DRIVING TO LEARN: A NEW INTERVENTION FOR PEOPLE WITH STROKE AND SPATIAL NEGLECT

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ABSTRACT

This paper describes a pilot study aimed at exploring the effects of using the *Driving to Learn* method in the sub-acute phase after stroke with spatial neglect. Five participants, aged 40-82 years, 10 days to 10 months post stroke with right hemisphere lesions and spatial neglect, did one test trial in a TIRO, a special powered wheelchair for people with cognitive disabilities. The trials applied principles for practice that were found to be appropriate for people with stroke and spatial neglect during the *Driving to Learn* project. All five participants obtained remarkably increased levels of alertness and ability to sustain attention during the trial. In three of them the observable signs of spatial neglect in forward navigation tasks had disappeared after a trial of 40 to 60 minutes.

BACKGROUND

Even though there is research pointing out the benefits of powered mobility for people with stroke, very few of them are provided with a powered wheelchair on discharge from rehabilitation centres (Mountain et al, 2010a & 2010b). Provision of powered mobility devices is directed by considerations about how limitations in perception, cognition, visual attention, and executive function may influence the ability to operate a powered wheelchair securely and skilfully (Turton et al, 2009; Mountain et al, 2010b). However, clinical guidelines give no clear recommendations on the choice of interventions (Ting et al, 2011). In stroke rehabilitation it is well known that the persistence of spatial neglect and cognitive impairment is a negative indicator for recovery (Parton & Husain, 2004; Cumming et al, 2009; Ting et al, 2011).

During a previous project named *Driving to Learn*, a special powered wheelchair was developed which had characteristics appropriate for users with cognitive limitations and attention deficits, and it was equipped with a 'one-for-all' seating unit that could quickly be adjusted from child to adult size without using any hand tools (Nilsson & Eklund, 2006). The project studied what could be achieved if children and adults with profound cognitive disabilities got the opportunity to practice in a powered wheelchair (Nilsson & Nyberg, 2003; Nilsson, 2007). In addition to the target group of 45 participants with profound cognitive disabilities, two reference groups – one with 17 typically developing infants and another with 64 participants with other degrees of cognitive disabilities – were engaged for comparison of indicators of achievements (Nilsson et al, 2011). During the project, it was observed that in three participants with stroke and spatial neglect (two men and a woman, aged 63 to 86 years) who were included in the latter reference group, their neglect symptoms faded away in just a few sessions. These promising findings initiated the pilot study described in this paper.

AIM OF STUDY

The aim of this pilot study was to explore the effects of using the method *Driving to Learn* in a special powered wheelchair in the sub-acute phase after stroke with spatial neglect.

LITERATURE REVIEW

SPATIAL NEGLECT

The term spatial neglect is interchangeably used with visual neglect, hemispatial neglect, unilateral neglect, and visual inattention, and it is characterised by a failure to report, orient to, or respond to events in the contralesional hemispace (Ting et al, 2011; Cumming et al, 2009). Right hemisphere lesions more often lead to severe and enduring neglect than lesions in the left hemisphere (Parton et al, 2004). Many patients with stroke are unaware of their spatial neglect and are thus not able to consciously modify their behaviour by turning their gaze towards the neglected hemispace (Parton et al, 2004; Ting et al, 2011).

INTERVENTIONS
Existing interventions aim to utilise remaining brain function (compensation), adaptation or environmental modification (substitution), or retraining of the brain function (restitution) (Ting et al, 2011). Trials with prism adaptation and virtual reality have been promising but are not yet recommended interventions for clinical practice (Parton et al, 2004; Ting et al, 2011).

NEUROPLASTICITY
The adult brain has the ability to reorganize and reconstruct after an injury (Kolb & Campbell Teskey, 2010; Ting et al, 2011). Complex environments and experiences can affect the synaptic organisation in the brain, and the modification of the neural networks underlying behaviours is reflected by changes in spine density and dendritic length; when there are indications of learning, there must have been a change in the neural networks responsible for the learning; conversely, for behaviour to change there must be a neurological change (Kolb & Campbell Teskey, 2010). However, the difference, and therefore the challenge, in rehabilitation of an adult with brain injury compared to a child is to modify neural networks already shaped and stable after a lifetime of experiences. The adult brain also has some natural system preventing neural generation, as new cells would disrupt the experienced neural network underlying perception, memory, and behaviour (Kolb & Campbell Teskey, 2010).

ATTENTIONAL NETWORKS
Attentional processes like orienting, alerting, and executive control interact in the preparation of quick and accurate responses to incoming information by selecting relevant, and ignoring irrelevant, stimuli (Chica et al, 2012). Visual attention is controlled by both cognition(top-down factors such as knowledge, expectations, and goals) and bottom-up factors reflecting sensory stimulation. Patients with spatial neglect have deficits in searching, detecting, and reorienting (shifting attention) to behaviourally relevant stimuli outside the focus of actual processing, rather than in top-down goal-directed orienting (Corbetta and Shulman, 2002; Posner, 2012). There are studies showing that persistence of neglect is predicted by the degree of impairment of sustained attention, and that alertness training can improve spatial deficits (Parton et al, 2004; Chica et al, 2012).

