Fishing for information: How children learn to interpret focus

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The Project

- Concerned with the interplay of pragmatic and prosodic information sources during discourse perception
- Brain markers for the processing of focus information in dialogs in
  - Adults
  - Adolescents (12 year olds)
  - Middle childhood (8 year olds)
  - Pre-schoolers (5 year olds)
- Identification of an appropriate (normal) development for perceiving focus information

Dialogs: Form and function

- Dialogs = suprasentential units for information transmission
- Sentences within dialogs are not independent from each other but also rely on a preceding context
- Information that is not mentioned in the context or contrasting facts = FOCUS (“centers” of information)
- In spoken language, prosody is a highly important means to mark FOCUS

Neurophysiology and focus perception in adults

- Visual processing of syntactic focus in sentences
  - Focus **positivity** for **new** information (Bornkessel et al., 2003)
  - **P3b** for **contrastive** information (Cowles et al., 2007)
  - **N400** for **inappropriate** focus referent (Cowles et al., 2007)

- Auditory processing of pragmatic and prosodic focus
  - Focus **positive** shift for **new** information (Hruska et al., 2004, Toepel et al., 2004)
  - Focus **positive** shift for **contrastive** information irrespective of prosodic realization (Toepel et al., 2007)
  - **Negativity** for **incongruent** focus accentuation (Toepel et al., 2007)

Neurophysiological markers in children

- Up to date, no neurophysiological evidence for focus processing

- Yet, markers found for syntactic, semantic and prosodic processing on single sentence level
  - Early left anterior negativity (ELAN) and a late, centro-parietal positivity (P600) for syntactic violations (Oberecker et al., 2005)
  - Negativity (N400) for semantic violations (Hahne et al., 2004)
  - Closure Positive Shift (CPS) in correlation to the processing of major prosodic boundaries (Pannekamp et al., 2007)

Open question

- Do children make use of the same focus marking cues as adults?
- Is prosody an inevitable cue for children to perceive focus in spoken language?
- Do children exhibit similar brain responses to focus information as adults?
- Alternatively, how do developmental shifts during discourse acquisition manifest?

Material: dialog types

- Short spoken question – answer pairs
- Child-adequate production (2 female speakers mimicking a dialog situation)
- 2 types of context questions:
  - New information
  - Contrastive information
- Combined with either appropriate or inappropriate prosodic realization
- 40 dialogs per condition → a total of 160 dialogs

Material: example for the dialog construction

	New information	**Correction of an information**
Question	Wen hat Thomas gefragt? Who did Thomas ask?	Hat Thomas Anne gefragt? Did Thomas ask Anne?

With literal translations

Material: example for the dialog construction

	New information	**Correction of an information**
Question	Wen hat Thomas gefragt? Who did Thomas ask?	Hat Thomas Anne gefragt? Did Thomas ask Anne?
Answer: prosodically congruent	Thomas hat LISA gefragt. Thomas did LISA ask.	Thomas hat LISA gefragt. Thomas did LISA ask.

With literal translations

Material: example for the dialog construction

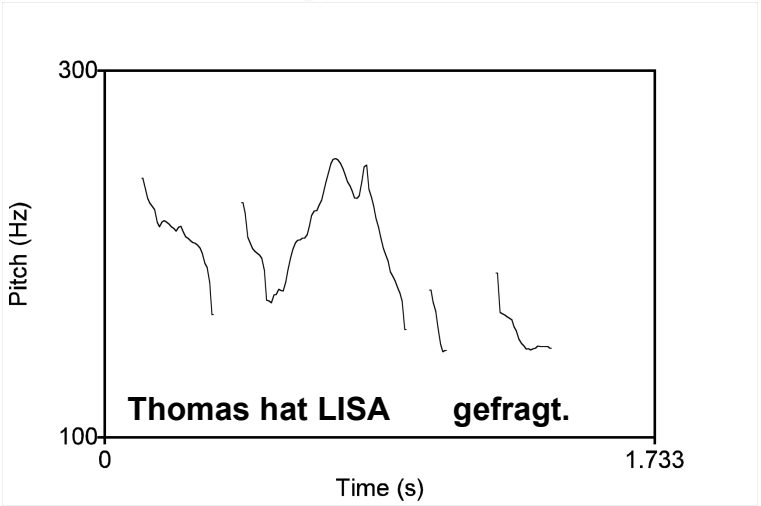
	New information	**Correction of an information**
Question	Wen hat Thomas gefragt? Who did Thomas ask?	Hat Thomas Anne gefragt? Did Thomas ask Anne?
Answer: prosodically congruent	Thomas hat LISA gefragt. Thomas did LISA ask.	Thomas hat LISA gefragt. Thomas did LISA ask.
Answer: prosodically incongruent	*Thomas hat Lisa gefragt. *Thomas did Lisa ask.	*Thomas hat Lisa gefragt. *Thomas did Lisa ask.

With literal translations

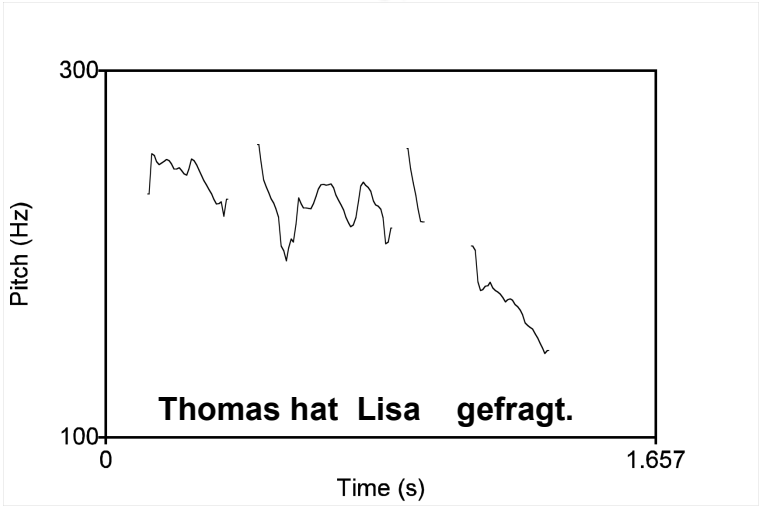
Material: example for condition NEW

Question NEW
Wen hat Thomas gefragt?

Answer prosodically congruent
Thomas hat LISA gefragt.



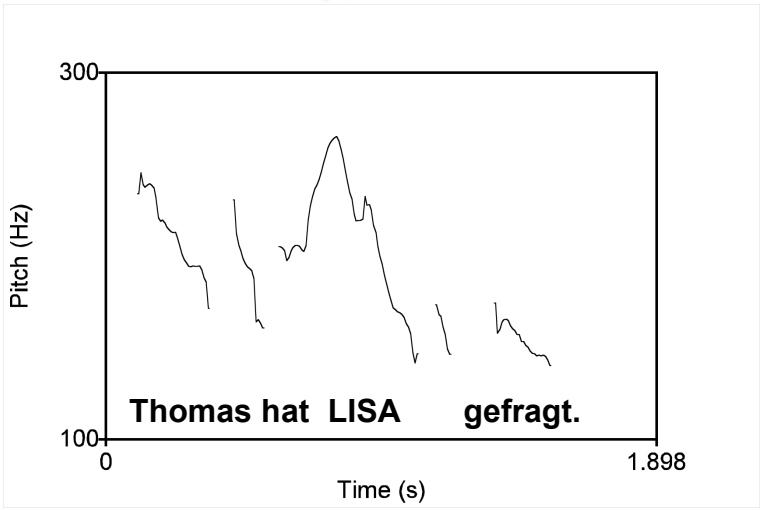
Answer prosodically incongruent
Thomas hat Lisa gefragt.



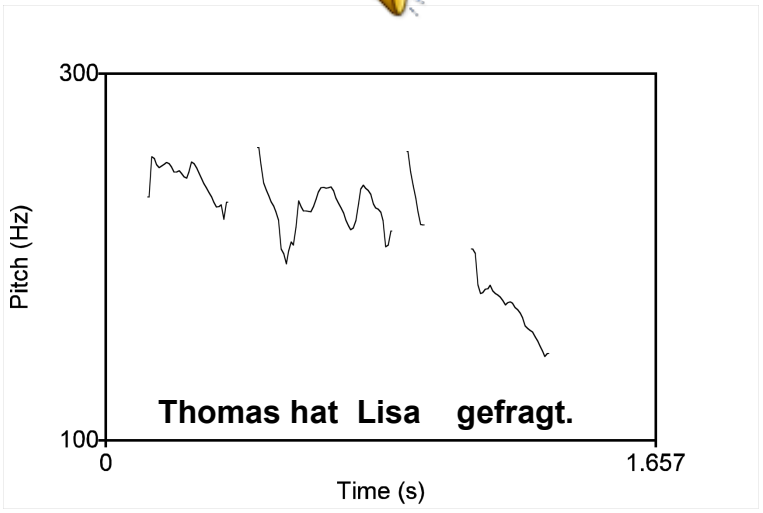
Material: example for condition COR

Question COR
Hat Thomas Anne gefragt?

