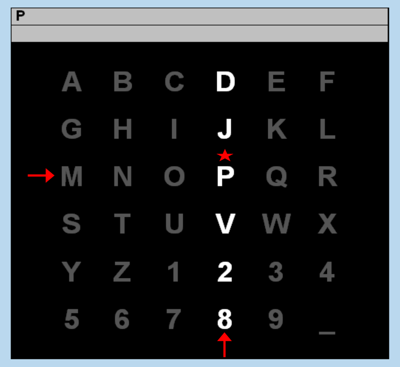

Fig 1: 6x6 P300Speller Matrix

A P300 BASED BRAIN-COMPUTER INTERFACE (BCI): MOVING TOWARD A COMMUNICATION SYSTEM FOR THE LOCKED-IN

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Fig 2: Example 4-choice stimulus

INTRODUCTION

Last year we presented data collected using a 6x6 matrix P300 Speller (Fig 1). The results demonstrated that the system may be a viable option for written communication; however, some patients may have difficulty using the system (Sellers, et al, 2003). The present study was designed to test a system based on a 4-choice oddball task that presents stimuli in an auditory, a visual, or a combined auditory and visual mode (Fig 2). Such a system could be used to answer yes/no questions. Classification performance was evaluated using three different methods of deriving step-wise discriminant analysis (SWDA) weights.

QUESTIONS

How does mode of presentation affect the elicited response?
Does the elicited response change over time?
What is the best method to use when selecting classification weights?

METHOD

One of four words (YES, NO, PASS, or END) was presented for 600 ms, at random, with an ISI of 1400 ms. The subject's task is to attend to one of the four words. The sequence constitutes an oddball task; 1 stimulus is attended (.25 of the presentations) and 3 stimuli are disregarded. The attended stimulus should elicit a P300 response.

TASK & DESIGN

Three ALS patients and three non-ALS control subjects participated in the experiment. Each participant completed 10 experimental sessions in a period of approximately 6 weeks. All sessions included 12 experimental runs. In six of the runs the participant focused on the word YES, and in six runs the participant focused on the word NO. Each run consisted of 25 sequences of the four stimuli for a total of 100 stimulus presentations per run. Stimuli were presented in one of three modes via counter-balanced presentation: 1) Auditory, 2) Visual, or 3) Auditory + Visual (AudVis).

ODDBALL DATA

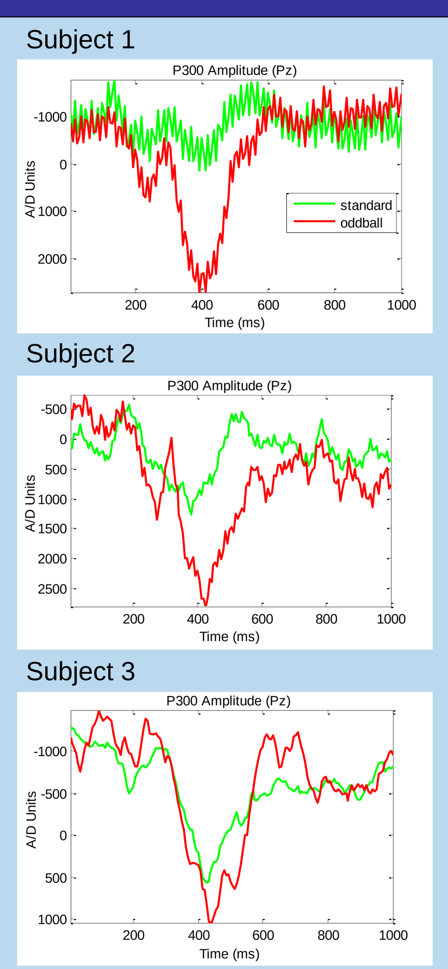
Standard visual oddball sequence for the non-ALS participants.

