



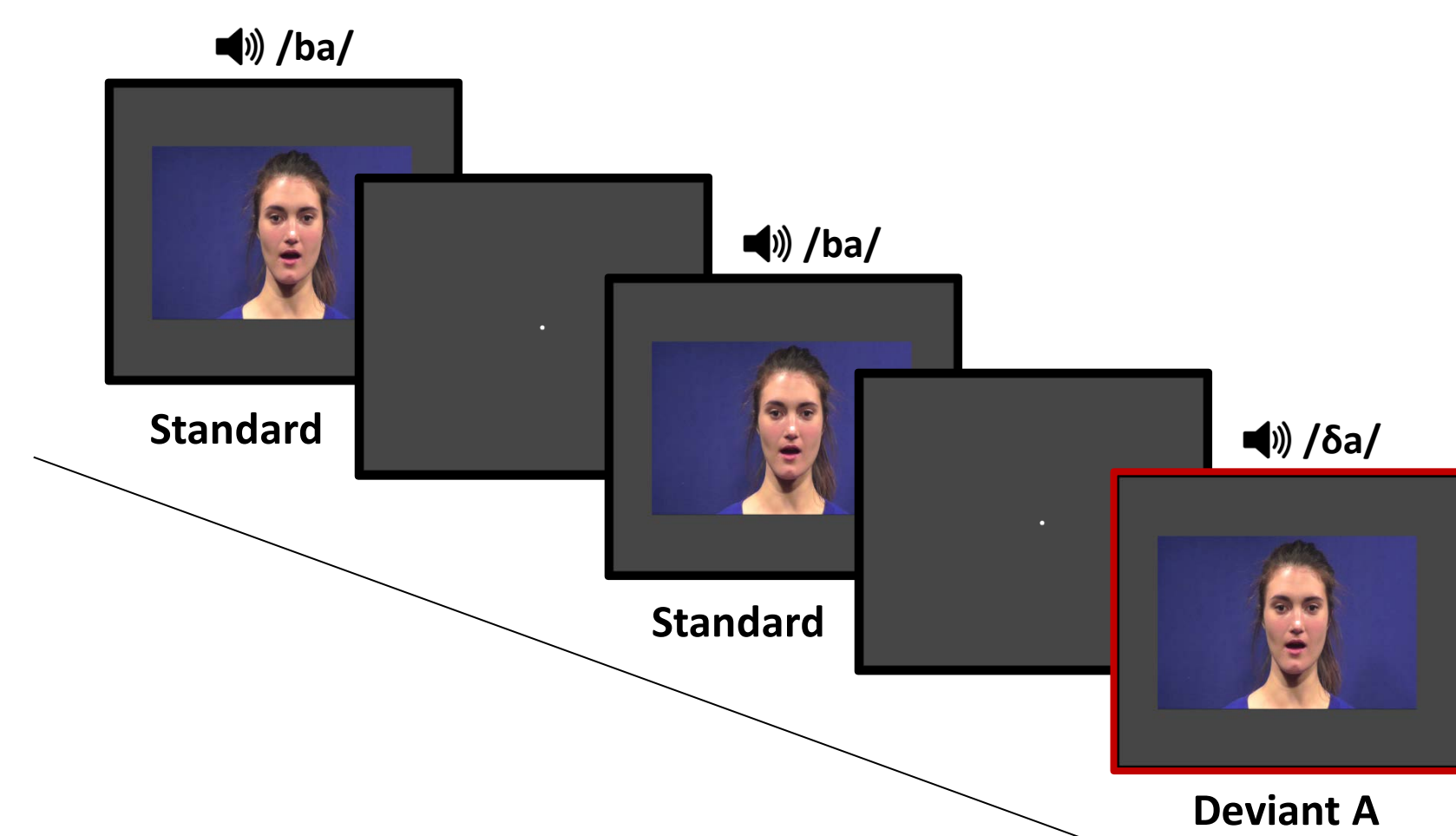
# Multistage audiovisual speech processing modulating the mismatch negativity

