Effect of Query Length and Prospect Symbol Confidence in EEG-based Typing Systems

P. Gonzalez–Navarro [1*], A. Kocanaogullari[1], B. Kadioglu[1], M. Akcakaya[2], M. Fried–Oken[3], Deniz Erdogmus[1],

CSL at Northeastern University[1], University of Pittsburgh, Pittsburgh, PA[2],

Speech–Language Pathology Department, Oregon Health & Science University, OR, USA [3]

*409 Dana Research Center, 360 Huntington Ave, Boston, MA 02115. E-mail: gonzaleznavarro@ece.neu.edu

7th International BCI Meeting, May. 21-25, 2018, California, CA

INTRODUCTION

Questions:
- Can we maximize the typing performance of BCI typing systems by choosing the most effective sequence length and prospect symbol confidence?

Goal:
- Find the the most effective presentation parameters (sequence length and confidence level) which maximize the typing speed and accuracy for BCI typing systems.

Contribution:
- We investigate the use of two types of stimuli for BCI typing systems: rapid serial visual presentation (*RSVP*) sequences and *prospect symbols* (i.e., the top candidate in the alphabet according to the current posterior probability), which generate two different brain responses, ERP and ErrP respectively. A non physiological evidence which comes from the context information(a 6 gram language model) is used jointly to detect the user intent.

Experiments:
- Task: Copy-word-task with 10 predetermined sentences for which the language model contribution ranges from friendly to adversarial are performed using EEG data obtained from 12 healthy participants.
- RSVP query length={6, 8, 12, 16} , confidence levels to display the prospect ={0.4, 0.6, 0.7, 0.8, 0.9, 0.95}
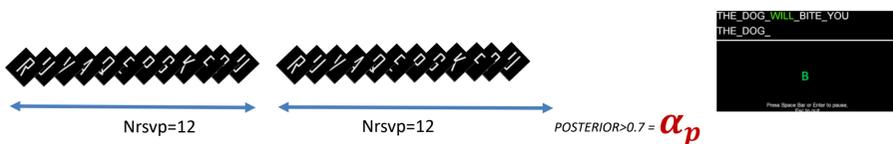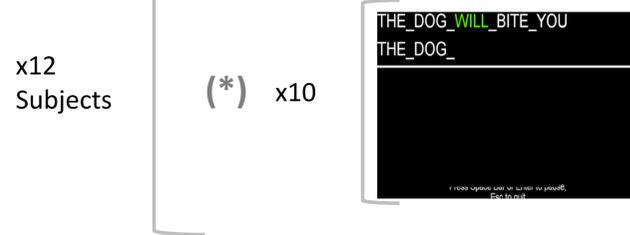

Final Results:
- Reducing the query length to Nrsvp =12 and use a confidence level of 0.7 to display the prospect symbol, we get the the best trade-off between typing speed and accuracy.

METHOD

3 Evidences to Detect User State:
RSVP &Feedback Stimuli + LM

1)Stimulus: RSVP Detect +ERP/-ERP

2)Stimulus: Feedback Symbol +FRP/-FRP

3) LM (Context Inf)

Inference: Bayesian Framework:

User State Given Physiological Evidence and LM

$$p_{stateED} (\text{user state} = \alpha | \mathcal{E}, F, LM) \propto p(\text{user state} = \alpha | LM) \, p(\mathcal{E} | \text{user state} = \alpha) \, p(F | \text{user state} = \alpha)$$

POSTERIOR   PRIOR   LIKELIHOOD   LIKELIHOOD

$$= p(\text{user state} = \alpha | LM) \prod p(\varepsilon_i | y) \prod p(f_j | z)$$


SIMULATION RESULTS

- **Task:**

Copy-word-task with 10 predetermined sentences for which the language model contribution ranges from friendly to adversarial are performed using EEG data obtained from 12 healthy participants.
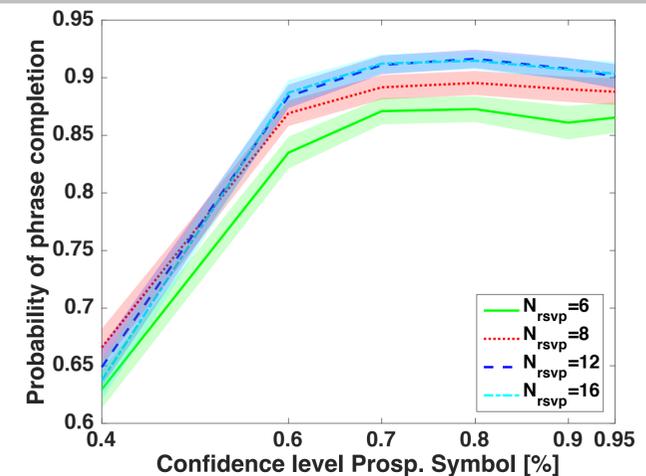
x12 Subjects   (*)   x10