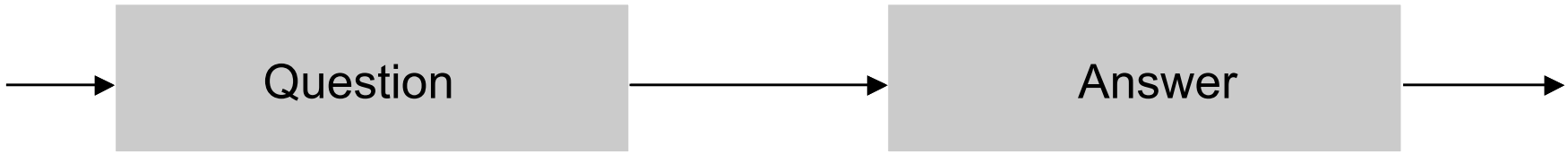
Answer prosodically congruent
Thomas hat LISA gefragt.



Answer prosodically incongruent
Thomas hat Lisa gefragt.



Test procedure



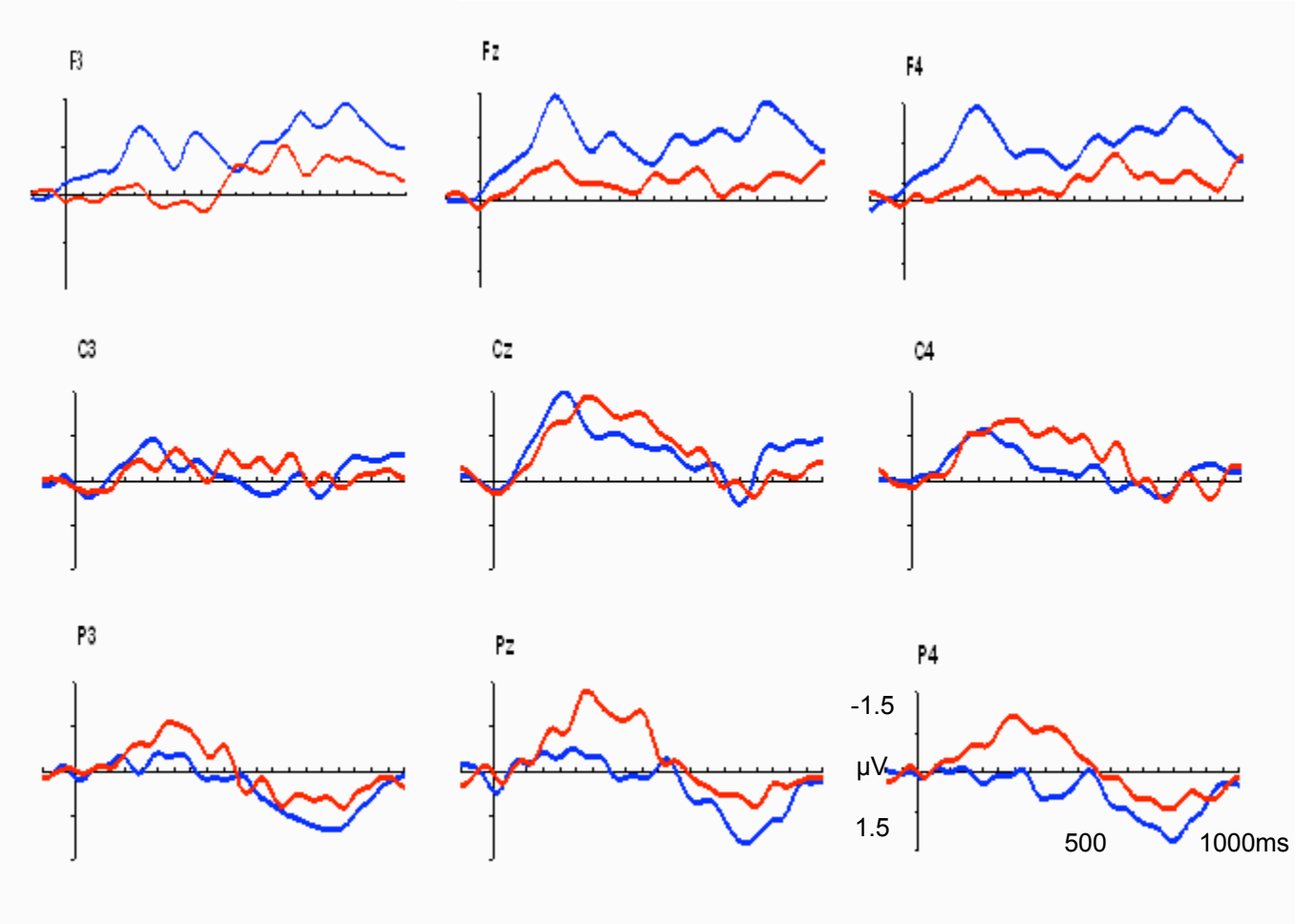
1000ms ISI 2000ms ISI 3000ms
(blink phase)

- Presentation of a crosshair starting 1000 ms before the trial and lasting until the end
- Comprehension questions in randomized order between dialogs for to assure attention

Adults

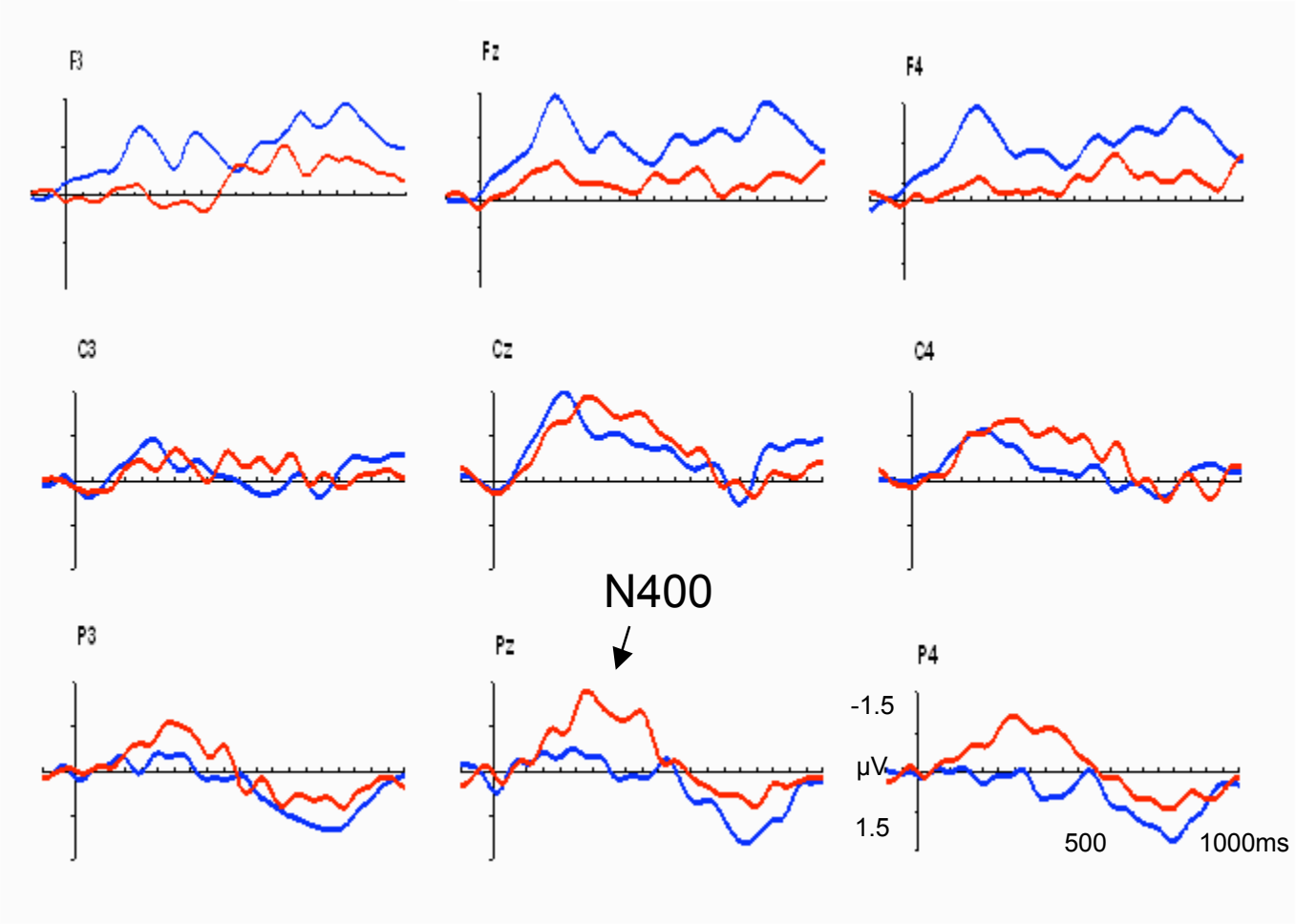
- Subjects: 31 students (15 female, 16 male)
- Mean age 23,8 years (19 - 32 ys)
- Right-handed
- Recording from 64 electrodes
- Sampling frequency: 500 Hz
- Online referenced to left mastoid, recalculated to the average reference offline
- Analyses on peri-stimulus epochs -100 to 1000ms to onset of focus position

