A COMPUTER BASED TRACKING TEST FOR QUANTIFYING HAND FUNCTION IN CHILDREN WITH CEREBRAL PALSY

Wright PA1,2 and Granat MH1

1Bioengineering Unit, University of Strathclyde, Wolfson Centre, 106 Rottenrow East, Glasgow G4 ONW, UK
2Address for correspondence: Department of Medical Physics and Biomedical Engineering, Salisbury District Hospital, Salisbury, Wiltshire SP2 8BJ, UK

ABSTRACT
A computer based tracking test, with quantitative outcome measures, was developed as part of wider research investigating the effectiveness of Functional Electrical Stimulation (FES) of wrist extensor muscles in improving hand function in children with Cerebral Palsy. The aim of this work was to investigate the feasibility of using the test to measure hand function in children with CP. Preliminary investigations of the test were made on three subject groups:
A) four able-bodied adults (for system evaluation)
B) four children with CP
C) four children with CP, before and after treatment with FES
In group B, there was no overall improvement. There was evidence of increased hand function in group C, with improvements in all outcome parameters (tracking error, p=0.11, two tailed t-test). It was concluded that a computer based tracking test could be a feasible method of quantitatively assessing hand function in children with CP.

KEYWORDS: Cerebral Palsy, Children, Tracking Test, Hand Function

INTRODUCTION
Upper limb impairment in CP may be managed by a combination of surgery, physiotherapy, medication, orthoses and FES. It is difficult, however, to compare how effective these different treatment options are in improving upper limb function as existing hand function assessments in this population are often subjective. There is a need for tests of hand function suitable for children with CP of varying ages and disabilities. The purpose of this research was to investigate whether a computer based tracking test was a feasible method of quantitatively assessing hand function in children with CP. Tracking tests have previously been used as a means of quantitatively assessing hand function for patients with a variety of neurological impairments; most commonly for assessment of patients with Parkinson’s Disease1.

In a tracking test, the subject is presented with a visual target signal, e.g. in the form of a trace on a computer screen. The subject attempts to follow the target signal as closely as possible with a second trace (the follower signal), which is controlled by varying the input to a transducer. The characteristics of the follower trace with respect to the target trace can be analysed to give measures of hand control.

Generally, each tracking test is divided into a number of trials. Part of each trial, or even whole trials, may be disregarded so that results are taken from steady state, e.g. the first 30 seconds of each one minute trial may be disregarded2. There is often a rest period after each trial to optimise performance, e.g. five two minute trials with a two minute rest period after each trial3.
EQUIPMENT
A Penny & Giles flexible electro-goniometer was attached with adhesive tape across the subject’s wrist to monitor wrist flexion and extension. One end block was attached just below the second metacarpophalangeal joint on the dorsal surface of the forearm. The other was attached on the dorsal surface of the forearm. The goniometer output was amplified by a strain gauge amplifier and sampled at 60 Hz by an Amplicon ADC card interfaced with a PC.
A representation of the computer screen during the tracking test is shown in figure 1. A Pascal program generated a target trace that moved from left to right across the screen. The target trace jumped between two of three vertical positions (approximately six centimetres apart) at a random point between one third and two thirds of the way across the screen. A follower trace moved from left to right across the screen at the same rate as the target trace. The subject controlled the vertical position of the follower trace by varying the amount of wrist extension which varied the voltage output from the wrist goniometer.
The system was calibrated before use so that the user was required to control the follower trace by moving from no wrist extension to fifteen degrees short of full wrist extension. This tolerance gave the subject the opportunity to overshoot the target trace. Both the digitised output from the goniometer and the data points from the computer generated trace were stored as a text file while the tracking test was being conducted.
The following four outcome measures were calculated (refer to figure 1):
• Summation of area between the target and follower trace (i.e. ‘d’ measured in vertical pixels and integrated over the width of the screen)
• Average movement time in seconds, mt (proportional to the number of horizontal pixels between 20% and 80% of the target trace jump)
• Number of overshoots over 20% above target trace jump
• Average reaction time in seconds, rt (proportional to the number of horizontal pixels for follower trace to travel 10% of the distance the target trace jumps)

Figure 1. Representation of computer based tracking test on computer screen
TRACKING TEST PROTOCOL
Vertical and horizontal adjustments were made to the system's position to enable the subject to be seated upright, with shoulders level, and with the impaired elbow flexed at 90 degrees. The subject’s impaired arm was supported with the wrist orientated so that gravity would have minimum influence in wrist extension/flexion movement. The subject was then asked if they were comfortable and ready. If they were the investigator instructed the subject to match the target trace with the follower trace as closely as possible.

The movement of the target trace from left to right across the screen was defined as a step. Each trial comprised twelve steps (each one ten seconds long) which were presented to the subject in succession followed by a fifteen second rest. There were four trials at each assessment session. The entire duration of the test was approximately fifteen minutes. In order to ensure steady state results, the first day’s results were rejected, only the results from the second and third trials were included in the analysis and the first step in each trial was rejected.

SYSTEM EVALUATION STUDIES
The use of the tracking test was investigated in two groups of four children with CP in both. Group B (mean age thirteen years, age range twelve to fourteen years, 2M, 2F) received no intervention and was assessed using the tracking test on five consecutive mornings. Group C (mean age thirteen years, age range twelve to fourteen years, 2M, 2F) was also taking part in a study investigating the effect of FES of wrist extensor muscles in improving hand function. Each child in group C was assessed using the tracking test on eight mornings – four consecutive mornings before treatment began then four consecutive mornings during the last week of the six week period of treatment with FES. On the last week of treatment assessment with the tracking test preceded treatment with FES.

RESULTS
The results from days two and three were compared with the results from days four and five in group B (figure 2). The results from days two and three (before treatment) were compared with the results from days six and seven (after treatment) for group C (figure 3). Each group had four subjects each of which had four parameters measured. There are therefore sixteen changes in the value of a parameter to be observed. In group B eight parameters improved, and in group C eleven improved.

![Figure 2 The normalised mean for group B of each parameter from days two and three compared with the corresponding mean from days four and five](image-url)
DISCUSSION
All subjects were compliant with the tracking test and did not have any difficulty in following
the instructions to complete the test. In group B, two parameters improved and two were
worse. In group C, improvements were observed in all the parameters. There was no
significant change in the number of overshoots, the movement time or the reaction time of
either group. However, the average error decreased (p=0.11) in group C, and since no similar
decrease was observed in group B, it seems reasonable to suggest that this is in fact a trend
illustrating that group C was more accurate in carrying out the tracking test because of an
improvement in hand function. The results of individual subject’s performances in the
tracking test are further evidence of this theory.
The test therefore appeared to identify an improvement in hand function in group C, as might
have been expected, given the therapeutic intervention with FES. This suggests that a
computer based tracking test is a feasible method for measuring hand function in children
with CP. Further development of the test will involve investigation into the variability of the
measured parameters.

ACKNOWLEDGEMENTS
This work was funded by the Science and Engineering Research Council and the Scottish
Office Home and Health Department [K/RED/6/31/F23]. The authors gratefully acknowledge
the help and co-operation of the volunteers.

REFERENCES
1. Dalrymple-Alford JC, Kalders AS, Jones RD & Watson RW A central executive deficit in
patients with Parkinson's disease Journal of Neurology, Neurosurgery, and Psychiatry, vol. 57,
2. Bloxham CA, Mindel TA & Frith CD Initiation and Execution of Predictable and Unpredictable