200 stimuli

Oddball probability = .25

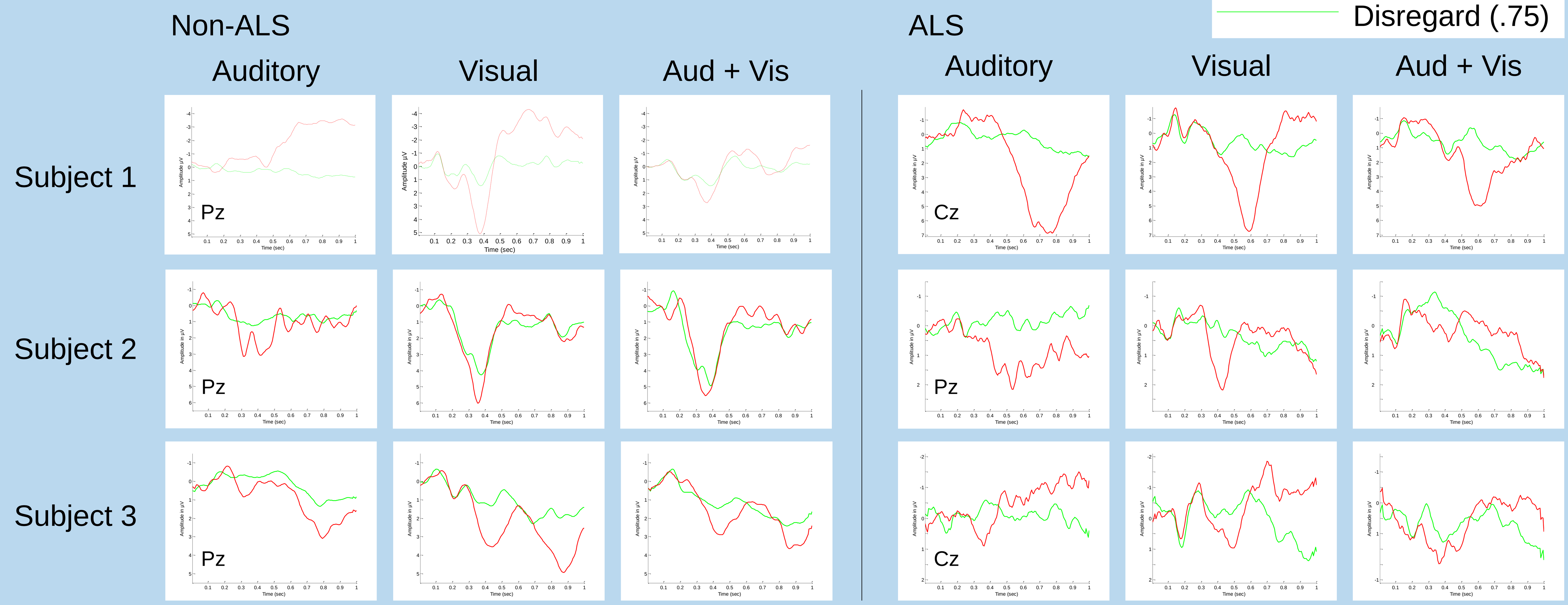
Stimulus presentation 600ms

ISI 1400ms



WAVEFORMS

Average waveforms Session 1

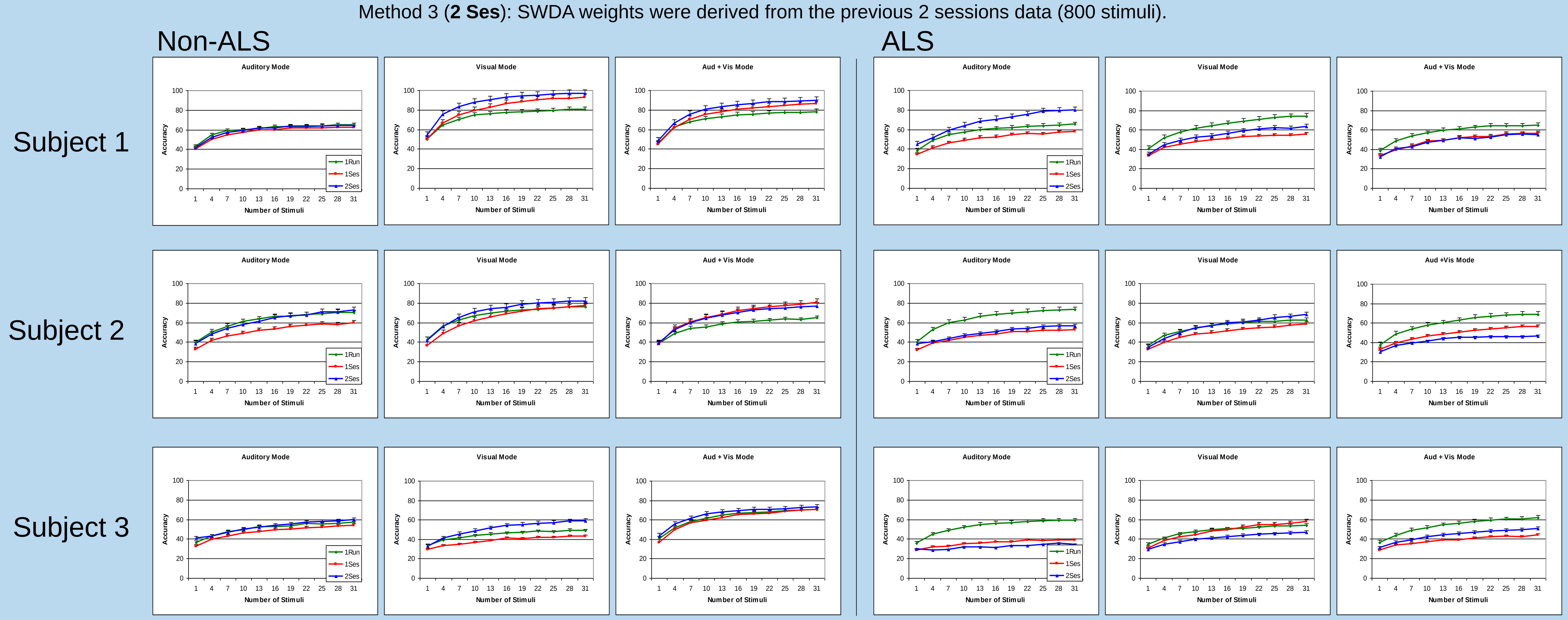


Waveform Results

Overall, waveform morphology remained similar across sessions within mode of presentation. However, as can be seen from the above waveforms, large differences were present within each subject for the auditory, visual, and auditory + visual modes. In addition, as can be seen below, classification performance varied substantially across mode of presentation.