Orestis Papaioannou<sup>1</sup>, Julia Strand<sup>2</sup>, Christian Gaulty<sup>1</sup>, Kevin Ortego<sup>1</sup>, Enriqueta Canseco-Gonzalez<sup>1</sup>;  
<sup>1</sup>Reed College, <sup>2</sup>Carleton College

## Background

- Previous studies<sup>1</sup> have reported that, under certain circumstances, incongruent audiovisual speech stimuli (e.g. a visual /ga/ with an auditory /ba/) are fused together to form an illusory percept (/da/ in the previous example). This phenomenon has been termed the McGurk effect.
- However, it is currently unknown *when* this integration occurs.
- We used the mismatch negativity (MMN), an event related potential (ERP) component that is sensitive to deviations in auditory patterns<sup>2</sup>, to investigate whether the McGurk effect takes place during that time period (roughly 200ms-300ms from stimulus onset).

## Design and Predicted Results

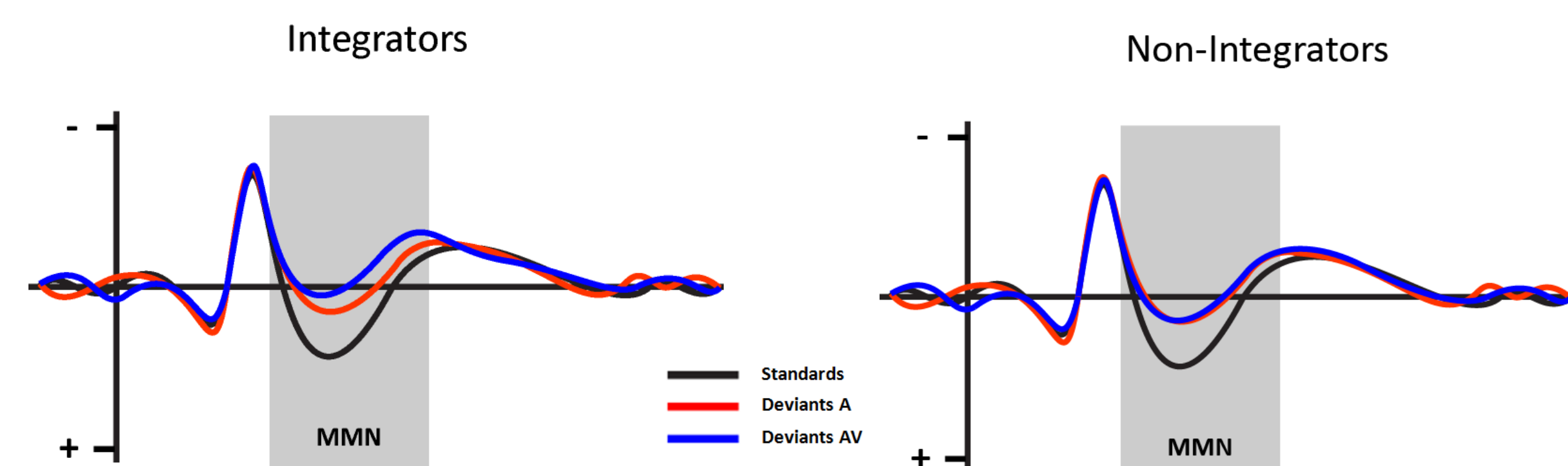


A graphical representation of the oddball paradigm used in this experiment

- We recorded EEG activity during an oddball paradigm. All stimuli consisted of a silent video of a person saying /ba/ or /da/, paired up with a computer generated auditory syllable.
- For standards, the paired auditory syllable was congruent with the video.
- For auditory deviants (Deviant A), the syllable consisted of an ambiguous syllable (/da/), lying on the boundary between /ba/ and /da/.
- For audiovisual deviants (Deviant AV), the ambiguous syllable (/da/) was paired with a different video, biasing perception away from the standard syllable.
- A distractor task was used, where participants were asked to respond whenever they detected a white square on the screen.
- After the recording session was finished, a behavioral measure was administered to assess the participant's susceptibility to the McGurk effect, allowing us to separate our participants into integrators (N = 10) and non-integrators (N = 11).