Adults (condition NEW): ROI statistics



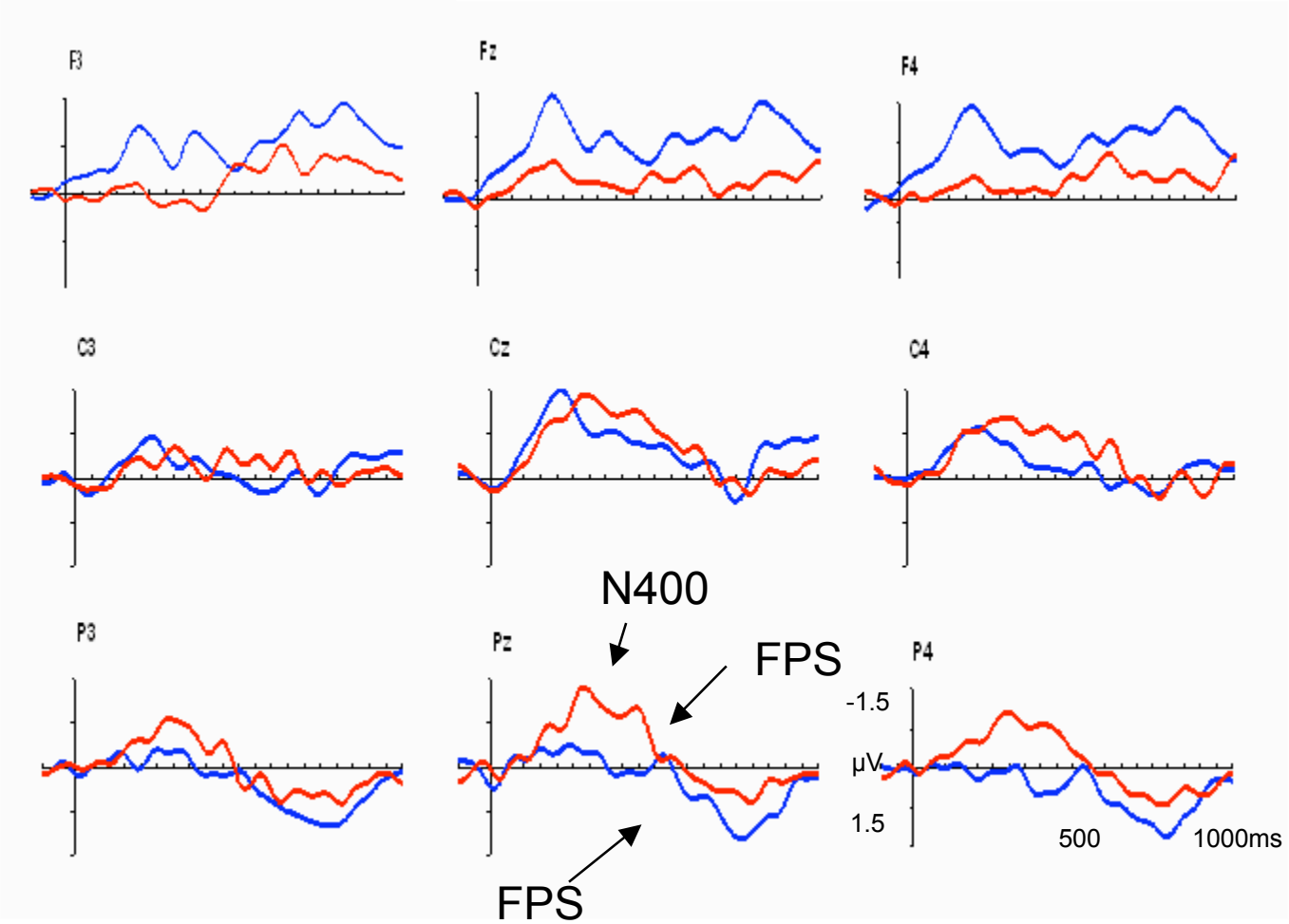
Congruent prosody
Incongruent prosody

Adults (condition NEW): ROI statistics



Congruent prosody
Incongruent prosody

Adults (condition NEW): ROI statistics



TW 200 – 400 ms
F(2,60)=18.38, p<.01

TW 600 – 800 ms
F(2,60)=6.27, p<.01

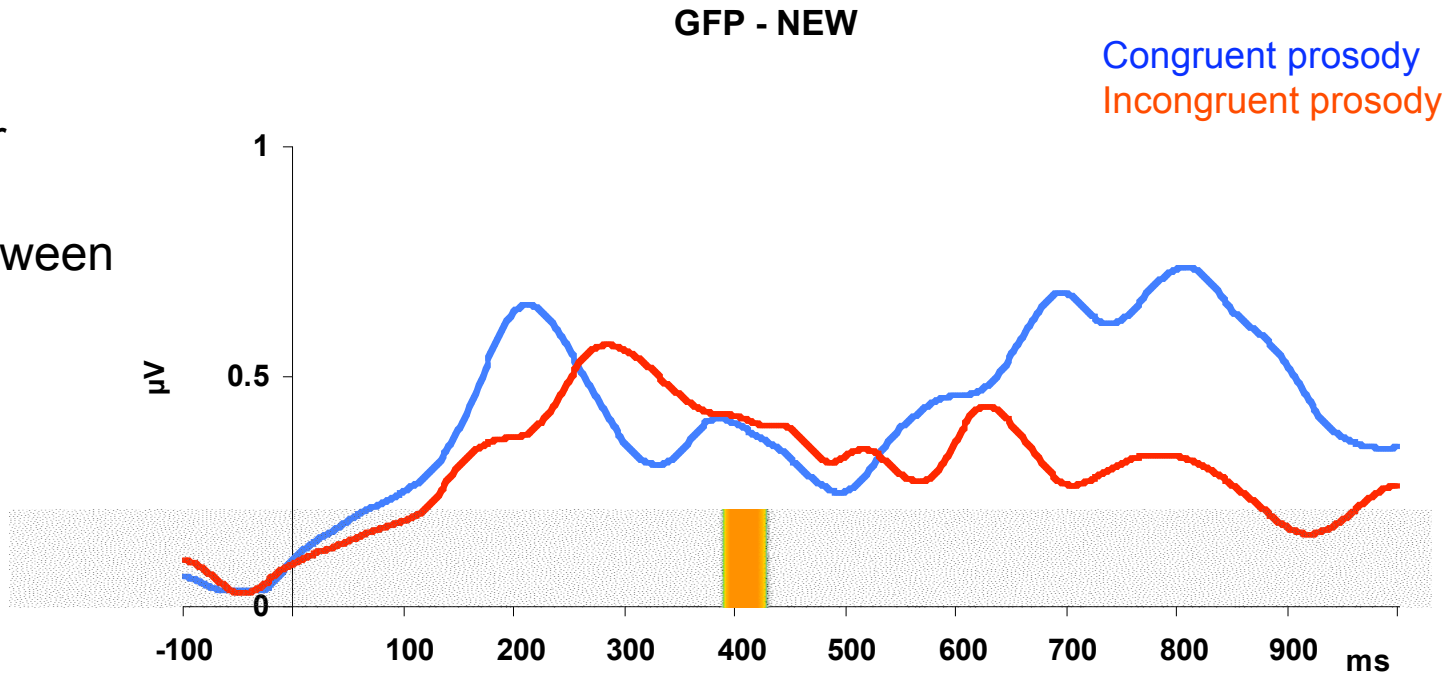
TW 800 – 1000 ms
F(2,60)=5.58, p<.01

FPS = Focus-correlated Positive Shift

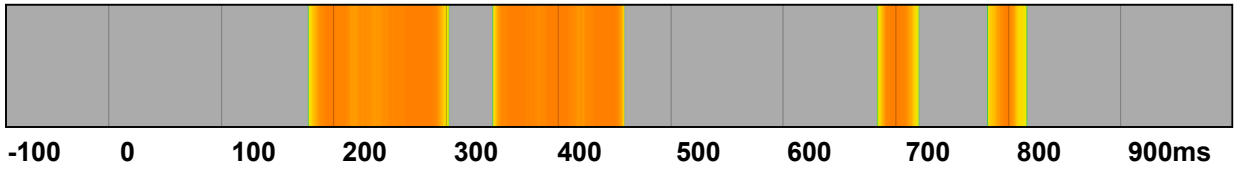
Congruent prosody
Incongruent prosody

Adults (condition NEW): Global electric field analyses

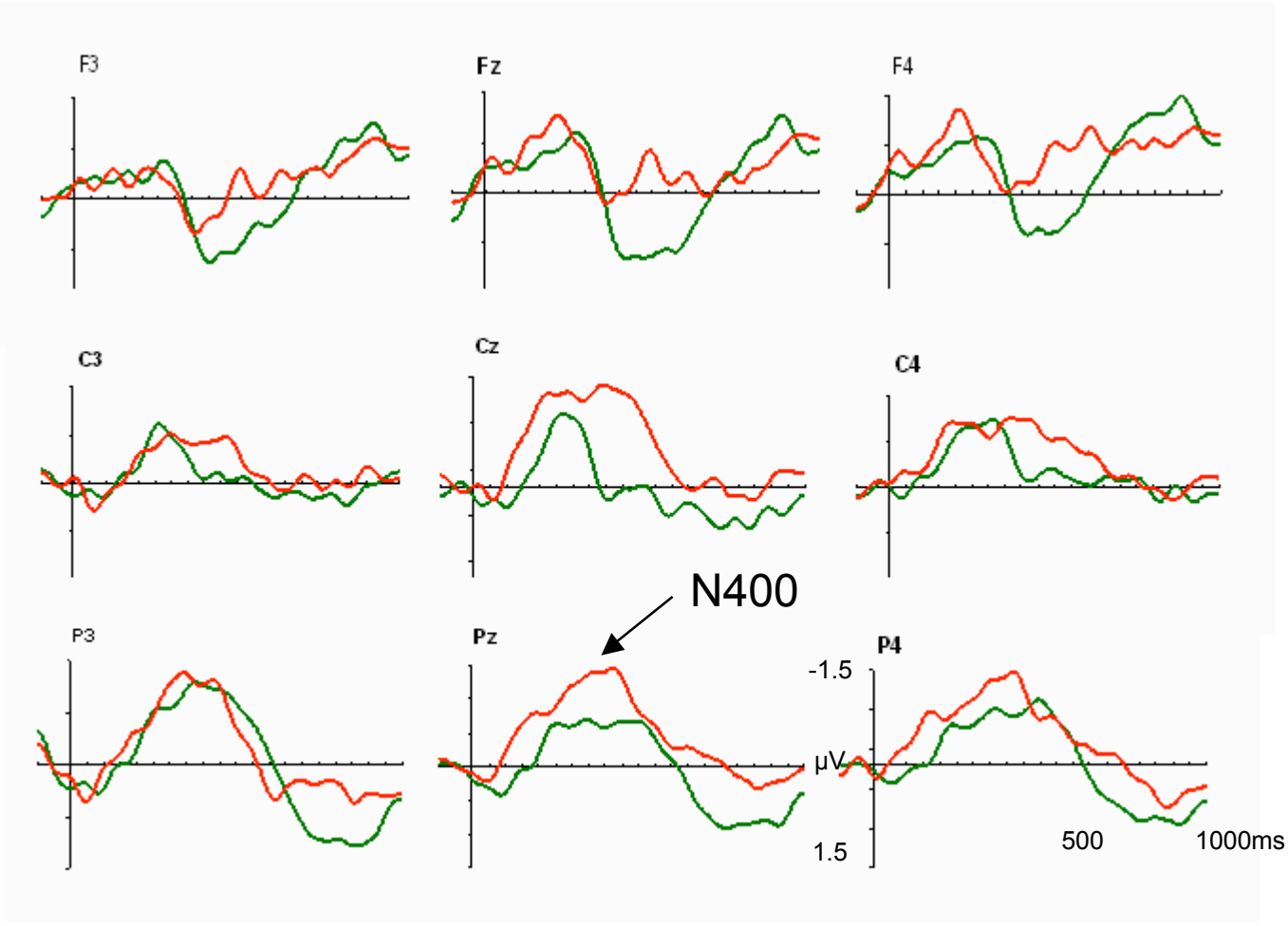
Global field power (GFP)
→ differences between 392-420ms



Topographic Dissimilarity (DISS)
→ differences between 180-304, 344-460, 686-722 and 784-820ms

