Elucidating the neural representation of dynamic expressions through EEG-based movie reconstruction

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Introduction

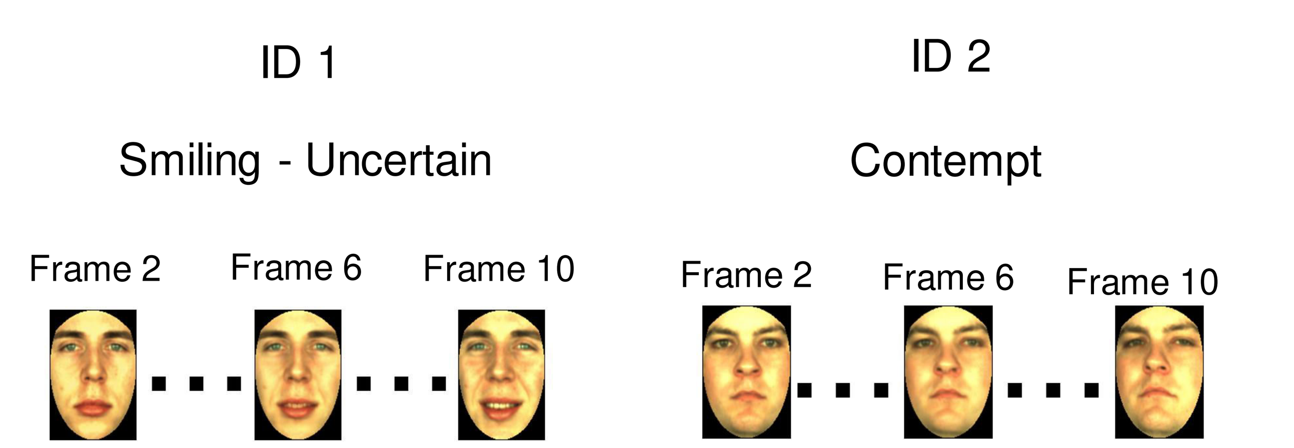
- Neuroimaging has established the involvement of multiple brain regions in facial expression recognition[1-4] and their ability to discriminate amongst the six basic emotional expressions (happy, sad, etc.)[5]
- However, the scope and complexity of expression is much larger (e.g., different types of happy expressions) and it is not clear how expressions are represented
- We use novel electroencephalography (EEG) methodology[6,7] to:

1. Decode a larger set of **more complex expressions.**
2. Reconstruct the appearance of **expression representations.**
3. Establish the feasibility of **EEG-based dynamic stimulus (i.e., movie) reconstruction.**

Methods

Stimuli

- 24 dynamic facial expressions including emotional (e.g., disgust) and conversational expressions (e.g., disbelief) from two Caucasian males[8]
- Dynamic stimuli: 10-frame, 1-second videos (1st frame was a neutral expression and the 10th frame was the peak expression display)



