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SPECIAL SECTION

Habilitating a Smile

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The treatment of muscle dysfunction in the muscles around the face is particularly challenging. In addition to being the most observable muscles in the body, the limited area with which to work, the high firing rate, and the increased risk of picking up crosstalk from muscles in close proximity all add to the challenge. This case report describes the treatment of a young child with seventh cranial nerve palsy of the face.

Introduction

Surface electromyography (SEMG) noninvasively records motor unit action potentials. In muscle physiology, an action potential is a short event, in which an electrical charge builds up in the cell membrane of a motor neuron and then is discharged. These action potentials are given off by the motor units during muscle recruitment (Basmajian, 1974). The ability to "read" muscle activity via sensors on the skin (as opposed to needle electromyography) opens up many possibilities for muscle rehabilitation. In this essay the treatment of a four-year-old boy with seventh cranial nerve palsy sustained at birth is explored.

Seventh Cranial Nerve Palsy

The facial nerve (cranial nerve seven) sustains impairment more often than any other nerve in the body (Graham, 1974). It originates at the brain stem and travels through the internal auditory canal, fallopian canal, and parotid gland. Often neurology text books state that rehabilitation for idiopathic facial paralysis is not necessary (Samuels & Feske, 1996), due to the high percentage of patients (upwards of 70%) who recover naturally (Peitersen, 2002). When paralysis during pregnancy is factored in, the rate of recovery drops to 61%. Typically, if spontaneous recovery has not occurred within 6 months of onset for paralysis due to injury, virus, or neurologic disorders, the outcome is poor (Cronin & Steenerson, 2003). One of the most vexing problems in this disorder is the frequent occurrence of "synkinesis" or the firing of nearby muscles when the target muscle is recruited. For example, during smiling, the eye will close. In addition, paralysis of the seventh cranial nerve affects oral competence, taste, and protection of the cornea (Evans, Licameli, Brietzke, Whittemore, & Kenna, 2005).

A Brief Historical Context

Evidence for the efficacy of SEMG biofeedback in treating facial nerve impairments has been reported by several authors. Brown, Nahai, Wolf, and Basmajian (1978) successfully used SEMG to treat an eight-year-old female with seventh nerve damage sustained during surgery and a 29-year-old female with cranial nerve damage as a result of an acoustic neuroma resection. Toffola et al. (2005) found that SEMG produced a better quality of recovery from the paralysis of Bell's palsy in comparison with kinesiotherapy. (Kinesiotherapy uses systematically prescribed exercise to restore strength, mobility, and endurance to damaged muscles.) In treating 24 patients with facial nerve paralysis, Cronin and Steenerson (2003) found that SEMG was particularly helpful by giving immediate feedback to the patient as well as inhibiting synkinesis.

The Case of John: Reservations, Reservations

Clearly the literature indicates that SEMG can be helpful in remediating the motor dysfunction of seventh cranial nerve palsy, but John's case might cause one to pause a bit. First, the child at time of treatment is four years and six months of age. Being a normal, healthy four-year old, he is very active. Even the best behaved four-year-olds have an attention span of about 5 minutes, after which they are on to something else. Second, targeting an SEMG site on the body (as compared to a limb) is always more difficult because the patient does not have the context of a limb moving in space. Of course, a mirror can be used, but it is not quite the same as volitionally causing (and seeing) a limb move. Third, the child is a male. Males naturally lag behind females in maturity at this age. Fourth, the facial muscles naturally have a higher frequency component than other muscles. This high frequency activity is needed to maintain the fine contours of the face. With facial muscles a relatively large proportion of the true SEMG signal will be filtered out if the high pass filter frequency is set too high, since a high pass filter eliminates frequencies below the range it is set at (Boxtel, 2001). Fifth, again related to age, is the yet-to-be-developed social motivation to change. A child of four is not yet overly concerned about his or her appearance. Last, the title of this article is "habilitating" rather than "re-habilitating." The patient never developed a motor plan for smiling, so there was nothing to "rehabilitate" or recover. These reservations notwithstanding, we decided to forge ahead and try to reverse some of the effects of John's birth injury.

John's History

John was born by "C" section at 34 weeks. His mother noticed poor suck shortly after birth. When he turned age four he was referred to occupational therapy due to lack of chewing on the left side. John had obvious facial "droop" on the left side. Developmentally he was on target for his age, aside from a slight hearing loss on his left side. Occupational therapy (OT) consulted this clinician, because in traditional OT, it is difficult to come up with exercises for a child this age that would effectively target the facial droop.

