Face tracking training in children with severe motor impairment: case report

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ABSTRACT

The article reports an interactive training experience in children with tetraplegia using a face tracking system. Classic assessment scale and specific interactive tasks were used to evaluate and carry out the treatment based on a multimodal approach. The aim of the training was to improve lateral head rotation and oral motor ability with a specific interactive patch connected to the head and face movement. Finally, further trajectory movements and computer control by means of face movement were evaluated. From a descriptive point of view the system proved to be a functional tool to help subjects with severe motor impairment and it empowered the use of their residual functional movements.

1. INTRODUCTION

Face tracking and interaction software provide alternative tools in the treatment of children with severe physical disabilities. They offer a new way to experience through an easy multimodal interface. Tetraplegic children generally depend on caregivers, for them this type of intervention can be a starting point to exert environmental control and therefore improve their quality of life. Interacting with enjoyable activities and making active choices through the new technology access may also prove to be pivotal in the rehabilitation efforts for this population (Sutherland 1968). Head tracking is an old technological topic (Toyama 1998), in the last year many articles have reported different systems using interaction based on visual face tracking technique, especially those that are virtually driven by computer mouse (Rispoli et al. 2014). This specific technology is related to the field of computer access device and assistive technology for people with communicative disabilities (Manresa-Yee et al. 2006; More et al. 2014), but we assume that it can also be aimed to enhance specific activities in a motor training experience.

2. SYSTEM

The system can be decomposed into global head and facial gesture movement control and becomes a feasible solution for different “hand-free” control. The face tracking is based on Free Frame dx9 and provide 66 different virtual marker point usable for interaction on the 2d x-y axes (Figure 1 A). The system requires a PC (we use an Intel core i5) with a commercial webcam equipment and a specific software VVVV (vvvv.org) for the interactive patch. The software was an easy hybrid visual/textual live-programming environment designed to facilitate the handling of large media environments with physical interfaces, real-time motion graphics, audio and video. This instrument easily allowed us to create systematically any patch we needed during the rehabilitative training experience. It has also given us the chance to change any interactive parameter or media feedback in real time and set increasingly challenging goals.

3. CASE REPORT

Here we describe the case of a 4 year old boy with tetraplegia (spinal cord injury transverse C2 -C3 lesion) due to a car-accident trauma. The child showed reduced face and head range of movement, oral motor dyspraxia, no speech ability and low motor initiative. The general assessment showed: suitable cognitive competence, good

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visual discrimination, no attention and memory deficit, appropriate emotive reaction and good age related education skills.

3.1 Motor Assessment

We selected different scales to assess head and face residual movements. Respectively, the *Clinical Rating Scale for Head Control - CRSHC* (Chavan 2008) to evaluate head postural movement, the *House-Brackmann* (House and Brackmann 1985) and *Sunnybrook Facial Grading Scale* (Ross et al. 1996) to assess face ability.

Table 1. *Head and Face Motor Assessment.*

CRSHC: Grade 0	Supine-Prone-Sitting: No head postural control, require full support.
House-Brackmann:Grade 2	Slight face weakness and asymmetry of smile, complete eyes closure
Sunnybrook Facial Grading Scale: 74	Voluntary movement: 84 Resting symmetry: 5 Synkinesis: 5

The clinical scales selected showed a low sensitivity to measure the child residual motor skill. Therefore, we used the face tracking system also as an assessment tool to evaluate two specific abilities, in pre and post training assessment: lateral head rotation and oral motor movement.

In literature, nose feature has been widely used to track a cursor position (Gorodnichy et al. 2002 and 2004; El-Afifi et al. 2004; Varona et al. 2008) and horizontal head movements are commonly the more reliable tracked trajectory (Sko and Gardner 2009).

We assessed the x-axis range of motion (ROM) using the nose pointing marker n.30, and asked to actively rotate the head on both side. The shift in degree was recorded from starting point 0 with nose in middle position to final position. The assessment reports an asymmetric ROM head rotation mainly on right side: left side ROM 9°, right side ROM 4° (Figure 1B).