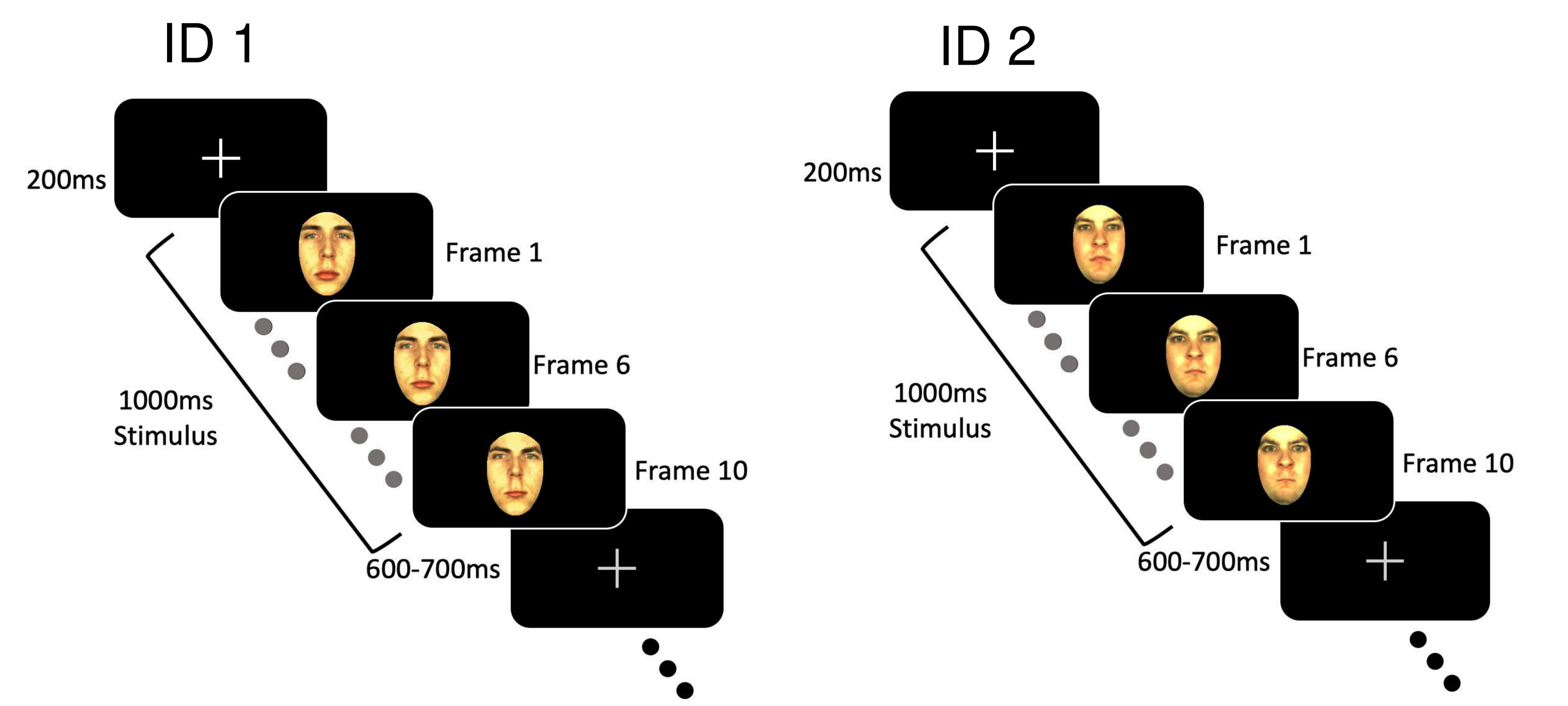
Experiment 1: Behavioural testing

- 20 adult participants completed two behavioural tasks
- In the first task, they completed the Emotion Recognition Index[9]
- Next, participants completed a facial expression similarity judgement task

Methods (cnt'd)

Experiment 2: EEG testing

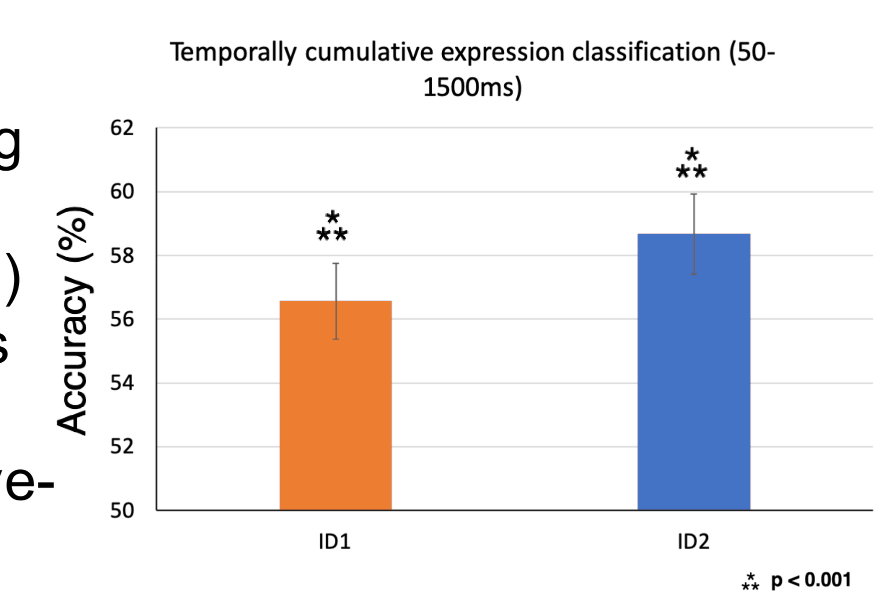
- 8 participants completed a 2-session EEG experiment (64 channel BIOSEMI system)
- Participants viewed sequences of dynamic expression stimuli while performing a go/no-go expression discrimination task
- Each expression was displayed 3 times per block x 32 blocks