Development of a Treatment Plan

John could produce a smile, but it was evident that co-contraction of other facial muscles was occurring (synkinesis). He would smile, but, at the same time, draw the edges of his lips back. The SEMG biofeedback thresholds were set on the following target muscles for treatment of John's smiling deficits: The zygomaticus (which produces retraction/elevation of the lips and smiling) was set to be rewarded at/above threshold. The buccinator (which produces retraction of the cheek toward the mandible) was set at/below threshold. The masseter was set to be monitored only. The buccinator and masseter were included in this treatment protocol to reduce the tendency for the reward to be triggered by activity other than a smile. Custom-made electrodes (MultiBio Sensors, El Paso, TX) about one-half millimeter in diameter were necessary because of the very small surface area available on the face of a child this age.

Basic Treatment Setup

John was seen for 14 1-hour weekly sessions. This clinician, the occupational therapist, and his mother were present for all sessions. John sat on a bench in front of a video monitor (to display the video reward when activated) with the SEMG monitor to his left at desk height. The program was set to reward the target constellation of muscle activity as described above, so that all criteria had to be met to achieve the video reward (zygomaticus "on," and buccinators "off"). This "go/no go" decision tree was constructed around what was deemed an appropriate smile. As long as the smile met these criteria, a "go" situation resulted in the playing of a digital video disc. Failure to maintain the "go" criteria resulted in "no go," at which time the video and audio would stop. Recovering the correct muscle pattern (a "good" smile) reactivated the video. A suitable objective occupational therapy measure of a "good smile" at this age does not exist, so we were left to document his progress by still and video pictures taken at every treatment session.

Maintaining the attention of a four-year-old on such a tedious task for one full hour was a huge challenge. We settled on a schedule of 2 minutes of work followed by 1 minute of play with a toy chosen by John. Even with such a plan, all three adults present had to be "active entertainers" every minute of the session. A four-year-old child is naturally inquisitive, and sitting on a bench practicing the correct smile is not high on the list of fun activities for this age!

Treatment Narrative

John's mother related that she was also concerned about John's inability to adequately close the left eye. She was concerned as well about how tired John became during the "smile treatment." It was explained to his mother that combining two motor tasks in the same session is not a good idea, but we could try it once. We alternated tasks for one session only, as John became confused about what we were asking him to do. The unsolicited comments about John's improved smile from his grandmother and his teacher were worth their weight in gold. Such comments affirmed that the learning taking place in the lab was transferring to John's life. There was some discussion on 4/13 as to whether we could increase the height of the smile on the left side to be more in line with the right side of his mouth. After some discussion, we agreed that the best plan would be to focus on endurance of his improved smile. Very often, a patient has difficulty re-finding the target motor movement after an interference task, so in addition to rest between training periods, the 1-minute break periods served as an interference task, providing an additional challenge to John's training. They allowed John to stand, walk, get on the floor, etc., rather than sit and maintain the same body position, before requiring him to refocus on training again. The decision to terminate treatment on 11/3 had many facets. Patients can become "overdone." Once a task is mastered, the continued use of a treatment plan can actually erode the progress attained, especially with children. The danger, then, is that the newly found motor skill can become aversive as a result of boredom.

Treatment Results

Figure 1 shows the longest consecutive (no breaks in the video reward) time for each treatment session. The stepwise progression is actually better than the typical profile in that peaks and valleys are usually more prominent. He improved from 11.2 seconds to 66.5 in 8 weeks. Figure 2 shows the percent success increasing from 42% to 84% in 8 weeks. Figures 3 and 4 show the smile before and after treatment. Figure 3 is the best smile he could produce at that time.

Closing Observations

Case studies by design are statistically weak in that one cannot be sure that the improvements that have occurred are not simply the result of the usual process of growth, especially in young patients. In this case, no appreciable improvement in John's birth injury had been observed in the ensuing 4 years. At the time the child was diagnosed, the attending physician stated categorically that improvement would not occur.