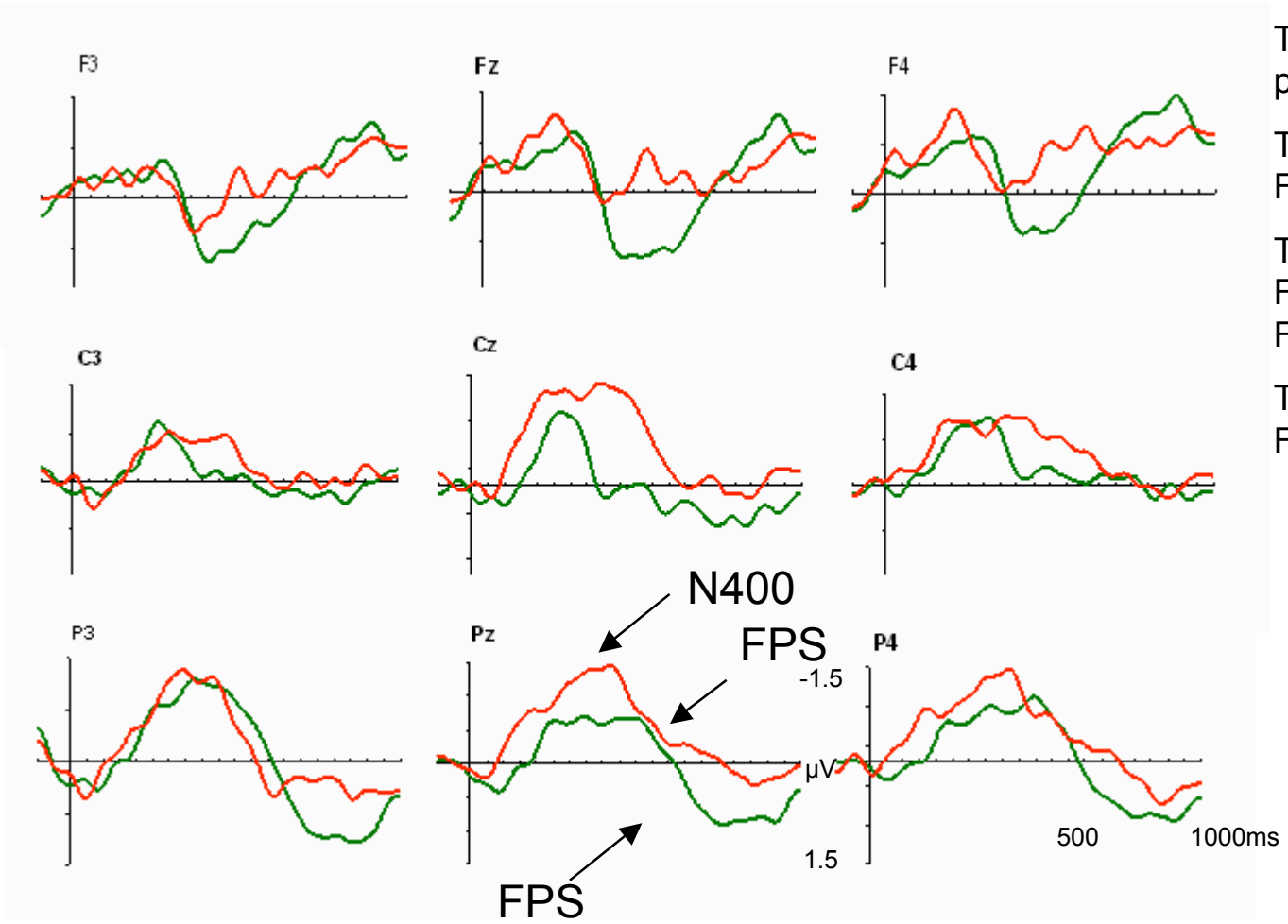


Adults (condition COR): processing of correction information



Congruent prosody
Incongruent prosody

Adults (condition COR): processing of correction information



TW 0 – 200 F(1,30)=5.71, p<.05

TW 200 – 400 ms F(1,30)=5.13, p<.05

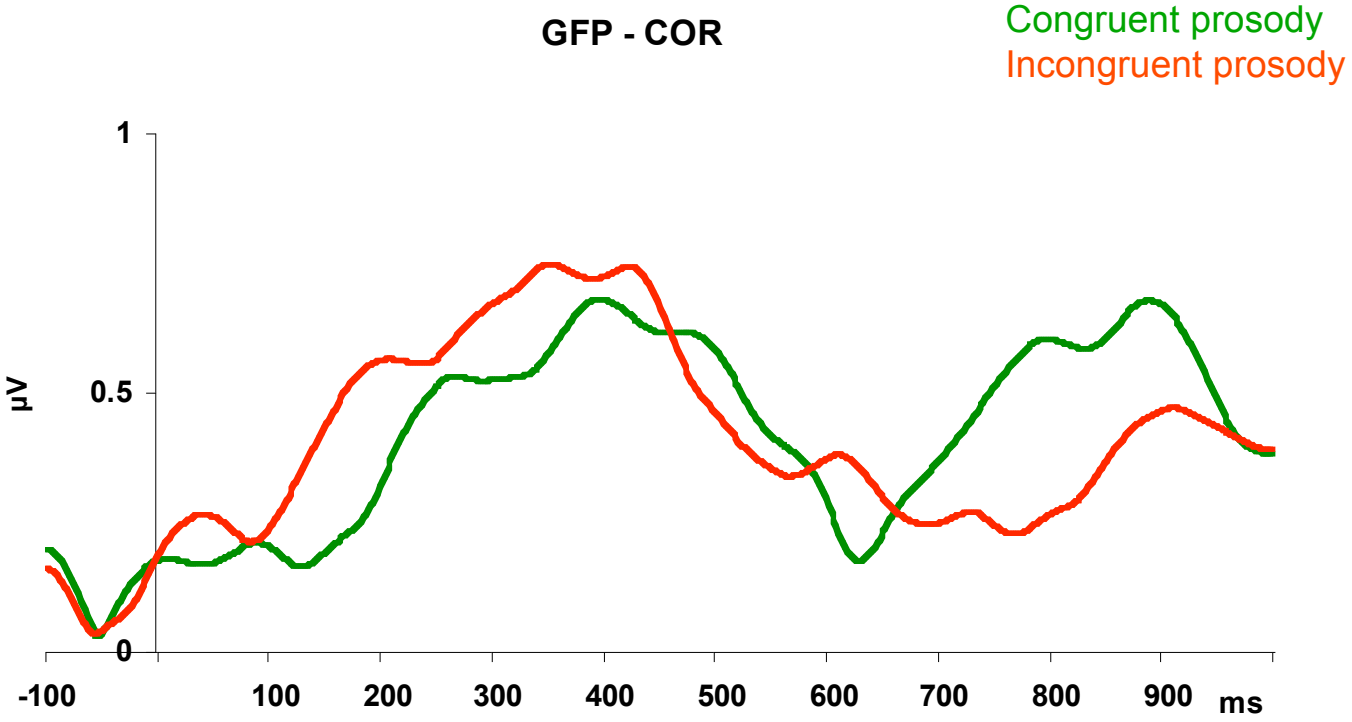
TW 400 – 600 ms: F(1,30)=19.92, p<.01; F(2,60)=4.42, p<.05

TW 600 – 800 ms F(1,30)=13.43, p<.01

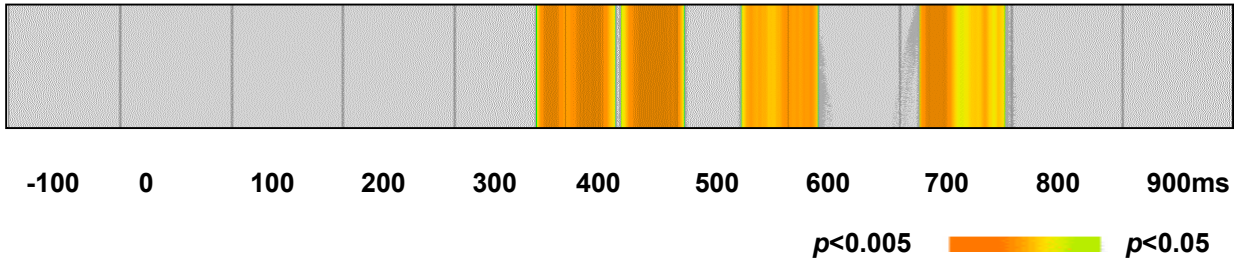
Congruent prosody
Incongruent prosody

Adults (condition COR): Global electric field analyses