Results

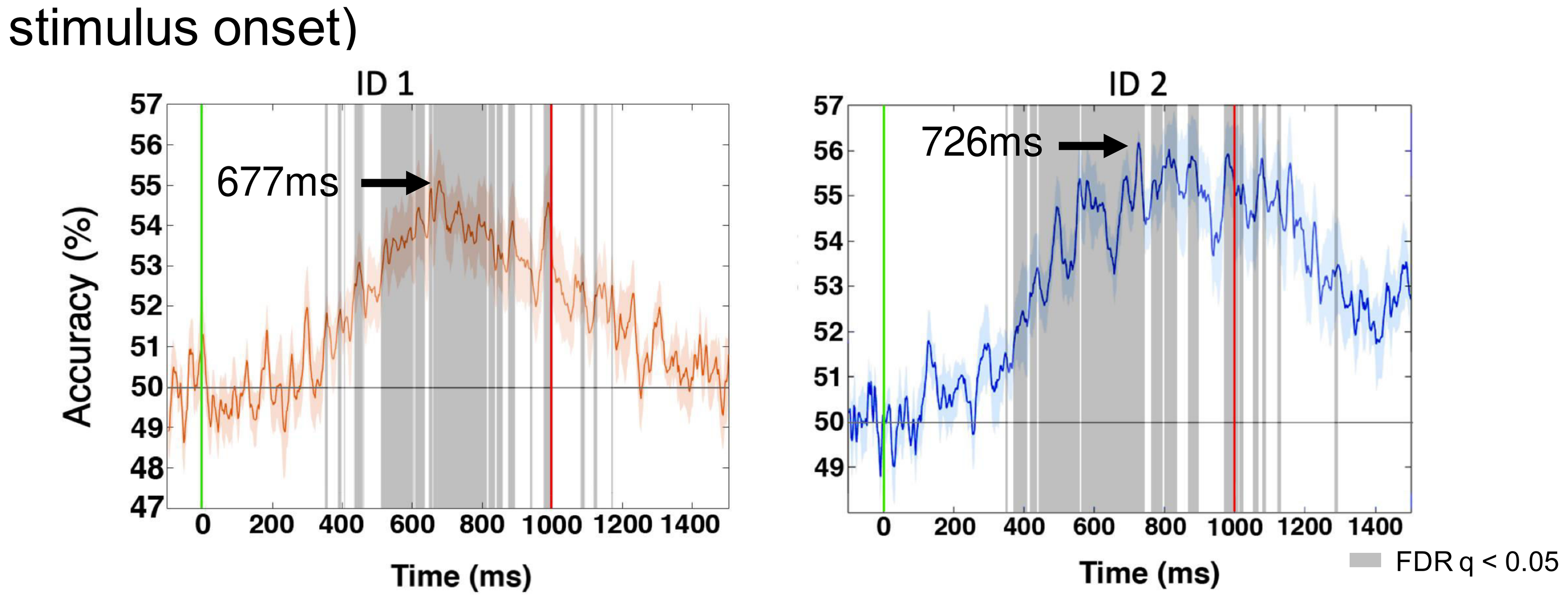
Temporally Cumulative Classification

- Paired stimulus classification using all EEG data between 50-1500ms (64 EEG channels x 742 time bins) on the final frame of each stimulus video.
- Expressions are decoded at above-chance levels (50%)
  - ID1 = 56.56%
  - ID2 = 58.58%



Time Course of Expression Classification

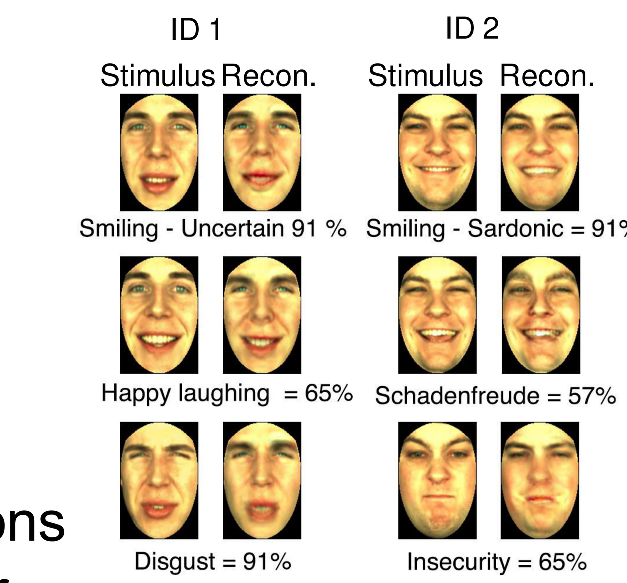
- Expression classification reaches above-chance levels at ~350ms
- Highest classification accuracy (between 670-730ms) occurs before the most expressive frame of the video (1000ms after stimulus onset)