- **Results:**

40 Monte Carlo simulation results (probability *of completion* and expected time to complete task in seconds) for twelve users on average, using synthetic EEG features from models calibrated with real ERP/ErrP EEG data for different configurations RSVP query length= {6,8,12,16} and confidence levels to display the prospect= {0.4, 0.6, 0.7 0.8, 0.9, 0.95}

Expected time to complete task :
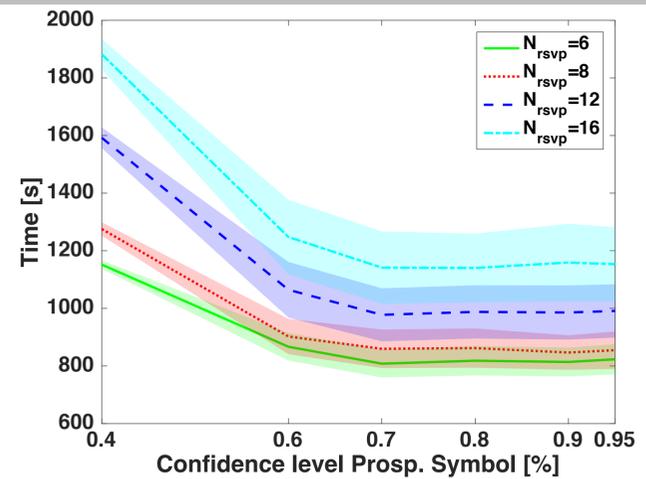
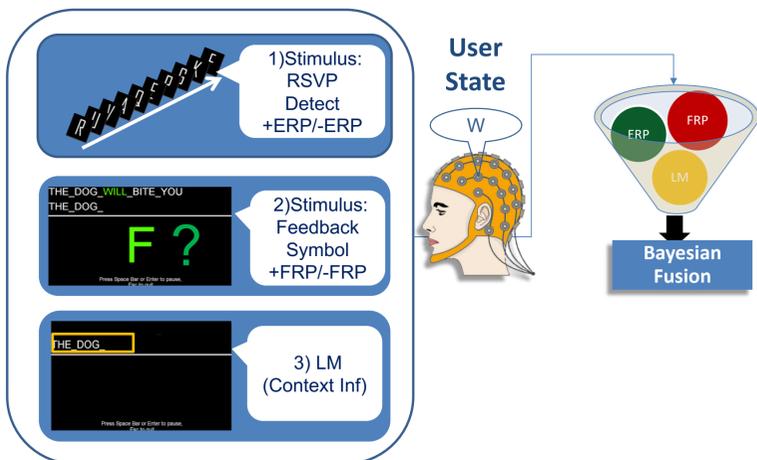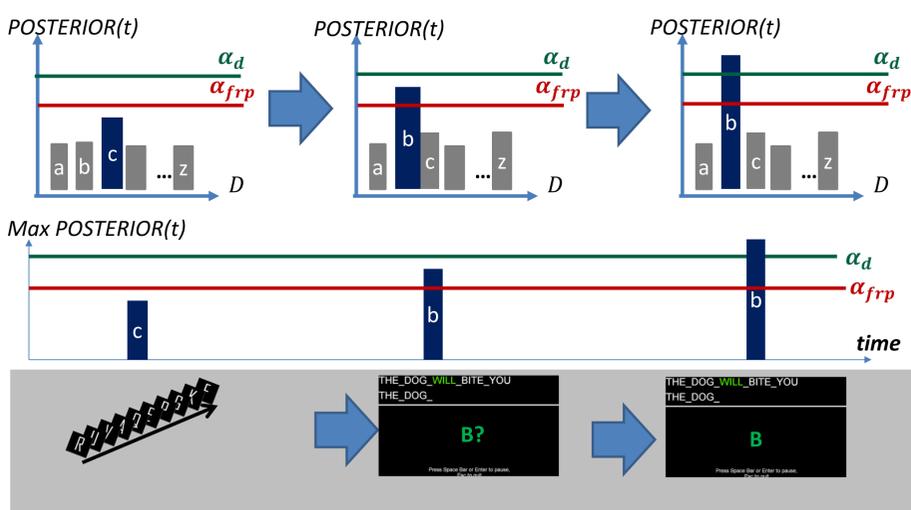Probability of completion task :

- Reducing the query length to Nrsvp =12 and use a confidence level of 0.7 to display the prospect symbol, we get the the best trade-off between typing speed and accuracy.

- Nrsvp=12
- $\alpha_p=$ confidence level prospect=0.7

Best Typing Performance

Speed   Accuracy

CONCLUSION

Results show that choosing an effective sequence length of the confidence level on a Bayesian fusion of ERP/Errp/LM improves human-machine communication in terms of speed and accuracy for deploying EEG-based typing systems in real scenarios.

Future work:
Design an adaptive query Length and Prospect Symbol Confidence framework.

References: [1] Moghadamfalahi, M., et al. Language-model assisted BCI for typing: a comparison of matrix and RSVP. IEEE TNSRE, 2015.