

## Introduction

For patients with ALS, the preservation of independent movement in one's environment is important to quality of life. Use of a wheelchair with eye-gaze controls would be a significant advancement preserving independence and quality of life for patients with this disease.

## Objectives

Our objective was to conduct a small pilot study to demonstrate the feasibility, safety, and responsiveness of an eye-gaze directed power wheelchair (PWC) for patients with ALS.

## Materials and Methods

We conducted an uncontrolled pilot study in 12 subjects with ALS, over 18 years of age. Subjects were excluded if they had prior use of eye-gaze technology, significant respiratory compromise (FVC < 50%), frontotemporal dementia, or other cognitive impairments. An eye-gaze controlled system that allowed the subject to direct their movements was mounted on the power wheelchair (Figure 1). The wheelchair moves in the direction the subject gazes on the screen using transparent arrows to indicate direction and a central red square to stop the chair (Figure 2). The subjects were also able to see their environment ahead on the screen. The subjects drove the eye-gaze controlled wheelchair around a standard course completing three trials (Figure 3). On the course, various tasks were measured: overall time to complete the course; stop on command; start on command; turning 90, 135, and 180 degrees; and time to back up in reverse over a short and long distance. The primary outcome measure was to assess the feasibility and safety of an eye-gaze-controlled power wheelchair in patients with ALS. The secondary outcome measure was to assess user satisfaction of the eye-gaze control system with regards to the performance of the wheelchair.



Figure 1: Eye-gaze system on power wheelchair



Figure 2: Eye-gaze system user interface. Gazing at the arrows allows user to direct the PWC while seeing their environment.

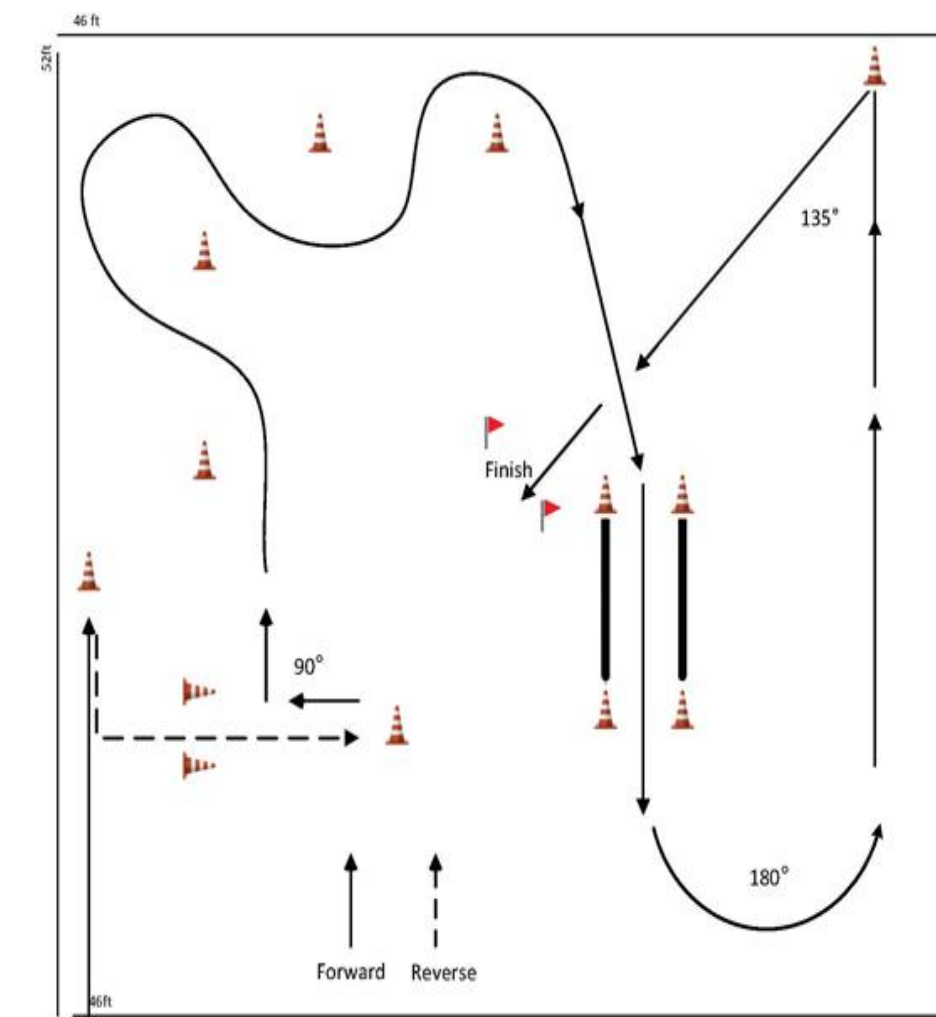


Figure 3: Map of course, list of maneuvers, and image of actual course.

- 1. Start on command.
- 2. Drive forward to cone, getting as close as possible without touching the cone.
- 3. Back an "L" through cones.
- 4. Make a right-angle 90° turn.
- 5. Weave through cones.
- 6. Drive between narrow barricades.
- 7. Make a sweeping 180° turn.
- 8. Make a very sharp 135° turn.
- 9. Cross finish.