Fig 1. Gällivare Hospital

SPATIAL NEGLECT AND LEARNING POWERED WHEELCHAIR USE
It is a well-known phenomenon that people with spatial neglect veer to one side when driving a wheelchair; there is less known about how to intervene to reduce this consequence of the neglect (Turton, 2009). A study by Mountain et al (2010) found that many people with stroke, also with spatial neglect, could learn to operate powered wheelchairs in a safe and skilled manner. All 10 participants in their study made improvements within only 2.5 hours of appropriate training.

METHODS
The pilot study was the first part of an implementation study of the new intervention, *Driving to Learn*, carried out at a unit with medical and stroke rehabilitation facilities at Gällivare Hospital (Fig. 1) in the northern part of Sweden. In agreement with the occupational therapists at the unit, a convenience sample was recruited for the pilot trials. The five engaged participants, aged from 40 to 82 years, had their stroke 10 days, 21 days, 2 months, 2.5 months, and 10 months before their trial in a powered wheelchair, and they all had a right-sided hemispheric lesion.

POWERED WHEELCHAIR
TIRO (Fig. 2), the powered wheelchair specially designed for practice with people with cognitive disabilities (Permobil, leaflet), was used for the trials. It has a 'one-for-all' seating unit which can be easily adapted to people of different sizes. The joystick is mounted in the middle of a Plexiglas tray mounted on the armrests; this placement not only allows for both right- and left-hand operation, it also means that the operating tool is in the midline of the visual field. The seating unit provides a stable upright working position with the tray supporting both forearms, which impacts on trunk, neck, and head stability. The electronics are specially programmed to provide immediate response and to make it possible to drive

Fig 2. TIRO

very slowly with low torque, allowing safer collisions. The chair is also equipped with a mechanical bumper to protect legs and feet, and the environment.

PRACTICE OF DRIVING TO LEARN

Initially each participant had time to relate to the trial leader (LN) and to recognise and test the functions of the powered wheelchair. This took place in a large combined kitchen and living room (Fig. 3), with space to explore what happened when the joystick was pulled or pushed in different directions. A test of driving into things at the lowest speed was made to reduce anxiety and get the bodily experience of a collision. Testing also included driving a couple of decimetres forward or backward and stopping on instruction.

After the introduction the participants were observed when driving a route around the ward, navigating straight along corridors, passing doorways, being distracted by noise and unexpected events, meeting people, making turns to the left and to the right. Based on interpretation of the observations, an individually adapted practice followed for each of the participants.

MAIN PRINCIPLES FOR PRACTICE:

- Start at low speed and increase speed in agreement with the participant; or ask what speed the participant wants for a specific task.
- Begin with tasks at a simple level and go to increasingly more complex task levels.
- Regularly shift between forward and backward driving, leftward-rightward turning, and clockwise/counter-clockwise circling.
- Allow veering, collisions, and other low-risk incidents, but stop the driving immediately at an incident and start a dialogue, giving feedback to facilitate the participant's reflection about what took place by asking questions like: "What happened?" "Why did it happen?" "How can you avoid it happening again?"
- After every dialogue, agree on which speed and level of complexity to go on with; or give time for a short stand-still in the powered wheelchair before proceeding with practice; or set the speed lower and select a simpler task.
- Adjust speed and tasks to provide the 'just-right' challenge for the participant.
- Encourage the participant to present own ideas on appropriate, more fun, or more difficult tasks, if possible building the session up using collaboration and dialogue.

EXAMPLES OF TASKS

- Shifting between driving forward and driving backward, for longer distances in a corridor.
- Driving around corridor corners towards the left and towards the right; and through doorways.
- Driving in a circle round a big rectangular table in the kitchen with plenty of space around it; or navigating in a circle round a billiard table in a training room with little space around it, making the navigation more difficult.

An example of increasing the level of complexity with particular regard to spatial neglect:

1. Driving forward in circles clockwise, with the table to the participant's right, in the ipsilesional visual field.
2. Driving forward in circles counter-clockwise, with the table to the participant's left, in the contralesional visual field.
3. Driving backward counter-clockwise, with the table to the right in the direction of movement (in the ipsilesional visual field).
4. Driving backward clockwise, with the table to the left in the direction of movement (in the contralesional visual field).