There were no measures of the quality of the smile of a child this age that could be used as an objective before/after measure. In this case, unsolicited observations of an improved smile by family members and teachers, who were unaware of this treatment, were as close to an objective measure of success as one could get. Perhaps the most beneficial aspect of this treatment was that sufficient learning occurred in the lab to enable the mother to help

Table. Percent success for a given treatment (tx) session; LTO: longest consecutive time within threshold goals without interruption

Date	Percent success	LTO (seconds)	Notes
2/14	n.a.	n.a.	Develop tx plan, zygomaticus uV = 54, buccinator increases with fatigue.
3/16	42%	11.2	Added eye closure (orbicularis), John able to use smile to activate/deactivate video on command.
3/23	64%	25.7	Alternate reward activation using smile as trigger for one half session, eye closure second half.
3/30	52%	1.4	Grand mother (unaware of tx) commented smile is more symmetrical, John more resistant to tx on this date.
4/6	67%	47.2	Visual improvements can easily be seen in smile, zygomaticus uv = 120.
4/13	56%	41	Decision made to increase endurance but not increase "quality" of smile.
4/27	62%	30	Continue with tx plan.
5/4	64%	43.1	Elevation of chin observed with increased fatigue.
5/11	84%	66.5	Arrived at session, sat on bench, smiled with no verbal prompts needed, 1st time he had done so!
6/15	79%	59	Teacher (unaware of his tx) commented on John's improved smile; John commented "It's not coming on cause I'm not smiling"; mother reported that a physician had commented early on that "His smile will never improve."
6/22	n.a.		Child ill.
8/24	66%	43	Initiated smile immediately upon sitting on bench; suffering from jet lag d/t vacation.
10/6	90%	70	Mother concerned about ending tx, though John has maintained progress over the six week break.

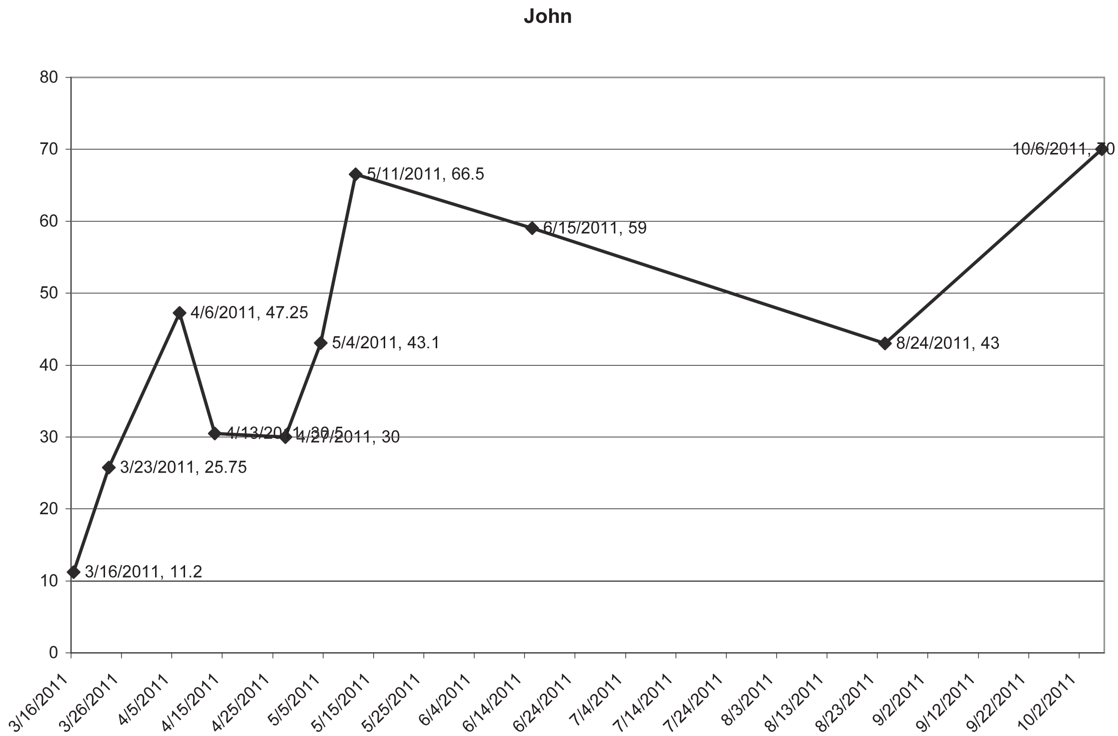

Figure 1. Longest consecutive time video reward on each treatment date.

