Contextual constraint and key membership influence neural correlates of melodic prediction violations

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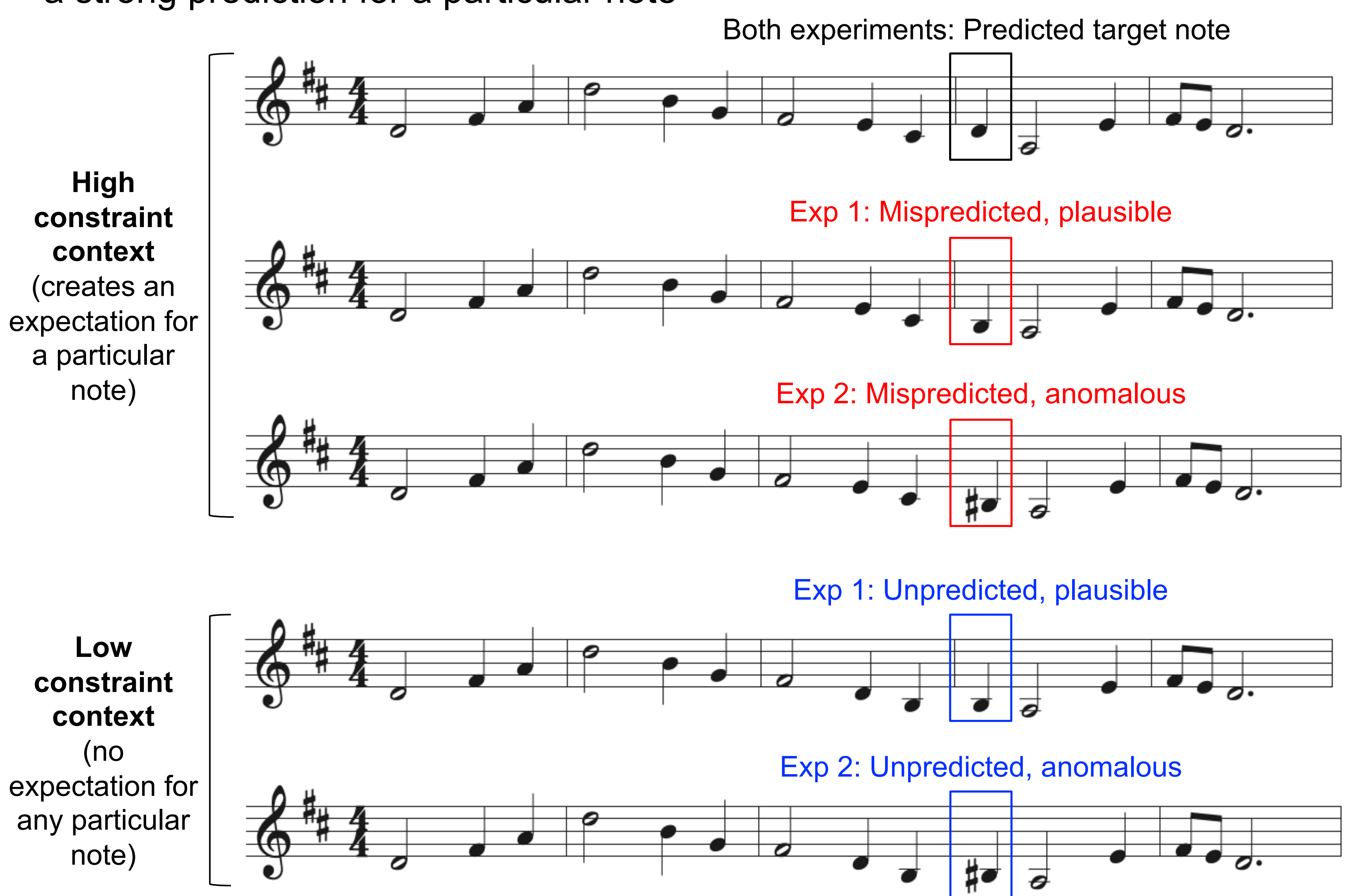
Introduction

- Melodic expectation has been extensively studied using behavioral and neural (ERP) methods.
- In current ERP studies of language, predictions are often examined by manipulating sentence contexts.
- In contrast, neural studies of melodic prediction violations have mainly used incongruent events (e.g., out-of-key notes) in fixed melodic contexts.