The second specific facial gesture detected was the open-close mouth control, action that has been reported as highly reliable in the tracking system accuracy (Jilin and Tao 2007). In our case, we have selected the relation within the two central lips markers, n.61 and n.64 (Figure 1C), to assess the mouth open-close rhythmic control with a specific game: the boy was required to eat a virtual fish in a timely manner, related to the food/target predictable movement (Figure 3 A/B). This game provides basic mouth rhythmic coordination and can be adapted at different speeds. The assessment reported a low mouth tone (often open) and reduced open-close speed and rhythmic control. The child was able to hit 2/20 target match, moving at a 10 sec. speed.

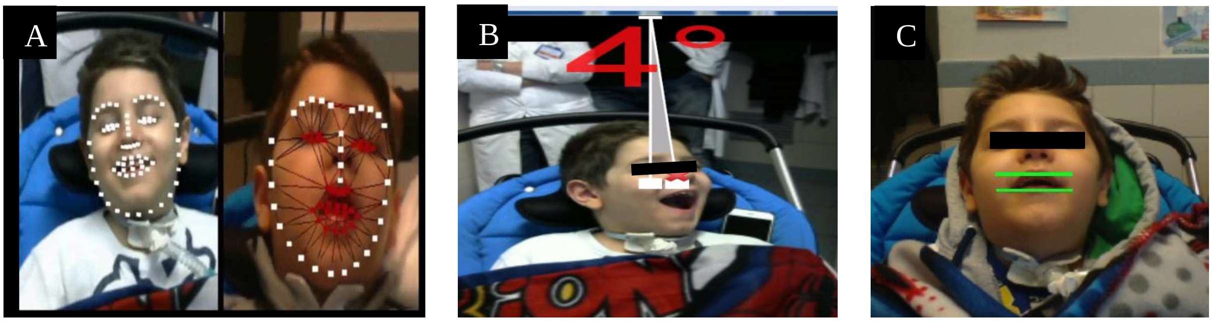

Figure 1. *Face tracking marker system and assessment.*

4. TREATMENT

The child received three daily classic rehabilitative treatments: physical therapy, speech and dysphagic training. Then, we introduced a fourth additional daily training with face tracking: 45 minutes, 5 days a week for 2 months. In our patient reaching active movement was a key point to the treatment, but with a classical training approach we were barely able to activate his stillness and motor initiative. Instead, the interactive face tracking intervention allowed us to more efficiently customize his treatment, by designing personalized patches focused and adapted to engage the user's needs in a growing demanding path.

The interactive tasks aimed to improve active head lateral rotation ROM were: lateral picture slider (Figure 2A), yes/no communication icon selection (Figure 2B), driving a radio commanded car Arduino hacked (Figure 2C) and a classic on line Pc game (i.e. Arcanoid). Lateral head movements activated all these exercises.

The patches aimed to enhance active oral motor synergy with interactive tasks were: video switch triggered by mouth, specific rhythmic “eat fish” game (Figure 3 A/B), different cartoon bubble in communicative context (Figure 3 C), one button on line game played with mouth activation. Open-close mouth movements activated all these exercises.

During the last training session we used more demanding tasks:

- autonomous pc experience using lateral cursor direction linked to nose/head rotation and right mouse click triggered by mouth (Figure 4A).
- training the other residual head motor trajectory (up-down or diagonal) with virtual basket game (Figure 4B) or classic memory game (Figure 4C).

The feedback used during all the training sessions was based on picture or video, with the aim of improving the child’s engagement. All the interactions, except for the common pc games, presented environments of augmented reality, where different graphic visual cues supported the real face webcam view.

Experimenting with the tracking game helped us to understand how we could increase the child motor performance step by step. We re-mapped the trigger feedback, the range excursion or the game speed in real time, therefore calibrating the system to the child performance in a demanding path request.