Global field power (GFP)
→ no significant differences



Topographic Dissimilarity (DISS)
→ differences between 376-508ms, 560-628ms and 720-796ms



Adults summary

- The processing of new and corrected information elicited a long-lasting focus positivity (FPS) in correlation to the critical noun starting at 500ms irrespective of its adequate prosodic realization

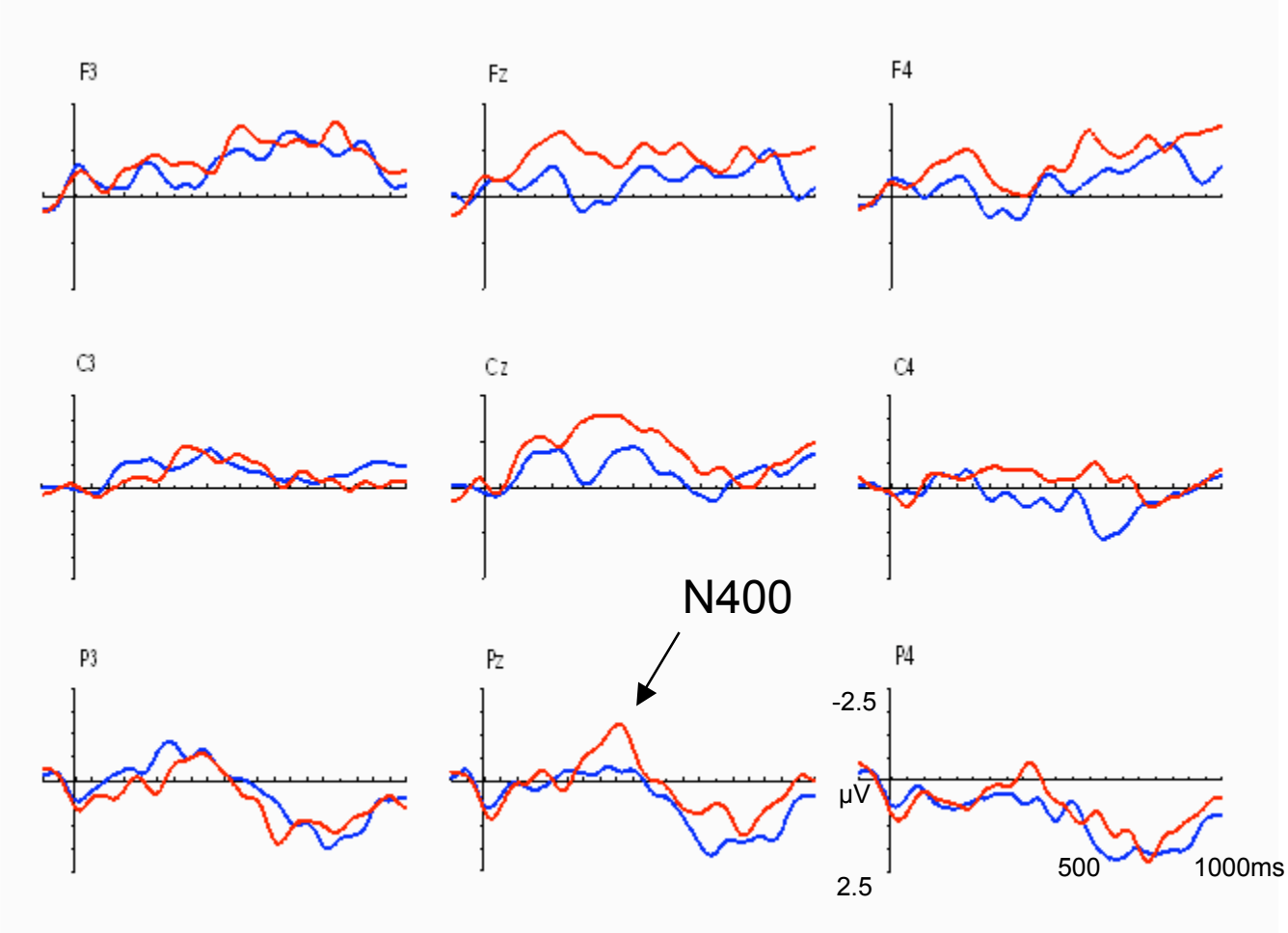
- Missing accents in pragmatic focus positions induced a negative shift (N400) preceding the focus positivity

