Single-switch control versus powered wheelchair for training cause-effect relationships: case studies

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Objectives. Traditional habilitation recommends the use of single switch control and simple computer games as pre-training of cause-effect relationships and joystick control before training in use of a powered wheelchair. Findings from studies of individuals at an early developmental level driving a powered wheelchair suggest it may be more effective to reverse order.

Methods. We studied the outcome of powered wheelchair activity in context (self-directed locomotion). Participants included 40 disabled individuals and 17 typically developed infants functioning at an early developmental level. The activity in the wheelchair was paralleled with the use of single switch controls connected both to toys and to a computer with simple "press-action" software.

Results. The cognitive understanding of the simple cause-effect (use of joystick causes the effect of motion of the wheelchair) developed earlier than the understanding (press on single switch causes activation of toy or apparatus).

Conclusion. The recommendation to use single switch controls as pre-training for driving a powered wheelchair corresponds with individuals with quite good cognitive function but not with individuals who function at an early developmental level. For individuals with severe or profound mental retardation the possibilities to understand cause-effect relationships are found in tools that affect all their senses, their whole body. A powered wheelchair is such a tool. When the individual activates the joystick, the wheelchair moves, affecting all senses and the individual's position in space. This event provides arousal, interest and motivation to further manipulate and explore the cause of the effect.

Keywords: Cause-effect relationships, powered wheelchair, single switch control, early developmental level, mental retardation, visual impairment

Individuals functioning at an early developmental level normally do not drive powered wheelchairs. Very young individuals (infants and toddlers) with physical disability are first trained to crawl, stand up and walk. They are then trained in walkers and manual wheelchairs. They may or may not be trained in use of a powered vehicle. Children, adolescents and adults with severe or profound mental retardation functioning at an early developmental level rarely get access to training in a powered wheelchair. They are thought to be incapable of learning goal-directed driving within a reasonable period of time. Individuals at an early developmental level may be recommended to use a powered wheelchair with line follower [7]. To control a powered vehicle requires several types of cognitive function: attention, decision making, problem solving, language (e.g. concepts) and memory [1].

In traditional habilitation pre-training, single switch controlled toys is recommended to enhance cause-effect understanding before the children are introduced to a powered wheelchair [7]. Single-switches are low-cost, portable, and easy to adapt to different toys or apparatus. They have been shown to be very useful for training in the understanding of simple cause-effect relationships. Specially designed computer games with joystick control are recommended so that the individuals can practice with a joystick before initiating use of a powered wheelchair. This enhances the understanding of steering, enhancing safety for the user and others [1].

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1. Studies on individuals at an early developmental level driving powered wheelchairs

In 1993 we initiated studies of individuals at an early developmental level driving a powered wheelchair [2, 6]. The individuals in these studies began training at ages ranging from 1 to 50 years. Forty individuals with varying combinations of impairment functioning at an early developmental level were studied. Furthermore, 17 typically developed infants aged 3–12 months were studied while driving a powered wheelchair [3]. Driving sessions were documented using videotape, observation protocols, and from in depth interviews with parents and caregivers.

In the initial phase of the first study of two preschoolers the benefit from pre-training with single switch controlled toys was uncertain. The method was tested with positive findings so we added trials with single switch controls to the study design.

2. Results from testing two preschoolers with single switch control

The first two individuals studied, a girl aged five and a boy aged four, did not show interest in using or exploring single switch controls. We assumed they did not understand the meaning of the use of the device. Both preschoolers had severe physical disabilities, severe vision impairment and severe/profound mental retardation. After 3 months of training with a powered wheelchair a test was performed with single switch controls. The switches were connected to toys which produced both sound and motion when activated. The girl showed an obvious interest for exploring and using the control but the boy did not. When driving the powered wheelchair the girl was aware that the joystick caused the motion of the chair, and she explored the regulation of speed and steering. Three months of training had given her the experience of using a cause and effect tool. This enhanced her interest in exploring and using the single switch controlled toy. The boy was in a stage of unconscious manipulating, his actions showed that he did not quite understand how to cause the motion of the chair. If by accident he caused the chair to move he could freeze to keep it going. But when it stopped he did not immediately repeat the successful act on the joystick. It took the boy about two more years of training with the powered wheelchair before he showed a similar interest in active exploration of single switch controlled toys and apparatus.