	Standard (72%)		Deviant A (14%)		Deviant AV (14%)	
	Video	Sound	Video	Sound	Video	Sound
Block A	/ba/	/ba/	/ba/	/da/	/da/	/da/
Block B	/da/	/da/	/da/	/da/	/ba/	/da/

- If the McGurk effect occurs during, or before, the time window of MMN, then Deviant AV should be perceived (at least in integrators) as more deviant than Deviant A and elicit a larger MMN.
- In contrast, perception in non-integrators should be less affected by the visual information, thus a similar-amplitude MMN for both types of deviants would be expected.



Predicted ERP results for integrators and non-integrators, assuming audiovisual integration in speech occurs during or before the time window over which the MMN is observed.

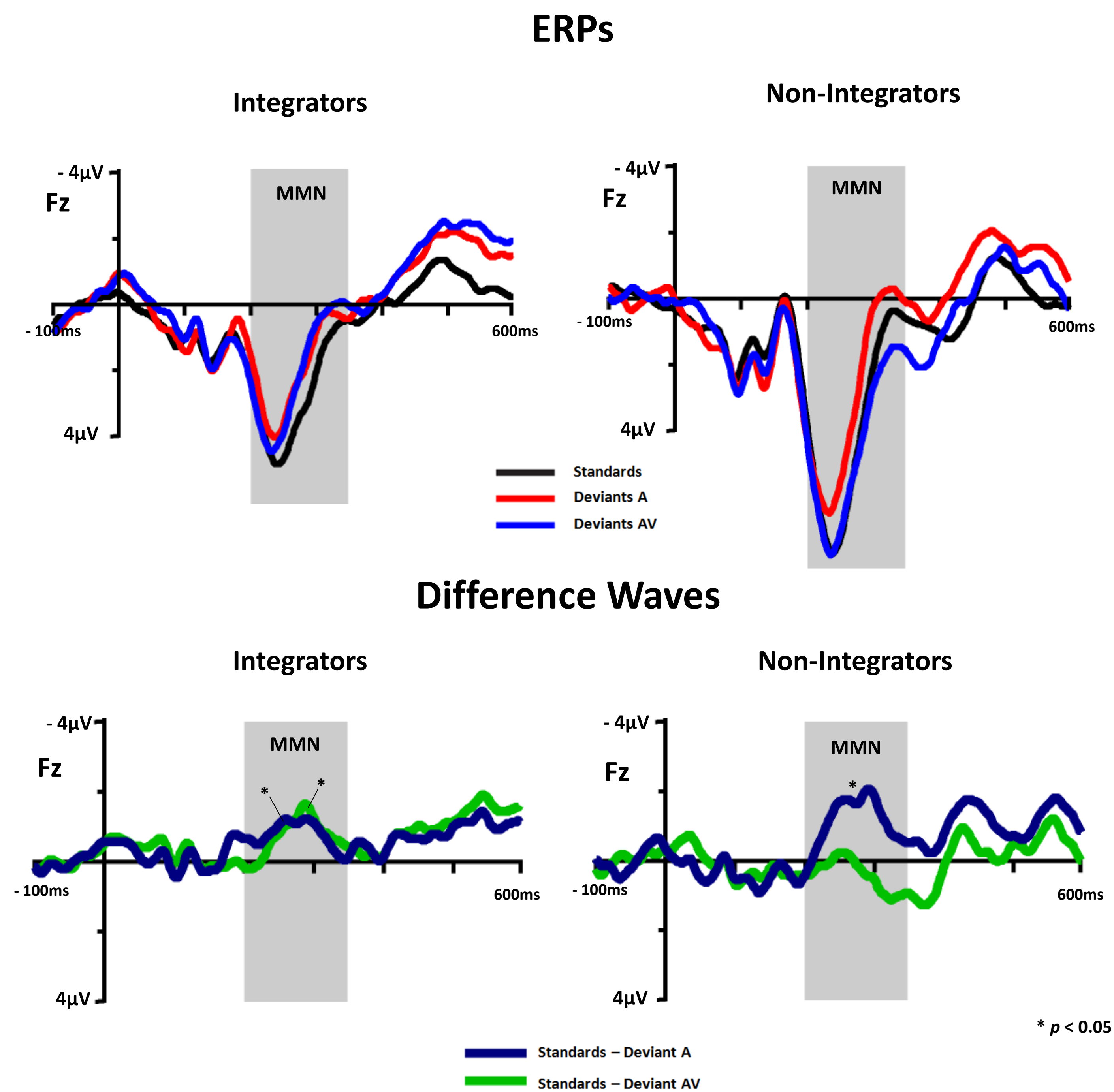
## References

<sup>1</sup>McGurk, H., McDonald, J. (1976), Hearing lips and seeing voices. *Nature* 264, 746– 748.

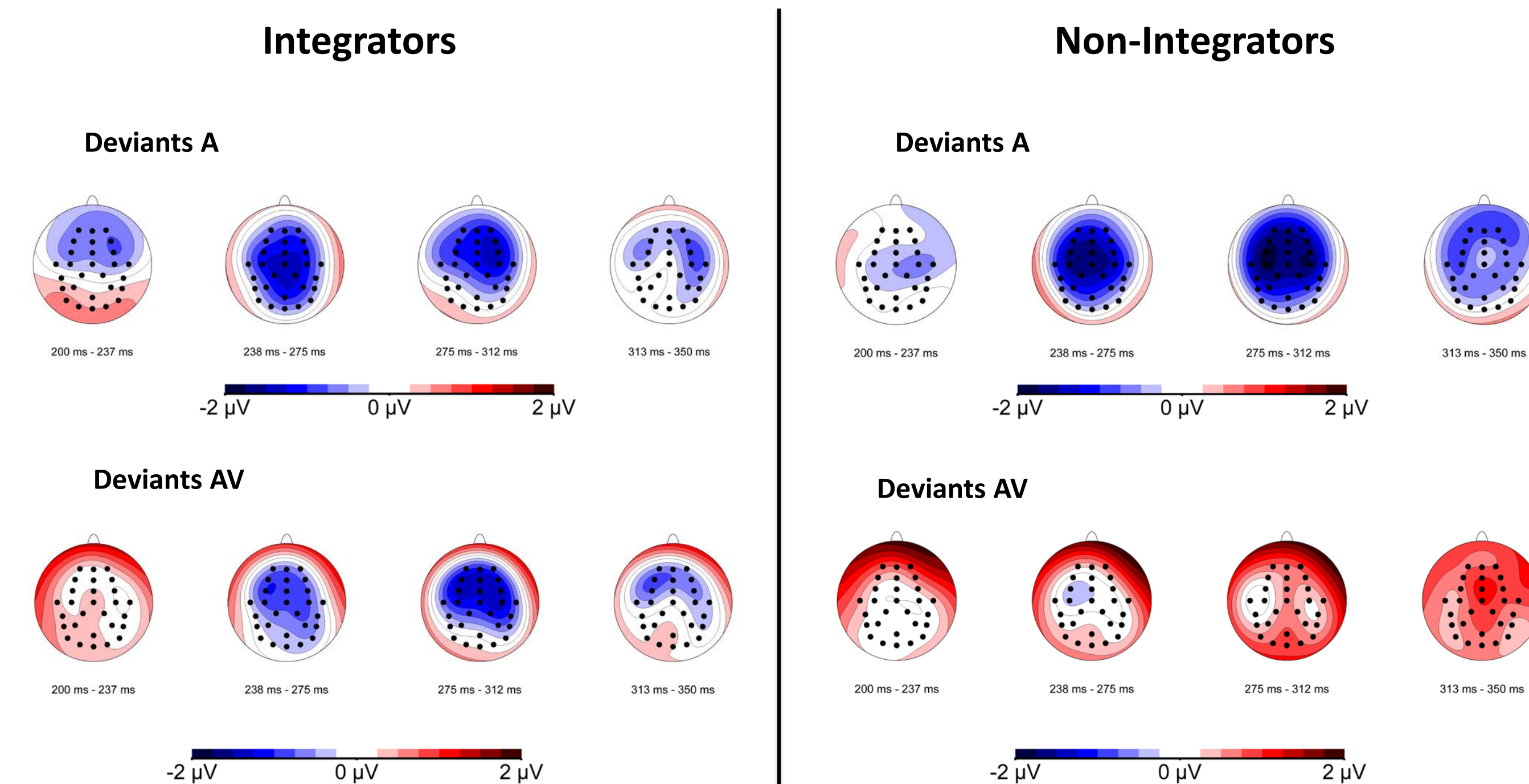
<sup>2</sup>Näätänen, R. (2001), The perception of speech sounds by the human brain as reflected by the mismatch negativity (MMN) and its magnetic equivalent (MMNm). *Psychophysiology*, 38, 1–21.