CLASSIFICATION

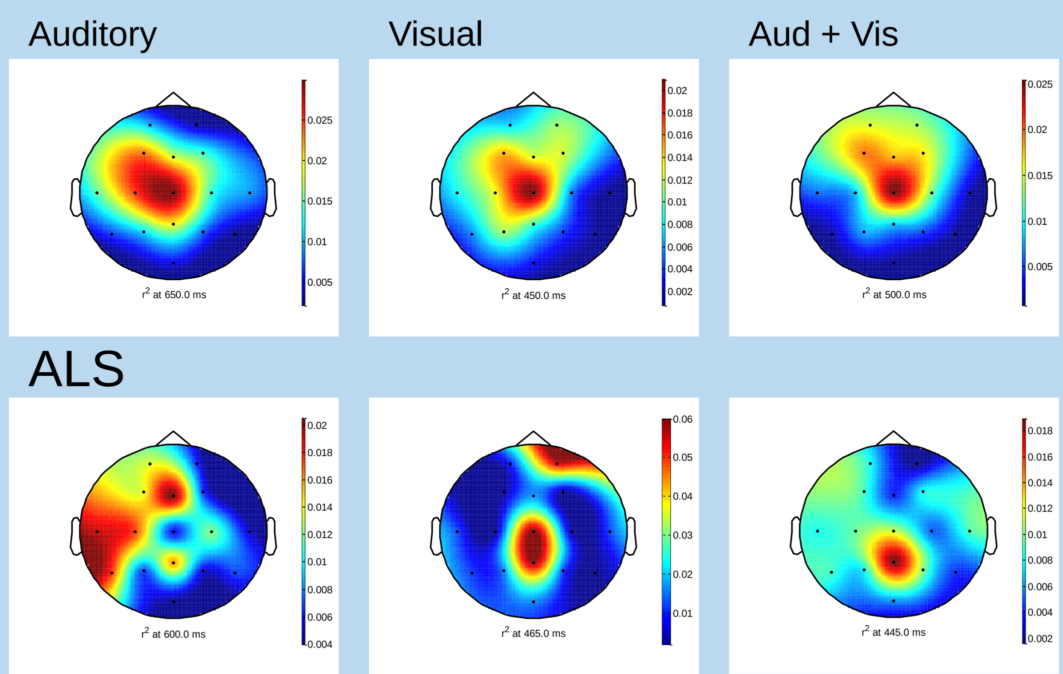
Method 1 (**1 Run**): SWDA weights were derived from the first run of the session for each mode of presentation (100 stimuli).
Method 2 (**1 Ses**): SWDA weights were derived from the previous sessions data (400 stimuli).
Method 3 (**2 Ses**): SWDA weights were derived from the previous 2 sessions data (800 stimuli).



Each curve represents classification accuracy as a function of the number of stimuli averaged before classification.

TOPOGRAPHIES

Example topographies for each mode of presentation. One non-ALS and one ALS participant are presented for comparison.



CLASSIFICATION RESULTS

Non-ALS subject's classification accuracy was not significantly different from ALS patients ($p=.13$). Increasing the number of stimuli before classification increased accuracy ($p<.0001$). Classification method 1 and 3 classified significantly better than Method 2 ($p<.007$). Overall, classification did not differ as a function of mode of presentation ($p=.27$) or by session ($p=.12$).

DISCUSSION

Classification accuracy was highest for Method 3 with the Non-ALS patients, and highest for Method 1 in ALS patients. This suggests less response variability across time for Non-ALS subjects. The null result of session indicates that the oddball effect does not significantly habituate over time. Despite waveform differences between modes, the null result of mode of presentation indicates flexibility in determining the optimal mode for an individual user.

CONCLUSIONS

The present data indicate that it is possible for patients to use a BCI device, with a moderate degree of success, in their homes. Individual differences contribute a great deal to the success of a BCI device; therefore, operating parameters (e.g., mode of presentation, classification weights) should be adjusted and updated frequently, and on a case-by-case basis.
Future research will focus on improving classification using different signal processing algorithms, and continuing to test stimulus characteristics to identify stimulus properties that elicit the largest difference between attended and non-attended stimuli.

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Supported by NIH (NCMRR, NICHD (HD30146) and NIBIB/NINDS EB00856)). The James S. McDonnell Foundation. and the ALS Hope Foundation