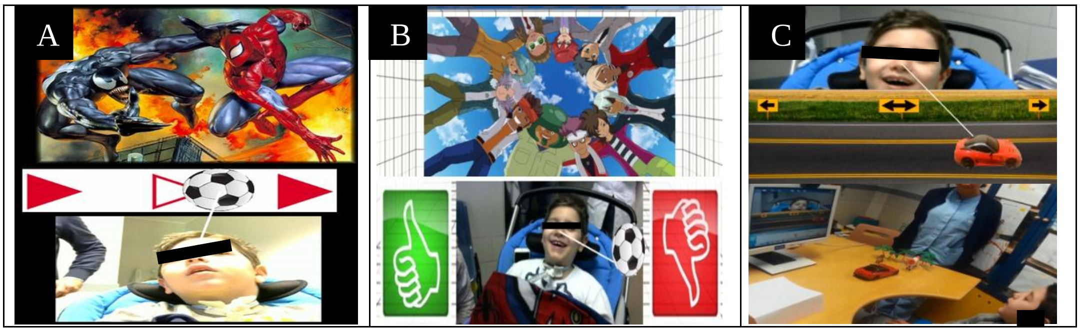

Figure 2. *Lateral head rotation interactive task.*

Figure 3. *Oral motor interactive task.*

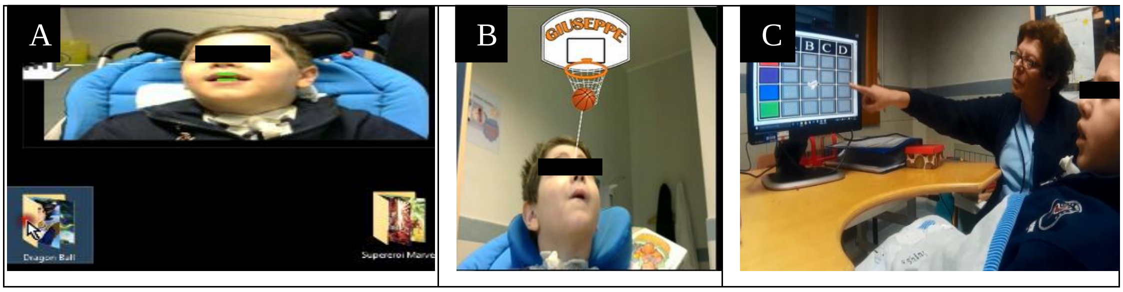

Figure 4. *Autonomous Pc experience and other motor trajectory.*

5. RESULTS

The patient motor training reported an improvement in lateral range of motion and in the mouth open-close control, as assessed with the face tracking system. The final evaluation reported increasing active ROM head rotation on both sides, mainly on right side, and enhanced target hit during the mouth assessment game.

Table 2. *Training results.*

	Pre training	Post training
Lateral head rotation	Left. side Rom 9° - Right side Rom 4°	Left. side Rom 12° , Right side Rom 6°
Oral motor coordination	2/20 goals at 10 sec. target speed.	20/20 goals at 6 sec. target speed.

Global enhancement in selective/synergic face gesture coordination was also observed. The main difficulties our patient encounter during the treatment were related to: 1. speed adaptability during common Pc game, 2. synergic head/mouth movement required during the pc autonomous experience and 3. accuracy in the up/down and diagonal motor trajectory recruitment. The high complex tasks required in the last session were useful to investigate and clarify the child's motor boundary residual skills. The aims of increasing compliance, engagement and general motor initiative were successfully achieved, especially taking into account the patient's stillness and immobility.

6. CONCLUSIONS

The system revealed itself as a functional multimodal user interface that can help subjects with severe motor impairment to empower their residual functional movements. The training also focused on initiative attitude and on introduction to iconic environment aimed at: active media selection, early communication experience, basic Pc control, common game playing and physical playing with a remote car. Therefore, an early approach with interactive technology in engaging experience can be considered a useful tool in a global training approach. Certainly, eye-tracking systems would have been more complete and simple to use for this kind of patients, but it would have led also to a less positive motor performance then the face-tracking system. For a better outcome an integration between the two systems should be planned to empower the visual ability in association with the active head/face skills.

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