3. Results from parallel training with powered wheelchair and single switch controls

A girl aged one year and ten months was simultaneously trained in powered wheelchair use and single switch control of toys and simple computer software. After seven months of training, with sessions less than once a week, she was able to drive the powered wheelchair. Her precision was not good but she understood speed, direction and steering. At about the same time she developed an understanding of use of the single switch controlled toys. When she simultaneously was pressing the switch and looking at the toy, it was interpreted as a conscious use of the switch to activate the toy. She also showed an interest in the connection between switch and toy. Part of her exploration included disconnecting and connecting the electric cables, finding out when it was possible to activate the toy. At age 3.5 years she was able to drive the powered wheelchair goal-directed, safely, and with precision in adjusting the speed. She was able to steer to or around stationary and mobile obstacles in the environment. At this age she also was introduced to a simple mouse controlled software. Prior to this time she had been trained with “press-action” type single switch controlled software. Since she understood the navigation of the wheelchair, it was thought that she would easily understand the navigation of the pointer on the screen. However, this was not the case. It took another year before she understood the connection between her action with the mouse control and the pointer’s motion on the screen. Though she understood the connection she did not have the precision and ability to coordinate the pointer to medium or small sized objects on the screen. This finding was surprising as her navigation skills with the powered wheelchair were very good. Navigation with the joystick for the powered wheelchair is a less abstract activity than navigating the pointer at the computer screen with a mouse control.

During the subsequent studies on more individuals at an early developmental level similar results were found. From 40 disabled participants 9 learned how to drive goal-directed. Only 2 of these 9 learned how to use a pointer at a computer screen. They did not use the pointer with precision and could only master simple software for training pointer-use. Fourteen of the 40 showed an interest in exploration of single switch controlled toys and apparatus. Only 5 from these 14 could press the switch and wait for the effect before they pressed the switch again.

Typical infants at the age 3 to 4 months explored the use of the joy-stick in the powered wheelchair. At age 7 to 8 months they showed an understanding of how to drive the wheelchair. They looked at desired destinations and tried to drive there, though, not always successfully. At this age they also showed an active interest in exploring single switch controlled toys and "press-action" computer software. None of the infants aged 3 to 12 months showed any interest or understanding of the use of pointer devices for computer [5].

These results suggest that the cognitive understanding of simple cause-effect (use of joystick causes the effect of motion of the wheelchair) develops earlier than the understanding (press on single switch causes activation of toy or apparatus). Less cognitive ability is needed to drive a powered wheelchair in a goal-directed manner than to use devices such as mouse, track-ball or joystick for computer control [4].

4. Discussion on training with single switch controls versus powered wheelchair

When using a single switch to control a toy or an apparatus, the caused effect often appears at a short distance (a press here, makes something happen there), and the effect of the tool does not affect all the body senses. Most often the caused effect only gives visual and auditory sensations, but sometimes vibration also can be included in the effect. The use of larger apparatus such as a powered wheelchair, where a press on a switch causes vestibular, kinesthetic, visual and auditory sensations, is expensive and rarely used. Often the same type of apparatus or toys connected to a single switch are also being used when the individual does not control the devices. These factors make it difficult for an individual functioning at an early developmental level to understand that he or she can influence and control things by pressing on a single switch control [9]. The longer the distance from the caused effect, the fewer senses activated. The more abstract function a tool has, the more difficult for the individual to understand the cause-effect relationship.

When using a powered wheelchair with a joystick mounted in the middle of a transparent tray placed in front of the driver, the caused effect includes both the driver and the tool. It also engages all body senses. Most often an inexperienced user of a powered wheelchair makes the chair go round in circles as he or she activates the joystick, the circling being explained by the lack of knowledge in how to steer the vehicle. The activity provides visual and auditory sensations, kinesthetic and vestibular sensations, and from this total bodily experience arises alertness. The joystick is placed in front of the driver rather close to the body making it easy to touch or hit the joystick accidentally. When the caused effect engages the whole body and changes the position in space, the individual is stimulated to repeat the activity. The accidental activity slowly grows more conscious, leading to active manipulation of the joystick to cause the effect, motion. What happens in the wheelchair happens with no one nearby and this effect does not occur other times. If an individual is transported in a wheelchair the caregiver normally propels the chair in a smooth, safe manner – not in circles. These factors make driving a powered wheelchair very useful in enhancing the understanding of simple cause-effect relations for individuals at an early developmental level. The closer the effect, the more senses are activated. The more concrete function a tool has, the easier it is to understand the cause-effect relationship.

5. Need for a simple powered wheelchair for training

A modern powered wheelchair is usually equipped with many technical facilities to make it easy to drive and easy to configure a special driving program for each individual. It is expected that the user has the basic cognitive capacity to develop goal-directed driving. Also special projects on powered mobility for severely disabled such as "Learning through smart wheelchairs" emphasizes the significance of using facilities such as bump tools, motion tools, different user tools (other than analog joystick) and line follower [7]. Some of the facilities make the function of the chair less predictable. Recognizing key relationships among events is an essential component of the ability to adapt behavior to such a novel experience as driving a powered wheelchair [10]. The more predictable the function of the tool, the easier it is to learn [8]. The basic principles for driving with a joystick must be learned first. Then, with growing consciousness, the special regulations may be understandable.

6. Conclusion

These case studies suggest that to promote understanding of simple cause-effect relationships for indi-

viduals functioning at an early developmental level, it may be more effective to have the individual drive a powered wheelchair, than to operate switch controlled toys or apparatus. The results also suggest that computer games for joystick control may not be as effective for individuals at an early developmental level.

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