- All effects corroborated by local and global analyses of the EEG signal

12 year olds

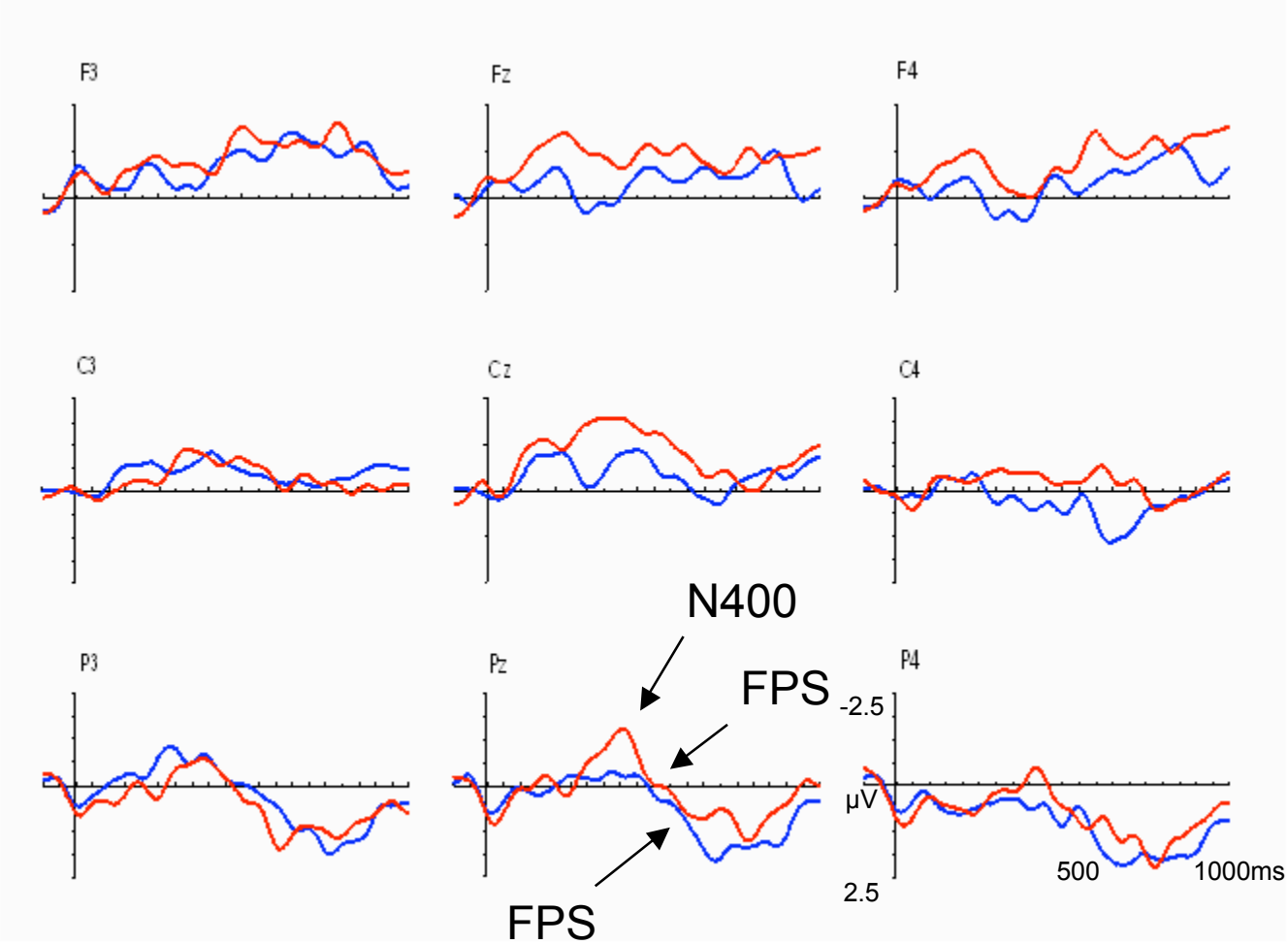
- Subjects: 30 kids (15 female, 15 male)
- 12 years old
- Right handed
- Recording from 32 electrodes
- Sampling frequency 500 Hz
- Online referenced to left mastoid, recalculated to the average reference offline
- Analyses on peri-stimulus epochs -100 to 1000ms to onset of focus position

