scheme. It is an electronic package that causes the hand to open in response to muscle contraction and automatically closes (as if crushing a cookie) when the muscle is relaxed (see Figure 1). Our objective was to determine which prehensor control scheme was successful in providing voluntary grasp and release in 2-year-old children. The prehensor control scheme they are fitted with at this age is likely to be the precursor for their future prehensor control schemes. We compared the function of the single-site Cookie Crusher system with the function of cable-operated voluntary opening mechanical devices in two 2-year-old children.

Method
Subject 1 is a 2-year-old boy with a left below-elbow congenital limb deficiency. He was initially fitted with a passive hand prosthesis at the age of 6 months. Subject 2 is a 2-year-old girl with a left short above-elbow traumatic amputation. Her injury occurred at age 6 months.

During each amputee outpatient clinic and occupational therapy appointment, the occupational therapist evaluated the children’s ability to open and close his or her prehensor voluntarily during bimanual play. The occupational therapist also interviewed the parents regarding each child’s prehensor use at home.

Results
Subject 1 began to use his passive hand prosthesis to swipe at objects immediately after fitting. According to his parents, at age 7 months, Subject 1 reached out to another infant with his left prosthetic arm during play. His parents reported that he wore the prosthesis “most of the day”; when he was not wearing it, he pointed to it, indicating that he wanted to wear it. At age 12½ months he spontaneously used his passive hand to assist in bimanual tasks (i.e., grasping a ball).

Subject 1 was fitted with a cable-operated voluntary opening split hook at age 13 months (see Figure 2). He used the prosthesis as a postural support, a gross assist, and an extension of his arm for hitting or reaching for objects for 1 year. The occupational therapist trained his parents in a program to promote grasp-and-release skills with the split hook. Despite the parents’ effort to follow the therapy program, the child failed to gain an active grasp and release using the prosthesis. Although the child remained a full-time wearer of the prosthesis, he never learned to open the terminal device.

Subject 1 was fitted with a Cookie Crusher myoelectric prehensor at age 25 months and immediately became independent in voluntarily opening and closing its hand (Figure 3). He began calling the prehensor his “helper.” He used it to grasp wrapped food items that required coordinated package opening with his contralateral fingers.

The Cookie Crusher circuit is now available from several manufacturers (i.e., Steeper in Great Britain and VAST in Canada), some of whom have incorporated this feature into their hand circuits.

Figure 1. Cookie Crusher prehensor prosthetic components.

Figure 2. Subject 1 at clinic appointment being fitted with cable-operated voluntary opening prehensor.
Subject 2 came for her first clinic appointment at age 18 months, 1 year after her injury, and was fitted with a passive elbow and mitt. She immediately used the prosthesis during bilateral play activities. Her parents reported that, 1 month after she received it, she wore the prosthesis 5 to 6 hr per day and pointed to it when not wearing it to indicate that she wanted to put it on. She was fitted with a cable-operated voluntary opening hand and passive friction elbow at age 27 months (see Figure 4). She continued to be an excellent prosthetic wearer (i.e., she continued with a consistent wearing schedule and used the prosthesis as a gross assist), but did not learn to voluntarily open or close her hand.

She was issued a Cookie Crusher hand (see Figure 4) with passive elbow at age 30 months and began using it as a prehensor immediately (see Figure 5). She actively engaged its open and close functions spontaneously when playing (see Figures 5 and 6).

Discussion

Our impression is that the Cookie Crusher control scheme for grasp and release works better with young children than the mechanical, cable-operated voluntary hook and hand because the former uses automatic, uninhibited associated movements. For example, in Figures 5 and 6 the dominant hand is grasping; consequently, the contralateral upper extremity muscles contract and relax symmetrically, "crushing the cookie," that is, stabilizing the object. These associated movements, also referred to as overflow, present as involuntary movements in the resting extremity when the opposite extremity is performing a voluntary movement (Cohen, Taft, Mahadeviah, & Birch, 1967). There is an increase in neuronal inhibitory activity as the central nervous system matures, resulting in a significant decline in the frequency of
overflow movement (Ashton, 1973; Cohen et al., 1967; Dejong & Haerer, 1990; Fog & Fog, 1963; Grant, Boelsche, & Zin, 1973). By the age of 9 years, associated movements are minimal and generally present only during situations that stress the central nervous system. If overflow does occur, one can consciously inhibit the movements (Cohen et al., 1967).

When a normally developing 2-year-old child engages in bimanual play activities, associated movements of the nondominant extremity often are observed. Associated or overflow movements were evident in the two subjects during play. For Subject 1, the single-site electrode was over his wrist extensors. When he contracted his dominant wrist extensor, both hands opened. When his dominant hand closed, thus relaxing his dominant wrist extensor, both hands closed (see Figure 3).

For Subject 2, the single-site electrode was over the elbow flexors. In a response similar to that of Subject 1, when Subject 2 raised her arms to hold an item and contracted her elbow flexors, both hands opened. Likewise, her prehensor closed symmetrically as she relaxed her dominant elbow flexors and her contralateral elbow flexors relaxed by associated reaction (see Figures 5 and 6).

We hypothesize that both subjects have successful voluntary grasp and release when using the Cookie Crusher due to their associated movements. Although cause and effect schemas develop between 7 and 9 months of age, we propose that the cause and effect relationship involved in operating a cable-operated voluntary opening prehensor is difficult for a 2-year-old to appreciate. Perhaps the 2-year-old is unable to relate the cause of flexing one's shoulder with the effect of the prosthetic hand or hook opening and closing. Both subjects were unsuccessful in prehensor opening using the cable-operated devices because the shoulder flexion movement involved in prehensor opening is not inherent in the normal grasping pattern. The cause and effect relationship used by the Cookie Crusher is intuitive because it is reinforced by a 2-year-old's associated movements. A child is intuitively able to open and close his or her prehensor and therefore comes better prepared to learn functional use from the therapist. We will continue to follow the choice of effective control schemes in these children as they mature.

The disadvantages of the Cookie Crusher are its expense and the scarcity of professionals able to fit it and provide training. Its cost is almost four times that of the cable-operated prosthesis. In addition, the child who wears this myoelectric hand requires specialized technological support for repairs and readjustments, as needed. Both subjects, however, clearly demonstrated the value of the Cookie Crusher over that of the cable-operated voluntary opening mechanical device by their ability to use the former functionally during play. Cosmesis also played an important role in parent satisfaction and may have influenced their encouragement of prosthetic wearing time and functional use. In addition, each child's and parent's satisfaction with immediate prosthetic prehensile use contrasted with their dissatisfaction or negative experience with the cable-operated unit.

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References


