

BRAIN-COMPUTER INTERFACES

- A direct communication channel between a brain and a computing device
- User wears an electrode cap and communicate through thoughts or other covert actions (a BCI command)
- Brain waves are recorded and converted into digital commands with signal processing and machine learning algorithms



OVERVIEW

BCI Command Model

- *character*: A thought or an action (reliably detectable through brainwaves)
- *command or word*: a sequence of characters
- *modality*: Eye Blinks (easy to detect, natural and covert)

The Usability Study

Shorter Characters: {BB, BB, BB, BB} Shorter Words: {BBBB, BBBB}

do users prefer shorter characters (and hence longer words) or shorter words (and hence longer characters) when performing commands?

EYE-BLINK COMMANDS

Construction and Representation

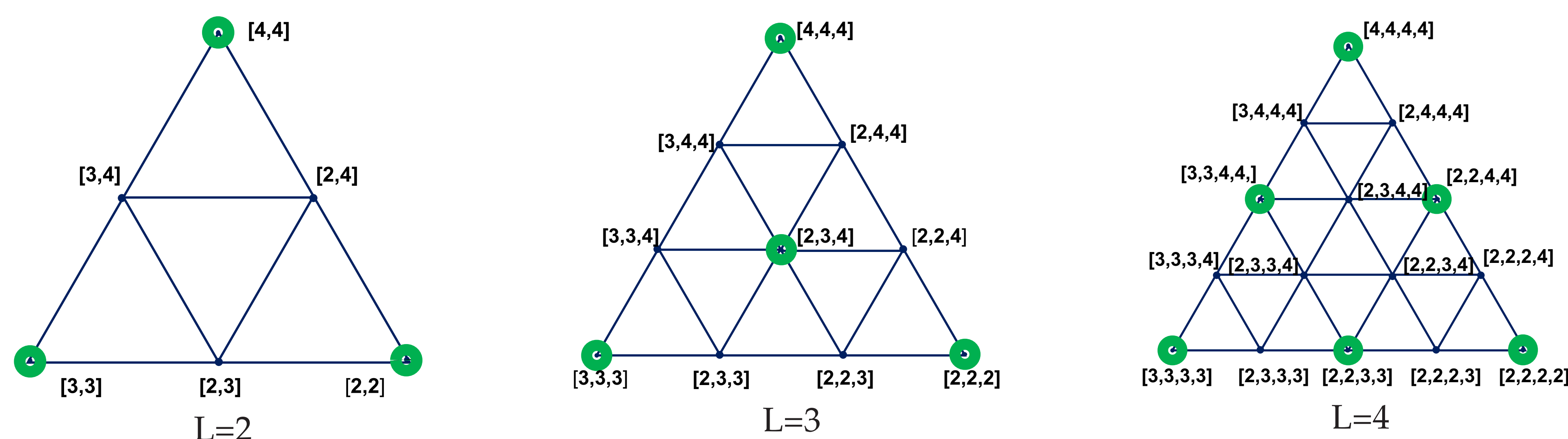
- *character*: multiplicity of eye-blinks (e.g. "2" represents a double blink)
 - *word*: sequence of characters separated by a "non-blink" (e.g. [2,3])
- $$\{ [A_1, A_2, \dots, A_n] \mid i, A_i \in \mathcal{N} \text{ and } A_i \leq M, i \leq N \}$$
- Restrictions: A character cannot be "1" (or single-blink), and $M, N \leq 4$

Command Space

- 117 different permutations and 31 unique combinations of commands
- Mapping of commands to 3D space ($\#2 + \#3 + \#4 = N : 3$ parallel planes)