- We have developed a new approach based on manipulating melodic context in terms of the degree to which it constrains expectations for one particular note.[1]
- Using this method to study ERP responses to unexpected notes, we can disentangle the effect of a note being low probability (unexpected) from the effect of it also violating a strong expectation for another specific note.
  - When a context leads to an expectation for one particular note, a different note can violate this prediction while still being in-key and congruous.
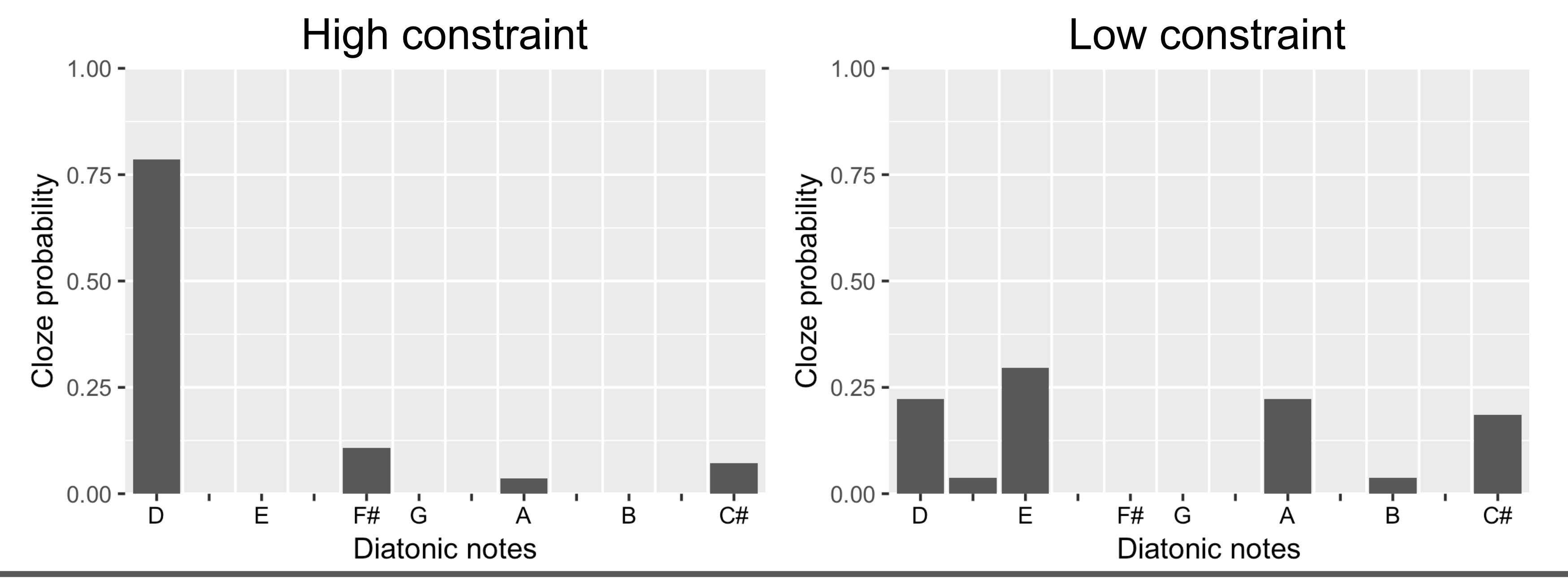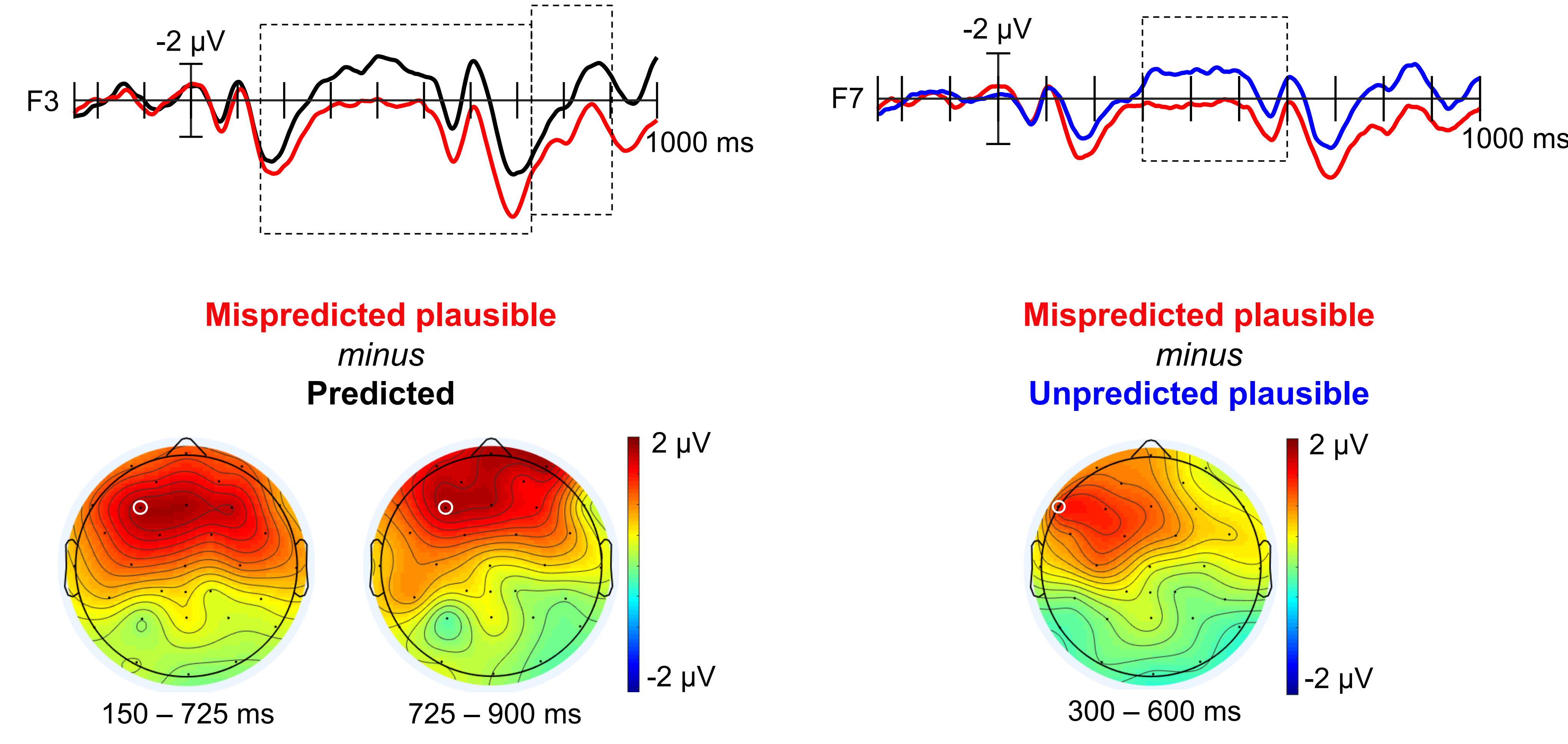