Fig. 3 Relating and testing area

MEASUREMENT AND FIELD NOTES

The instrument for assessment of the process of learning joystick use developed during the *Driving to Learn* project (Nilsson et al, 2011) was used during this pilot project to measure powered wheelchair use at the start and end of a session. This instrument assesses eight phases of learning in each of the following eight categories: activity form, behaviour and activity, hand and arm movement, consciousness of joystick use, alertness, motive, driving style, and expression. To illustrate, the phases of learning in the category of driving style are:
1. Guided or accidental; 2. Keep on driving after release of guidance; 3. Self-initiated voluntary; 4. Intentional, intended, destined; 5. Experimental, explorative; 6. Goal-directed but unskilled; 7. Mastery of steering; and 8. Secure, skilled navigation.

Each trial was observed by two or more occupational or physical therapists acquainted with the participant, and field notes were taken on their commentaries regarding actual performance compared to previous treatment and recovery of spatial neglect.

RESULTS/FINDINGS

A general finding of the trials was that all five participants showed a remarkably increased alertness and ability to sustain attention compared to what they revealed in other interventions and activities.

Three participants (21 days, 2 months, and 10 months post stroke, aged 40 to 72 years) in 40 to 60 minutes stopped veering to the left while driving forwards in a corridor; managed taking both right and left turns without coming too close to the corner; took a centred position while driving through doorways; and managed to drive around a rectangular table both clockwise and counter-clockwise without colliding with the furniture. Measurement at start of the session: 4-5; at end: 6-7; alertness and attention increased rapidly but fluctuated with tasks' level of complexity; initially stops were needed to re-establish sustained attention but, at the end, attention had become more stable.

One participant (10 days post a second stroke, aged 80 years) in 60 minutes went from not being able to cooperate in transfer, not interacting and keeping eyes shut, not understanding the function of the joystick, to becoming alert, cooperative, responding to communication, and driving the powered wheelchair forward around a table. Measurement at start of session: 2; at end: 5-6. Alertness and attention increased continually over the session.

One participant (2.5 months post stroke, aged 82 years) had a most severe spatial neglect with additional sensory and cognitive deficits, and at rest held his head stiffly turned to the right. In 30 minutes he went from being uncooperative and not understanding the function of the joystick to trying to make the wheelchair move in a forward direction in the corridor, holding his head in a straight/forward position. However, he did not turn his head across the mid-line more than twice; this was during a dialogue after colliding into the left wall of a corridor. Measurement at start of session: 2; at end: 3-4. Alertness rose markedly but he got tired quite quickly.

It was noted that all the occupational and physical therapists commented in the field notes that the participants had not showed this level of alertness and attention in any other activity.

DISCUSSION

The findings from this pilot study are encouraging, as three out of five participants in one trial of 40 to 60 minutes made a shift from neglecting information from the contralesional hemispace to increased attention to both visual fields. This indicates that the new intervention, *Driving to Learn*, might be beneficial for people with stroke and spatial neglect.

Explanations for the positive findings may be related to the nature of powered wheelchair use, which is 'multitasking in motion' - it is an activity that requires alertness and sustained attention, activates sensory-motor functions, and involves mobility in interaction with objects, people, and environment. Therefore the intervention involved factors affecting synaptic organisation such as complex environments, sensory and motor experience, task learning, and play (Kolb and Campbell Teskey, 2010). Also, the use of specific tasks targeting the visual attention deficit and instant dialogic feedback to signs of neglect may have enhanced the outcome.

The intervention generally started at a simple, undemanding level of powered mobility use at low speed, and increasingly moved to more complex, demanding levels at higher speed. At every moment of a session, the level of demand was adapted to user reactions and performance. The intervention was also characterised by frequent shifts between speed setting, directions, turns and tasks. Shifting in between task sets is effortful and demands attention (Corbetta and Shulman, 2002). Thus speed and the performance of tool use in an increasingly complex environment may have influence on the increased ability to sustain attention but also to shift focus of attention. The safe collisions (which are an important bottom-up influence) and the instant dialogic feedback (which is an important top-down influence) were directing attention to behaviourally relevant information in both visual fields (Corbetta and Shulman, 2002; Posner, 2012), thereby facilitating reflections, increasing self-awareness, and enhancing executive control (Ting et al, 2011).

The findings of this pilot study are in line with the positive findings of Mountain et al (2010b) who also found that, with the use of appropriate tasks for training, people with stroke and spatial neglect could learn to use a powered wheelchair.

However, the findings should be interpreted with caution as this is a pilot study with few participants, and the findings may depend on each of the studied participant's cause of deficits, spatial neglect severity, any combination of additional impairments, and the length of time passed post-stroke. Stroke with spatial neglect is a heterogeneous phenomenon with individual presentation of deficits depending on the site of lesion in the brain (Parton et al, 2004; Ting et al, 2011). Also age influences the possibility of recovery and neural re-organization (Kolb and Campbell Teskey, 2010).

CONCLUSIONS

In stroke patients with spatial neglect, taking part in appropriately planned sessions of powered wheelchair use may rapidly improve alertness and ability to sustain and shift attention between relevant locations of interest in both visual fields. A larger study is needed to confirm the encouraging findings and to explore if the effects are long- lasting, and if they influence activities in daily living and independence.

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