<sup>3</sup>Strand, J., Cooperman, A., Rowe, J., & Simenstad A. (2014), Individual differences in susceptibility to the McGurk effect: Links with lipreading and detecting audiovisual incongruity. *Journal of Speech, Language, & Hearing Research*, 57, 2322-2331.

## EEG Results - MMN



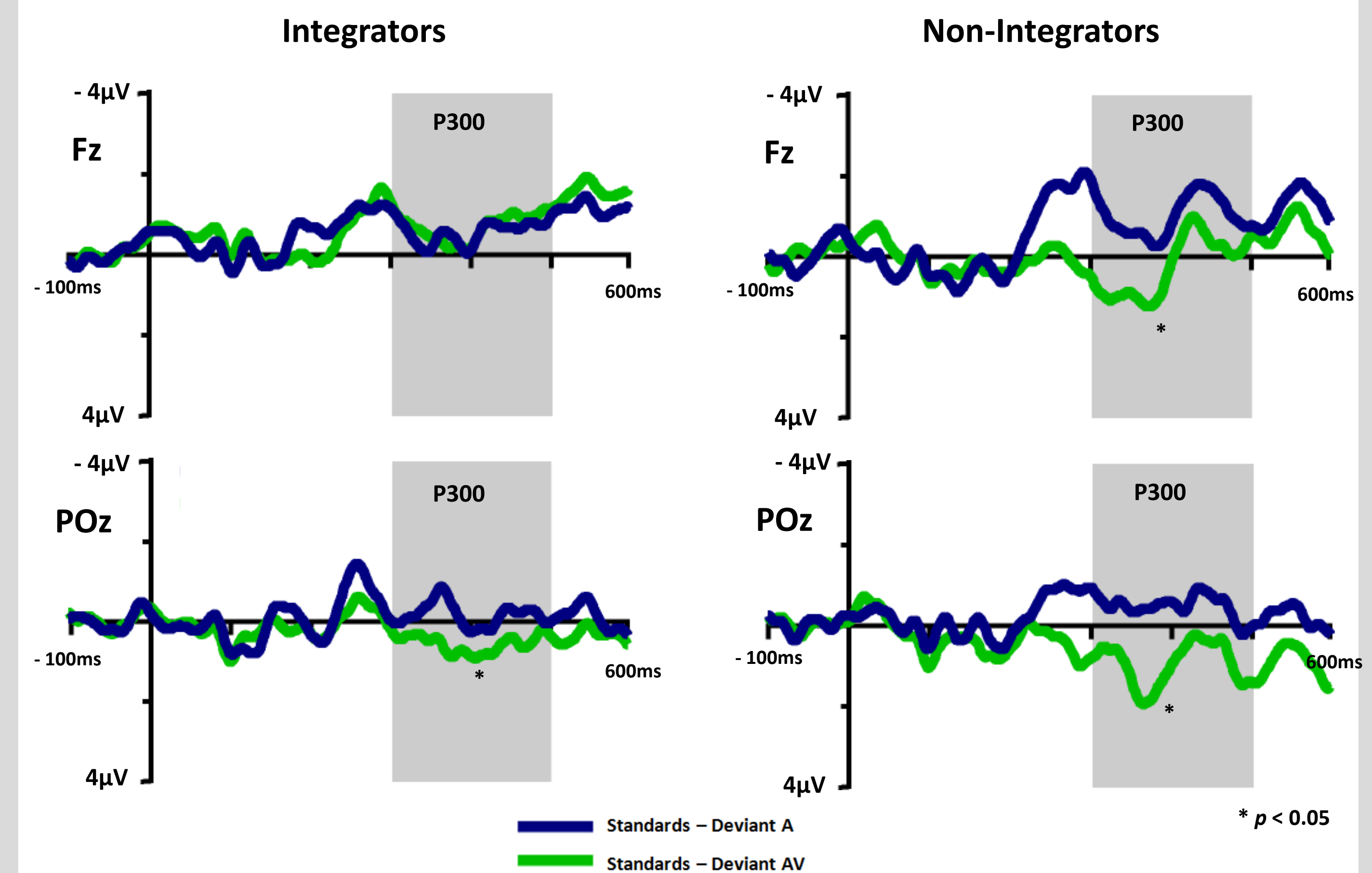
## Difference Maps



- We found a significant mismatch negativity (200ms-350ms after sound onset) in both groups for deviants A, as well as for deviants AV in integrators. However, no significant differences in this time window were found for deviants AV in non-integrators.
- No significant differences were found between the MMN elicited by deviants A or deviants AV for integrators. A significant difference was observed for non-integrators, with deviants AV being significantly more positive over the time period.
- A mixed ANOVA revealed a main effect of deviant type ( $F = 12.79, p < 0.01$ ), but not group ( $F = 1.23, p > 0.1$ ), and a significant interaction between group and deviant type ( $F = 6.93, p < 0.05$ ).

## EEG Results – P300 complex

### Difference Waves



- A significant positivity was found in posterior electrodes between 300-500ms for deviants AV in both integrators and non-integrators. This positivity is likely a P300b, which has a similar distribution and timing, and is often reported in oddball paradigms.
- A significant positivity was also found in fronto-central electrodes, but only for deviants AV in non-integrators. Due to the frontal distribution and relatively sharp peak latency, this is more similar to a novel P300, which is also found in presentations of deviant or unexpected stimuli.

## Conclusions

- Our results suggest that audiovisual integration of speech *does not* occur during, or before, the time window where the MMN occurs.
  - Integrators showed a similar sized MMN to both types of deviants, despite deviants AV being perceptually more deviant