Selecting the Representative Commands

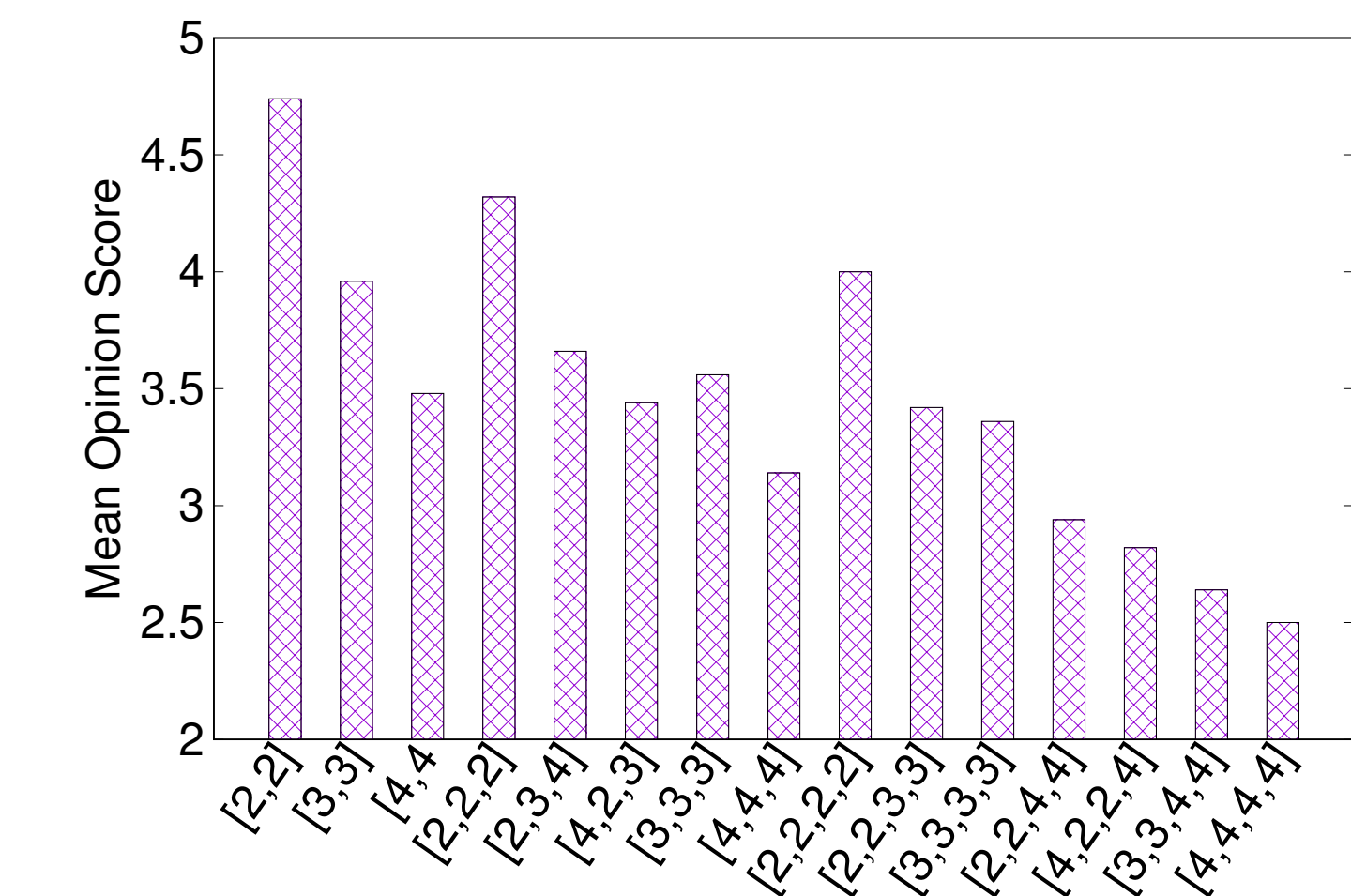
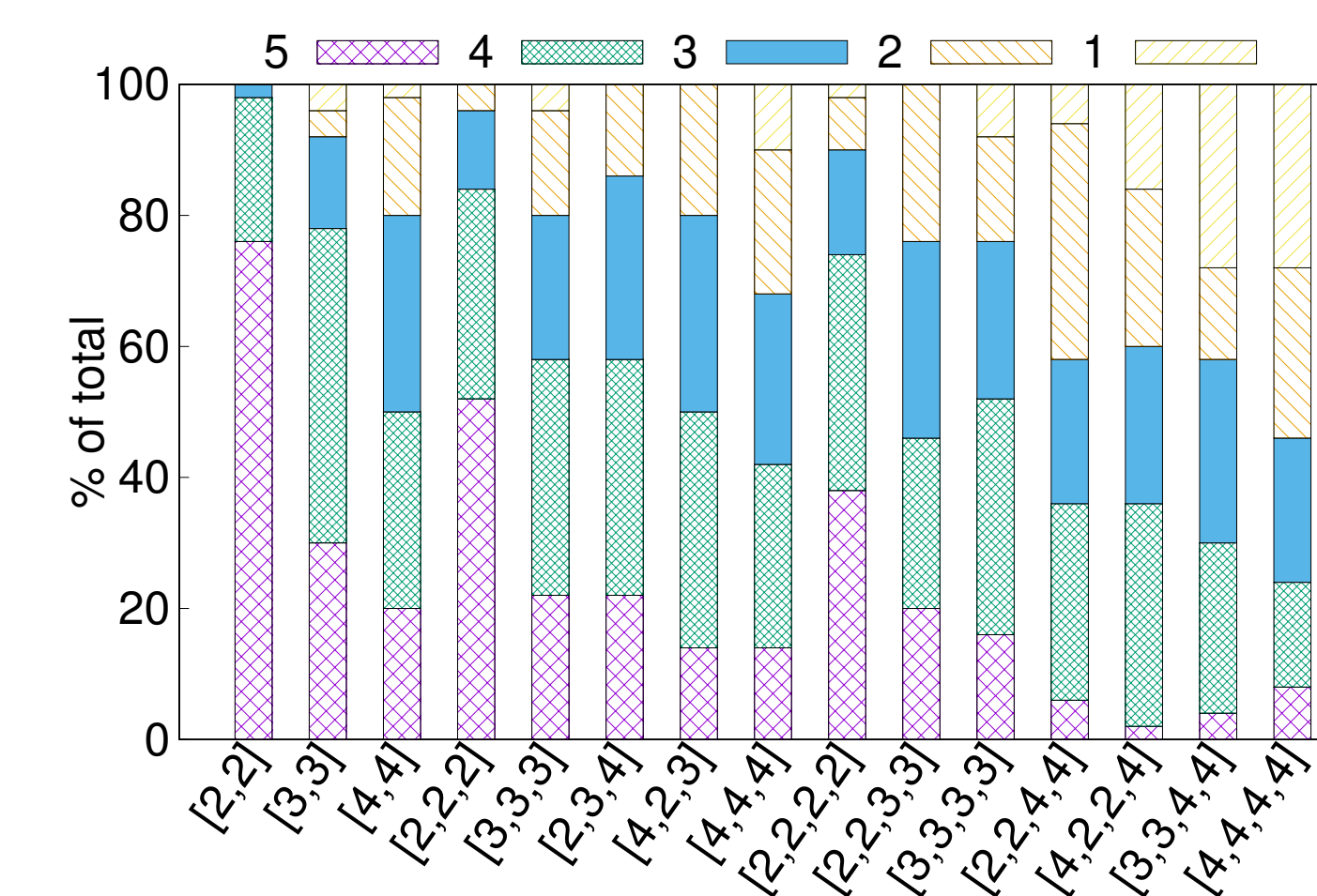
- All commands are within a 1-hop distance from the representative commands while minimizing the cardinality of the representative set
- Two additional commands ([4,2,3] and [4,2,2,4]), to study the effect of permutation



EXPERIMENTAL INSIGHTS

50 users performed the 15 blink commands, and rated them on an mean opinion score (MOS) scale of 1 to 5 (1 being most difficult, 5 being very easy)

- Longer commands with shorter word lengths are preferred over shorter commands with longer word lengths. For e.g. [2,2,2,2] is more comfortable (MOS: 4.0, % of 5s: 38%) as compared to [4,4] (MOS: 3.48, % of 5s: 20%).
- Thus, for a given BCI application with a required vocabulary size, N should be increased before M to ensure user comfort.
- For a particular character combination, different character permutations impacts usability (e.g. [2,3,4] and [4,2,3] has % of 5s as 22% and 14%, and MOS of 3.66 and 3.44 respectively).



FUTURE WORK

- Exploring the command usability with different permutations
- Extending the analysis to other BCI modalities