12 year olds (condition NEW): ROI statistics



Congruent prosody
Incongruent prosody

12 year olds (condition NEW): ROI statistics

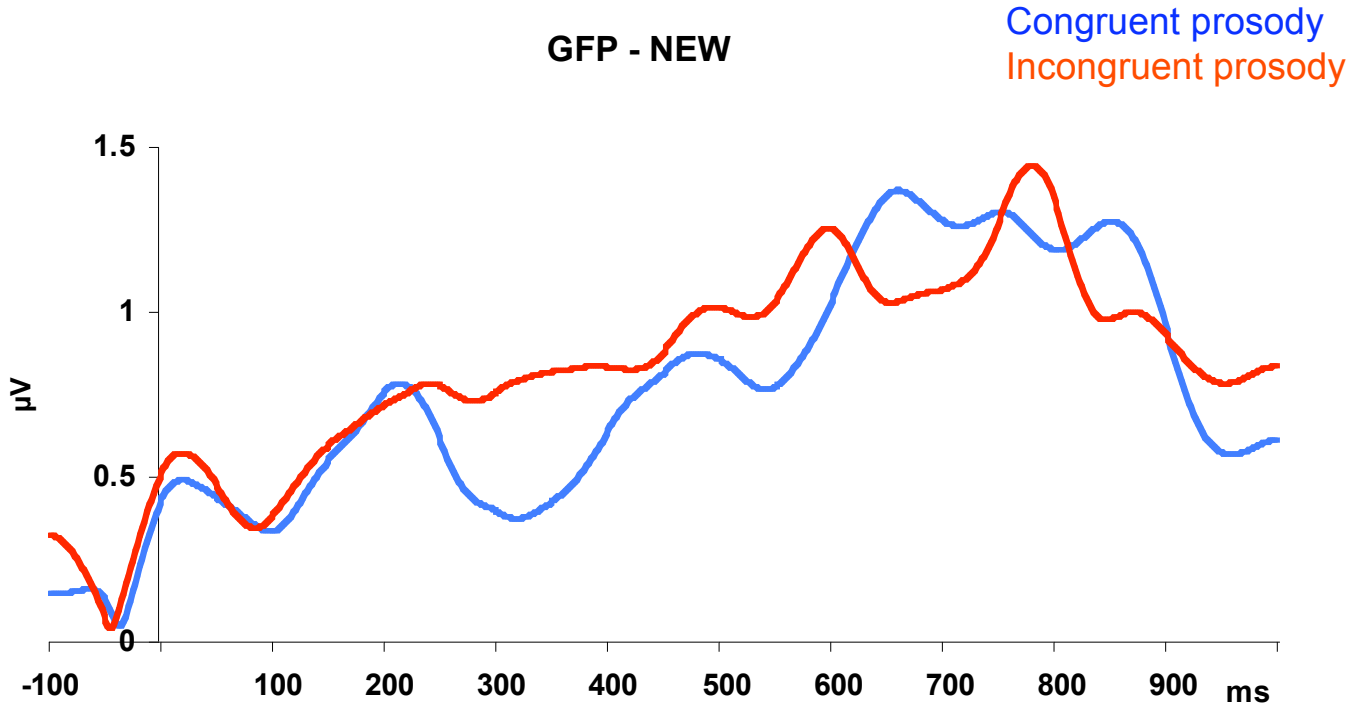


TW 200 – 400 ms
F(1,30)=4.28, p<.05

Congruent prosody
Incongruent prosody

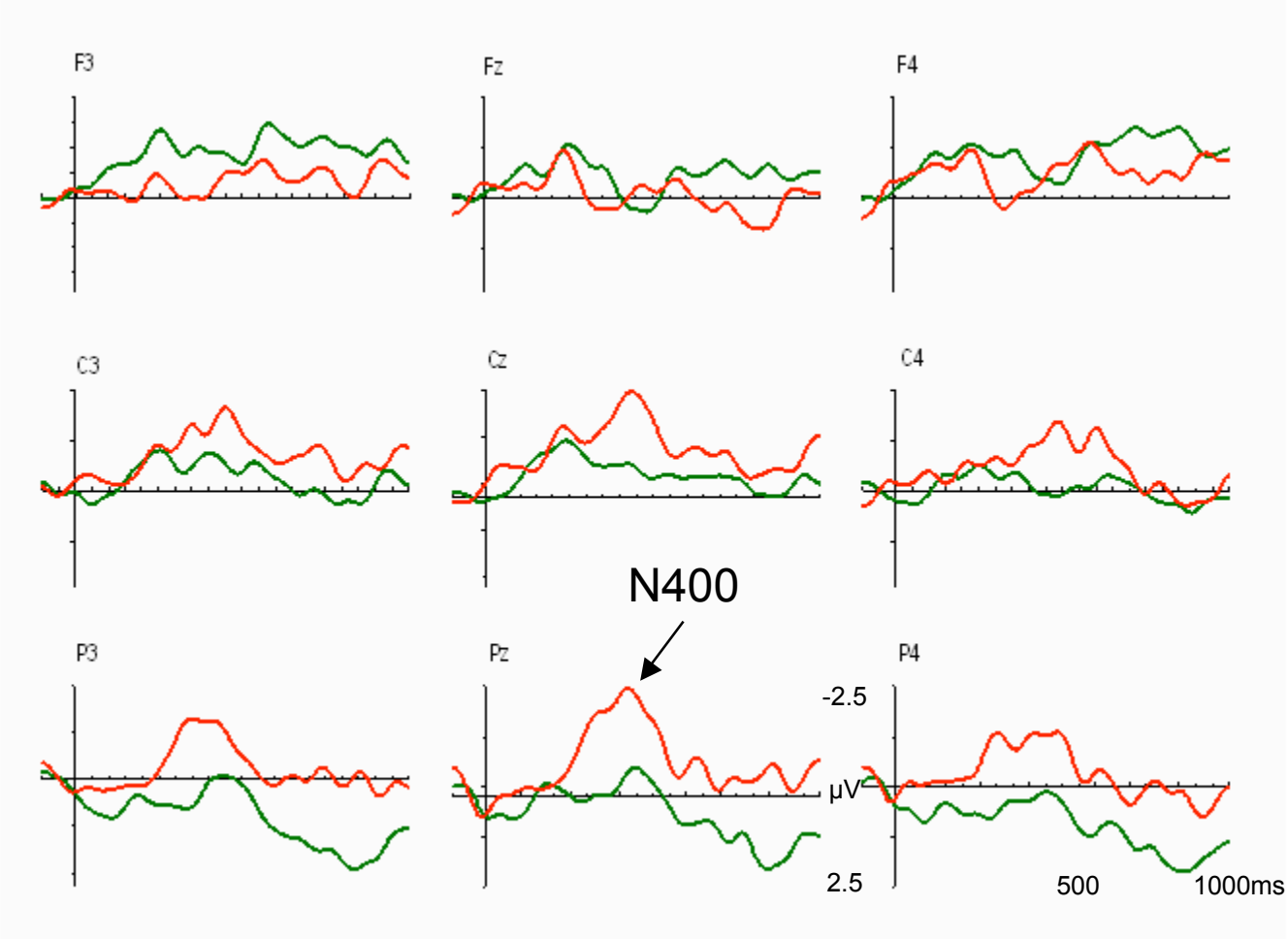
12 year olds (condition NEW): Global electric field analyses

Global field power (GFP)
→ no significant differences



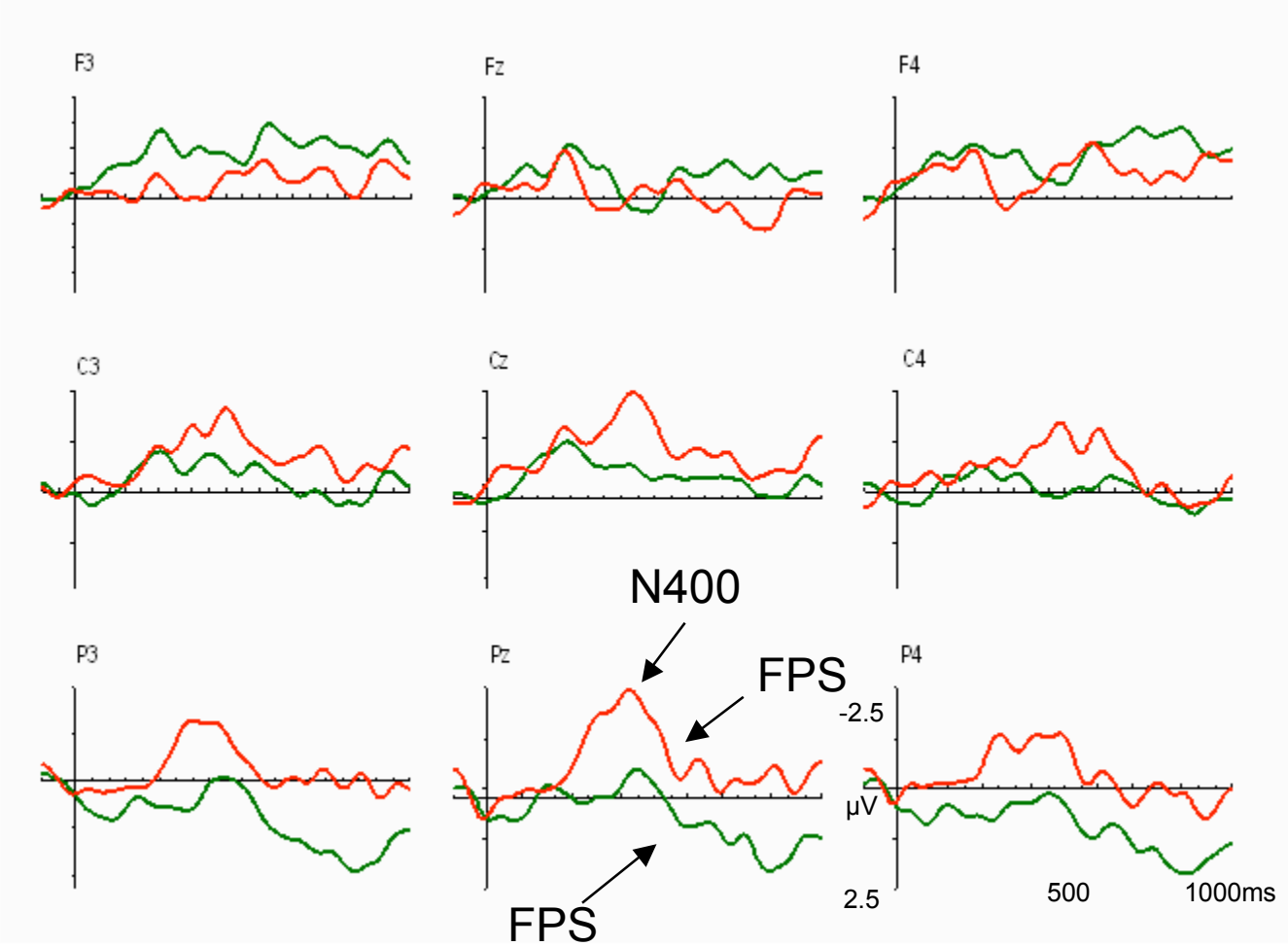
Topographic dissimilarity (DISS) → no significant differences