  - Non-integrators did show a difference between deviants, but in the opposite direction than what would be expected if this difference was due to the McGurk effect.
- However, the unexpected lack of MMN found for deviants AV in non-integrators is intriguing. Perhaps, some other process is occurring during that time, one that affects groups/deviant types differentially, which is somehow overriding the MMN. However, the functional significance of this difference is still unclear.
- One possibility is that this is due to some incongruency detection mechanism. Poor integrators have been shown to be better at detecting audiovisual incongruencies<sup>3</sup>, which might explain why this effect is particularly pronounced in non-integrators.
- Another possibility is that there is a visual deviancy effect that is particularly potent in non-integrators. The presence of a relatively sharp-peaked frontocentral positivity around 300ms for deviants AV in non-integrators, points possibly towards a novel P300, which is likely linked to this visual deviancy. In fact, a more posterior P300b-like component, present in both groups, only for deviants AV, may suggest that the participants were attending to this difference (as if it was task-relevant).

## Future Research

- Further research could isolate the effect of congruency, by using unambiguously congruent or incongruent stimuli, to see how they affect ERPs in a similar context.
- Similarly, investigating how visual deviancy affects the MMN, or ERPs in general, may help explain the lack of an MMN for deviants AV in non-integrators.
- Lastly, this study showcases how different the electrophysiological responses of integrators and non-integrators are, and suggests that this distinction should be taken into account in future experiments investigating audiovisual integration in speech.