## Results

14 subjects were screened, and 12 subjects completed the trial. All of the subjects were able to complete three runs around the course and the associated maneuvers safely. The mean time for all of the subjects to complete the course got faster with each successive run (Table 1 and Figure 4). The subjects were able to safely perform the runs and avoid obstacles. Overall, the runs were completed with very little variability in times to complete the course and to perform the various maneuvers (Table 1 and 2). The subjects rated the system's ability to complete each task very highly and the overall responsiveness of the system as excellent (Table 3).

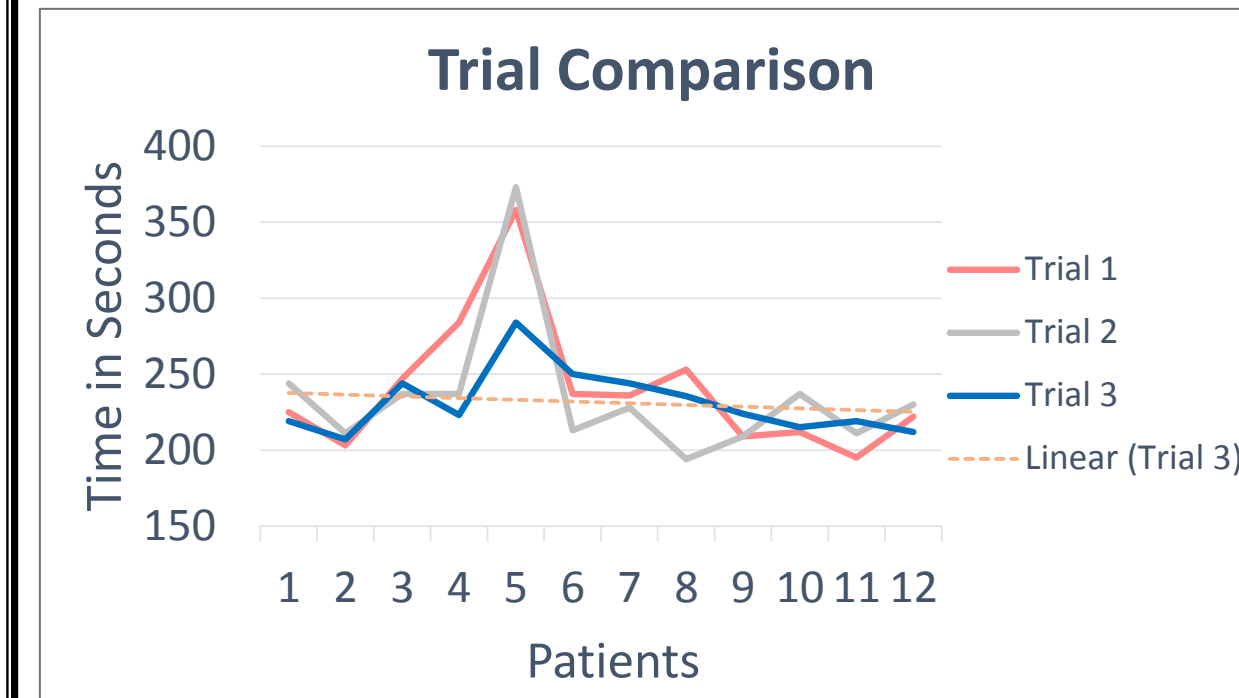


Figure 4: Graph showing trend of improvement to complete the course with each successive trial

Table 1: Times to complete the course

Subject ID	Time in seconds		
	Trial 1	Trial 2	Trial 3
SWE-01	225	244	219
SWE-03	203	211	207
SWE-04	247	237	244
SWE-05	284	237	223
SWE-06	358	373	284
SWE-07	237	213	250
SWE-08	236	228	244
SWE-09	253	194	236
SWE-11	209	209	224
SWE-12	212	237	215
SWE-13	195	211	219
SWE-14	222	230	212
<b>Average</b>	<b>240</b>	<b>235</b>	<b>231</b>
<b>Std. Dev</b>	<b>45</b>	<b>46</b>	<b>22</b>
Green	3	4	4
Black	6	2	4
Red	3	5	4

Table 2: Times to complete maneuvers

Tasks	Mean	Min.	Max.	S.D.	Tasks complete
Overall Time (s)	236	194	373	39	n/a
Stop on command	1	1	2	0	12
Start on command	1	1	1	0	12
Negotiate & avoid obstacles	97%	0	0	NA	11
Turn 90°	6	2	30	5	11
Turn 135°	7	4	13	3	11
Turn 180°	14	5	43	6	11
Back up short	14	6	34	6	12
Back up long	24	12	56	9	12

Table 3: Secondary End Point User Experience

User Experience Questionnaire	Average
Responsive to stop	4 - Very good
Responsive to start	5 - Excellent
Negotiate & avoid obstacles	4 - Very good
90° turn	4 - Very good
135° turn	4 - Very good
180° turn	4 - Very good
Back up	4 - Very good
Overall responsiveness	5 - Excellent

## Conclusions

This small pilot study suggests that the hands-free or eye-gaze controlled power wheelchair is a feasible and safe system for power mobility. The user experience was very favorable. This system has tremendous potential to improve the quality of life and independence of patients with ALS.