Methods

- Participants: at least 5 years of musical experience within the past 10 years
- Task: listen attentively and answer occasional memory probes
  - No acceptability judgments
- Stimuli: 60 pairs of 10-15 note novel melodies that either did or did not lead to a strong prediction for a particular note
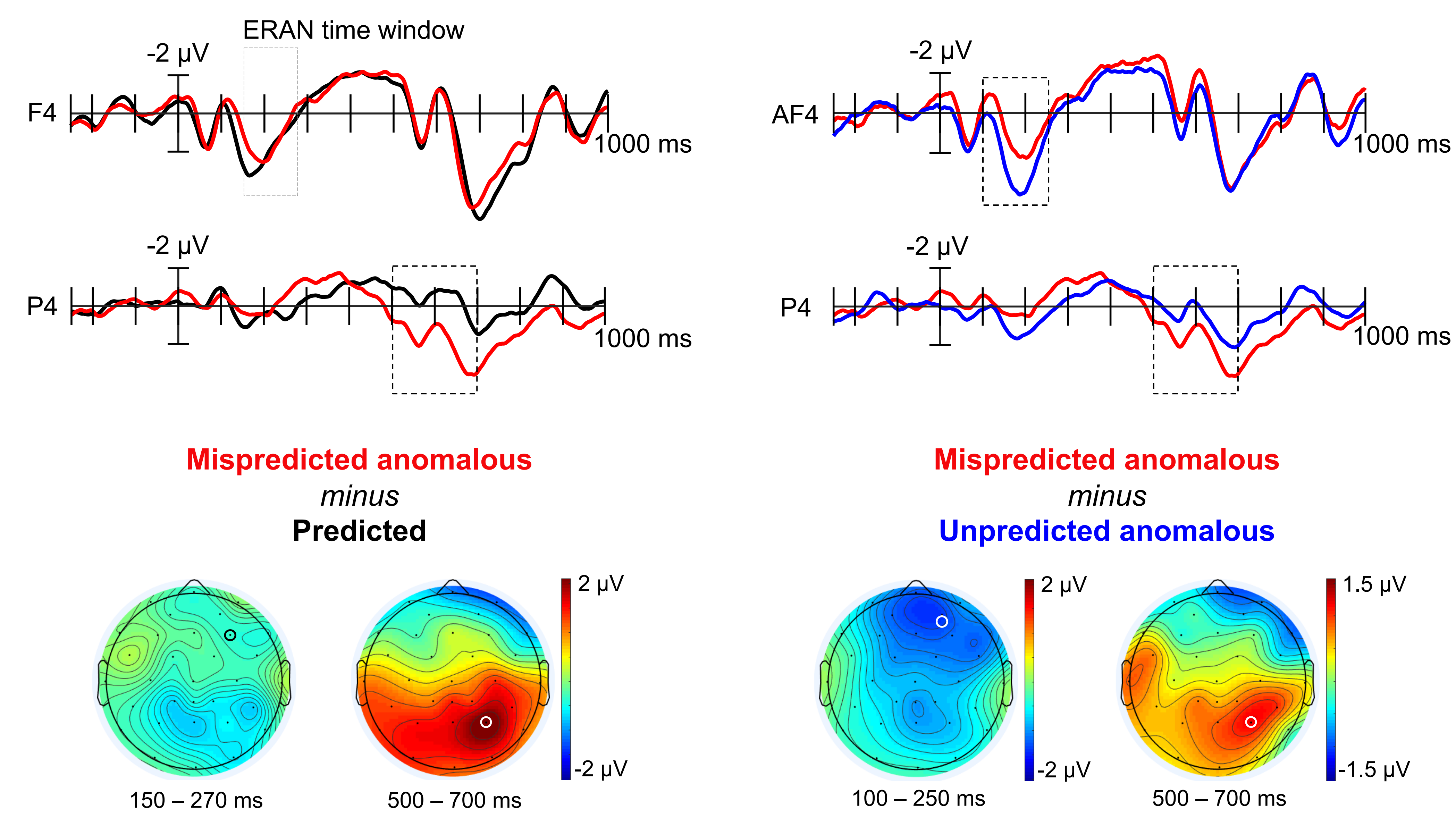

Experiment 1: in-key target notes

Mispredicted plausible *minus* **Predicted**

150 – 725 ms   725 – 900 ms

Mispredicted plausible *minus* **Unpredicted plausible**

300 – 600 ms

- In constraining melodies, unexpected notes elicit a bilateral frontal positivity relative to **expected notes**
- No sign of the early anterior *negativity* (150-300 ms) often associated with musical expectancy violations[2]
- Observed a previously reported early anterior positivity: 280-600 ms[3]

- Unexpected notes in constraining melodies elicit a left-lateralized anterior positivity compared to unexpected notes in non-constraining melodies
  - Significant in time window of late anterior positivity in language studies (600-900 ms)[4,5]
  - Begins earlier (significant at 300-600 ms)

Experiment 2: out-of-key target notes

Mispredicted anomalous *minus* **Predicted**

150 – 270 ms   500 – 700 ms

Mispredicted anomalous *minus* **Unpredicted anomalous**

100 – 250 ms   500 – 700 ms

- Out-of-key notes vs. **expected notes** in constraining melodies elicit:
- No significant early effects (i.e., no ERAN)
- Late posterior positivity (P600)

- Out-of-key notes in constraining melodies vs. out-of-key notes in non-constraining melodies:
- More negative early frontal ERPs[6]
- Late posterior positivity (P600) resembles same contrast in language[4]

Conclusion

- In **Experiment 1**, in-key target notes that violated a strong prediction (i.e., unexpected notes in a constraining melody) elicited a late anterior positivity compared to the same unexpected target notes in non-constraining melodies.
  - This result differs notably from the early right anterior negativity that has previously been associated with musical expectancy violations.[2]

- In **Experiment 2**, out-of-key target notes elicited a late posterior positivity (P600) compared to expected notes in constraining melodies.
  - Again, no early anterior negativity was observed.

- Across these experiments, we found brain responses to unexpected notes that differ from the responses reported by many music studies.

- However, these results bear a striking resemblance to the neural responses found in language studies using comparable manipulations of word expectedness and sentential constraint.

References

1. Fogel et al., 2015 *Frontiers in Psychology*
2. Miranda & Ullman, 2007
3. Pearce et al., 2010
4. Kuperberg et al., 2019
5. Federmeier et al. 2007
6. Hsu. et al., 2015

Audio examples: bit.ly/Fogel-CNS