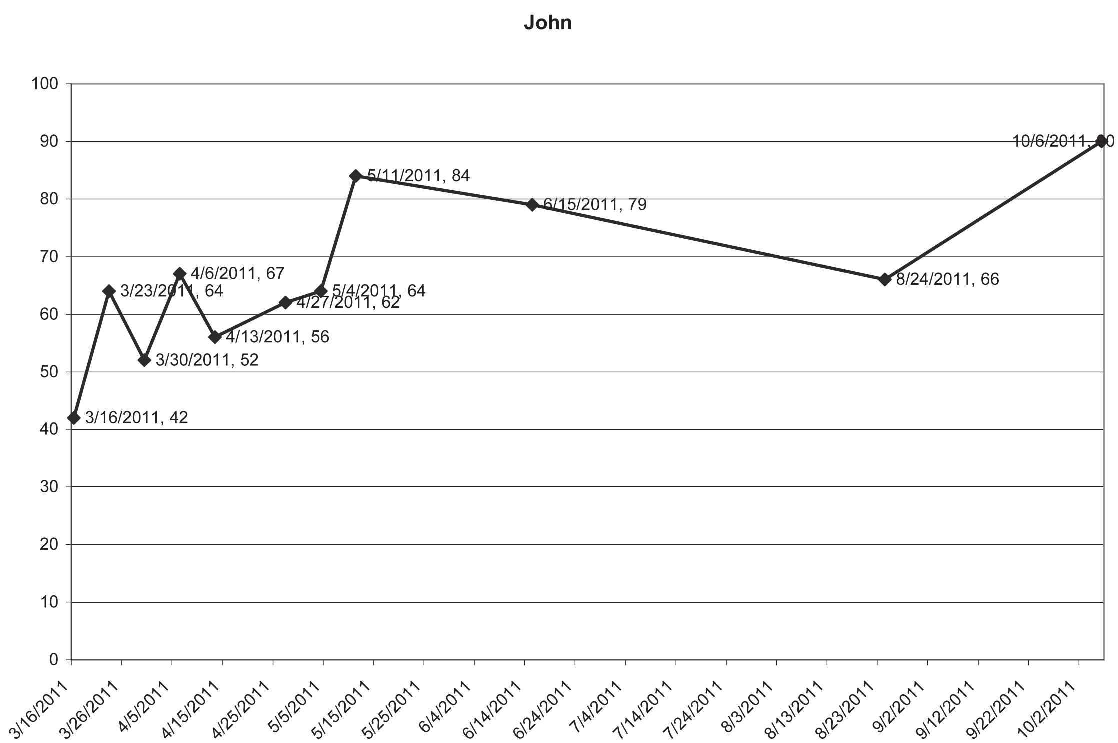

Figure 2. Percent success by treatment date.

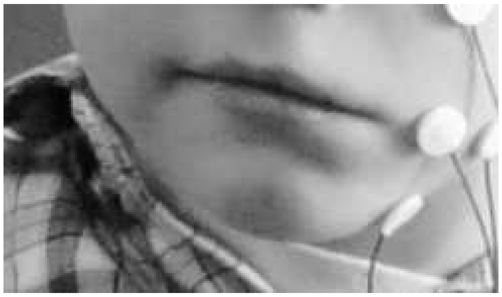

Figure 3. Before treatment.

John "practice" his smile outside of the treatment sessions. As early as the second treatment session, the prompt "do good smiling" was used to trigger the production of a smile, which, if of sufficient quality, triggered the video onset. The treatment described here is a combination of bricks (learning theory principles) and mortar (the artistic application of same). At what point does one turn off the monitor display of the SEMG readings so the patient must perform by "feel"? If done too soon it leads to frustration; if the display is continued too long it leads to dependence on an external cue. At what point is the patient asked to do a mental stressor (such as adding by 7's) while performing the motor task? If done too soon frustration results; if not done at some point, the patient is ill prepared to use the new skill in the real world. There is a moment-by-moment evaluation of where the patient is in mastery of the skills during each session.

Unfortunately the science of motor control has been, and still is, neglected by psychology (Bolek, 2008; Rosenbaum, 2005). This is unfortunate because there is much potential in the technique to rehabilitate those who have sustained a life-altering injury.

Figure 4. After treatment.

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