Results (cnt'd)

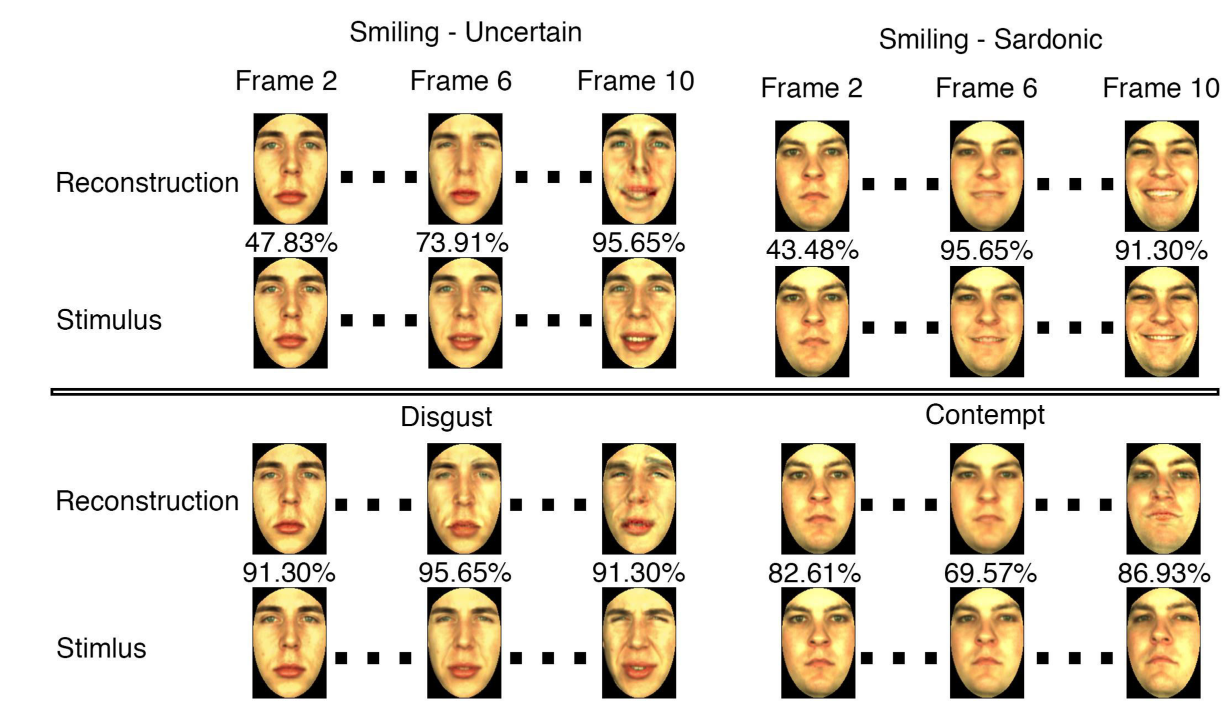
Temporally Cumulative Reconstruction

- Static facial expression stimuli (i.e., the final frame of each stimulus video) are reconstructed from EEG data at above-chance levels
  - ID1 = 60.82%
  - ID2 = 60.95%
- Neural and behaviour-based reconstructions are significantly correlated with each other ($r = .51$, $p < 0.05$)



Frame-by-frame Reconstruction

- Frame reconstruction is based on a 50-300ms interval after frame onset
- Above-chance classification was achieved for all frames
- Reconstruction accuracy peaks for middle frames



Conclusions

- **Innovate:** we develop a new approach for visualizing dynamic percepts from EEG data
- **Discover:** we find that neural signals encode rich and detailed expression information beyond that necessary for decoding just six basic emotions

We provide proof of concept for EEG-based movie reconstruction and we use it to reconstruct dynamic expression representations.

References and Acknowledgments

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This research was funded by the National Sciences and Engineering Research Council of Canada (to JSC and AN).