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Utility of optical facial feature and arm movement tracking systems to enable text communication in critically ill patients who cannot otherwise communicate

M.B. Muthuswamy [a], B.N. Thomas [b], D. Williams [b], J. Dingley [c,b,*]

[a] Department of Anaesthetics and Intensive Care, Royal Gwent Hospital, Newport NP20 2UB, United Kingdom
[b] Department of Anaesthetics and Intensive Care, Morriston Hospital, Swansea SA6 6NL, United Kingdom
[c] College of Medicine, Swansea University, SA2 OUL, United Kingdom

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ABSTRACT

Purpose: Patients recovering from critical illness especially those with critical illness related neuropathy, myopathy, or burns to face, arms and hands are often unable to communicate by writing, speech (due to tracheostomy) or lip reading. This may frustrate both patient and staff.

Two low cost movement tracking systems based around a laptop webcam and a laser/optical gaming system sensor were utilised as control inputs for on-screen text creation software and both were evaluated as communication tools in volunteers.

Methods: Two methods were used to control an on-screen cursor to create short sentences via an on-screen keyboard: (i) webcam-based facial feature tracking, (ii) arm movement tracking by laser/camera gaming sensor and modified software. 16 volunteers with simulated tracheostomy and bandaged arms to simulate communication via gross movements of a burned limb, communicated 3 standard messages using each system (total 48 per system) in random sequence.

Results: Ten and 13 minor typographical errors occurred with each system respectively, however all messages were comprehensible. Speed of sentence formation ranged from 58 to 120 s with the facial feature tracking system, and 60–160 s with the arm movement tracking system. The average speed of sentence formation was 81 s (range 58–120) and 104 s (range 60–160) for facial feature and arm tracking systems respectively, ($P < 0.001$, 2-tailed independent sample *t*-test).

Conclusion: Both devices may be potentially useful communication aids in patients in general and burns critical care units who cannot communicate by conventional means, due to the nature of their injuries.

1. Introduction

The ability to communicate effectively is a fundamental aspect of patient care. It is well recognised that the inability of patients to communicate their needs with staff or relatives is a source of emotional and psychological distress, which can have a negative impact on their recovery [1–3]. This can be a common scenario in critical care units where patients lose the

* *Corresponding author at*: Department of Anaesthetics and Intensive Care, Morriston Hospital, Swansea SA6 6NL, United Kingdom. Tel.: +44 01792 703280; fax: +44 01792 703278.
E-mail address: j.dingley@swan.ac.uk (J. Dingley).

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ability to communicate verbally due to tracheal tubes and tracheostomies, and communication relies on lip reading, gestures and writing. It can be particularly problematic in the setting of burns critical care if patients have sustained burns to the face, arms and hands, sometimes with an inhalation injury, especially if ventilated via an elective tracheostomy in which case speech, lip reading and writing all become difficult or impossible.

Various specialised communication tools have been developed specifically for those with severe long-term disabilities, such as wearable pupil tracking sensors, however these can be expensive and require some training to set up and operate effectively. Some methods have been used in the critical care setting in an attempt to overcome communication difficulties. These include basic tools such as pen and paper, letter boards and writing tablets as well as more advanced text-to-speech devices [4–7]. These have been associated with varying degrees of success, but many require manual dexterity and are therefore not a suitable option for burns or trauma patterns similar to those described above.

Here we have taken two low-cost movement tracking systems which make use of relatively recent technology advances and used them to control on-screen text generation software, evaluating each system in volunteers. Neither system requires dexterity of the hand or fingers to operate or any contact with the body. The first operated using a laptop webcam tracking movements of the head and face to move a "mouse" pointer to select letters on-screen, and the second method used a laser/optical gaming system sensor to track gross arm movements for selection of letters on-screen in a similar way. We hypothesised that both could be suitable communication tools for patients in critical care units who cannot communicate verbally and with limited upper limb function.

2. Methods

2.1. *Technical aspects*

Two communication systems were evaluated, both of which used an on-screen cursor to create text via an on-screen keyboard.

2.1.1. *System 1: facial feature tracking to control an on-screen mouse pointer*

The first of these was a free for non-commercial use webcam-based facial feature tracking system (Headmouse 1.5, Neural Information Processing Group, Eotvos University, Hungary)[8] (Fig. 1). This software uses the patient's head movement to control a mouse, which can then be used to select letters on a laptop screen to create sentences. As most laptop computers now have a webcam integrated into the top of the screen, this method just requires a laptop computer facing the patient to function.

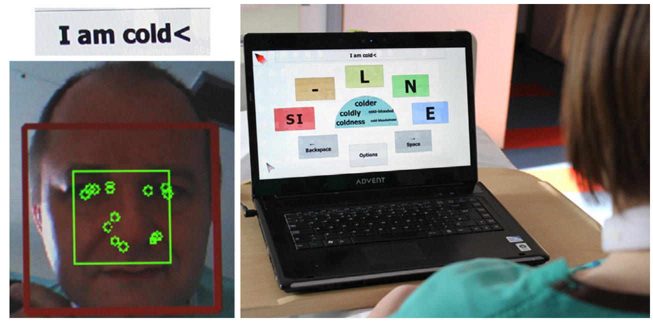

Fig. 1 – Use of the Headmouse facial feature tracking system. Via a webcam in the top of the laptop computer screen the software automatically locates key features on the face of the subject, which can be different for each individual, tracking their movement to control an on-screen mouse pointer to select letters and spell words.

2.1.2. *System 2: tracking of arm movements to control an on-screen mouse pointer*

The second system was an infrared laser/camera combination in a commercial gaming sensor (Kinect^{TM} 360 sensor, Microsoft Corp, Redmond, WA, USA) connected to a laptop computer running open-source free modified movement tracking software [9] allowing the device to follow arm movements to move an on-screen pointer and so select letters (Fig. 2). This device projects a series of infrared dots out into the conical field of view of an integrated infrared camera and is readily available separately from the games console for approximately US$100. The dots seen by this camera appear closer together on objects that are nearer to the camera. In this way the system can detect outlines of objects and also be aware of their distances from the camera, for example the outline of a human being against a background. The software was modified so that instead of tracking the human body, as when used as a gaming sensor, it instead followed the outline of the arm only. Gross patient arm movement could then control a mouse, which, as with the Headmouse, could then be used to select letters on the attached laptop screen.

Fig. 2 – Use of the Kinect^{TM} arm movement tracking system. Via the Kinect^{TM} gaming sensor on right of the image the software on the attached laptop computer collects information on the outline of the right arm, tracking its movement to control an on-screen pointer to select letters and create words.