12 year olds (condition COR): ROI statistics



Congruent prosody
Incongruent prosody

12 year olds (condition COR): ROI statistics



TW 200-400ms
F(2,60)= 4,25, p<.05

TW 400-600ms
F(1,30)=12,38, p<.01

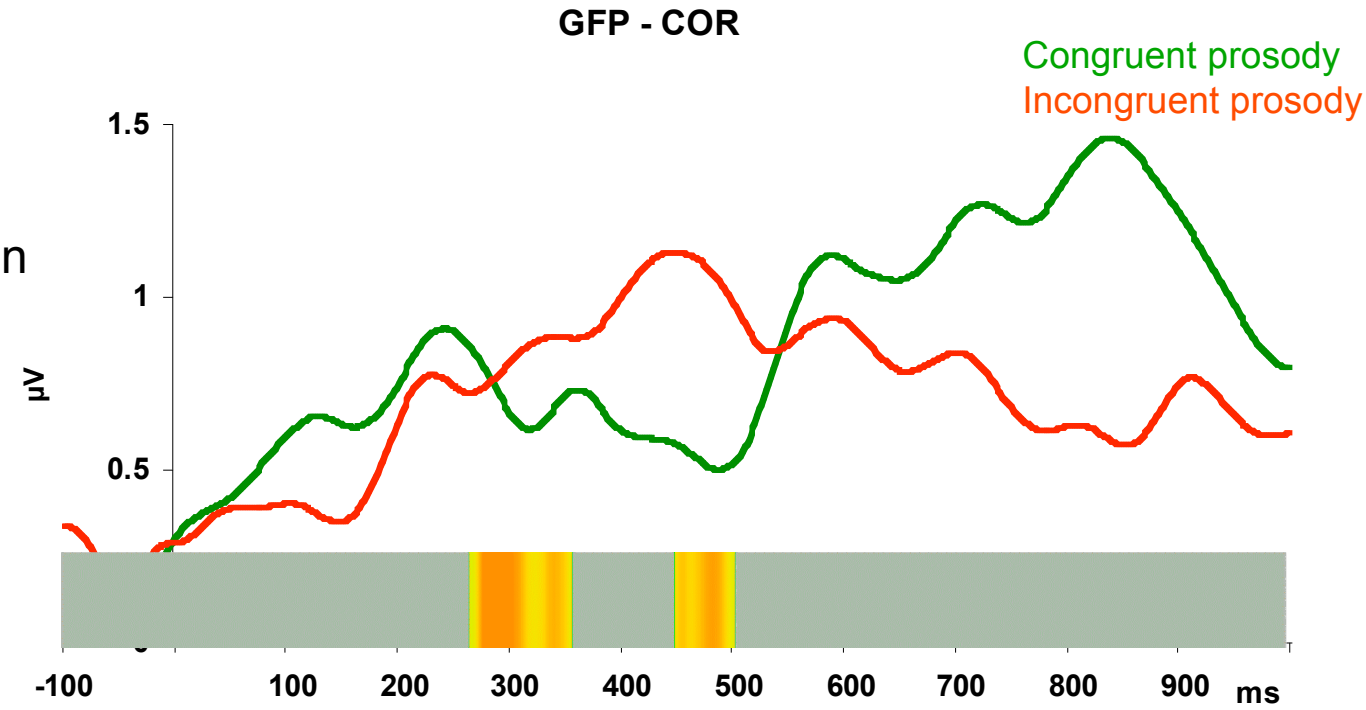
TW 600-800ms
F(2,60)=4,58, p<.05

800-1000ms
F82,60)=4,00, p<.05

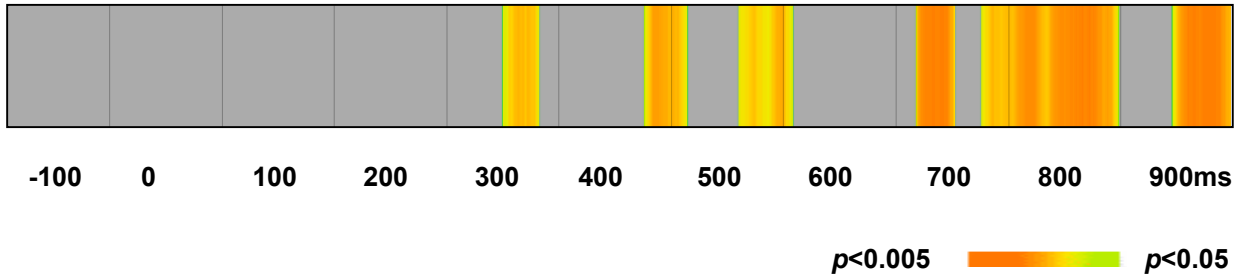
Congruent prosody
Incongruent prosody

12 year olds (condition COR): Global electric field analyses

Global field power (GFP)
→ differences between 266-358ms and 450-504ms



Topographic Dissimilarity (DISS)
→ differences between 352-384, 476-514, 560-608, 776-898 and 946-1000ms



12 year olds summary

- The processing of new and corrected information elicited a long-lasting focus positivity (FPS) starting at 500ms in correlation to the critical noun irrespective of the prosodic realization

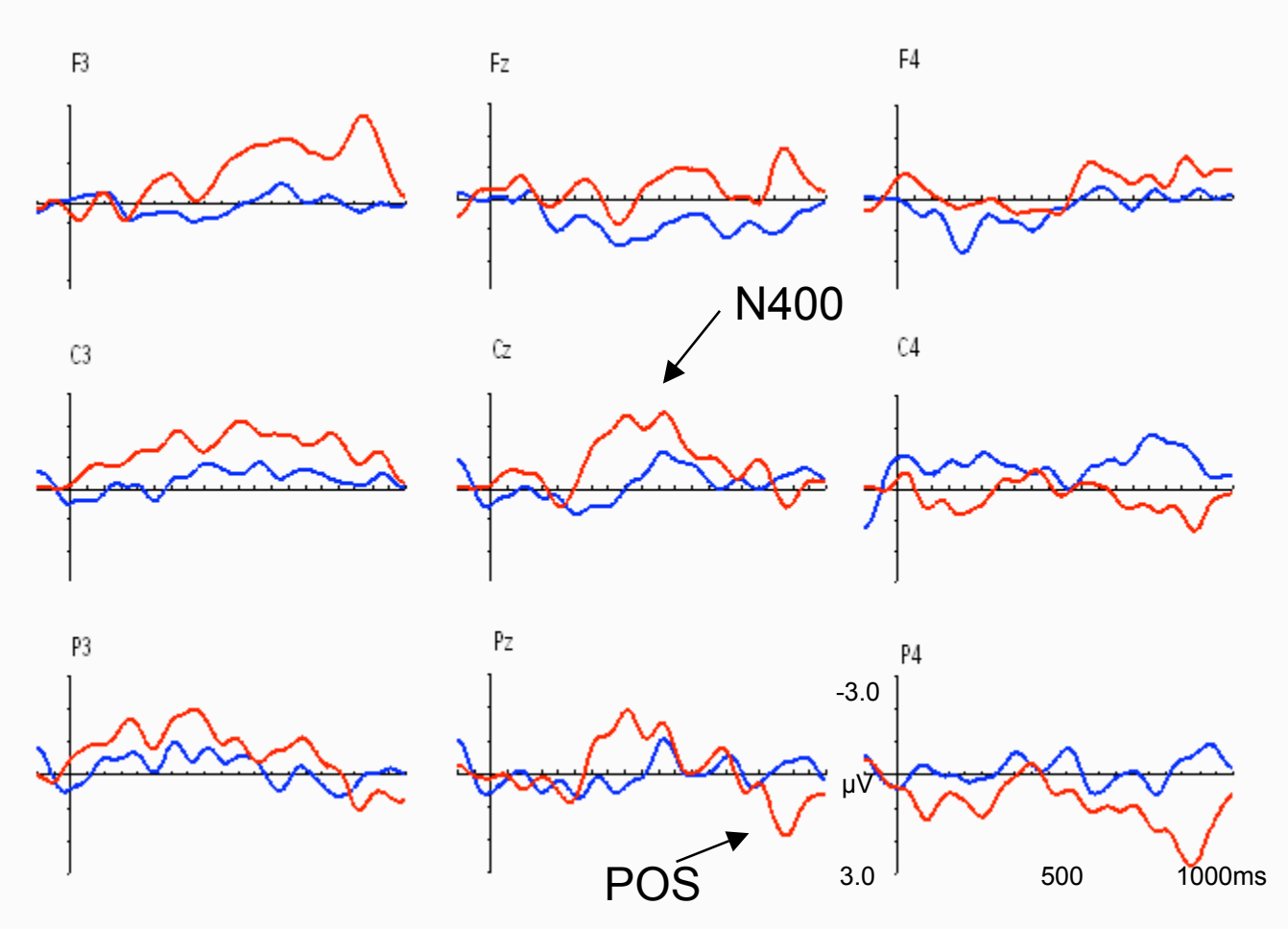
- Detection of a missing accent in condition NEW elicited a local mismatch reaction (N400)

- Detection of a missing accent in condition COR induced a more global mismatch reaction (N400); i.e. reflected also in GFP and DISS

8 year olds

- Subjects: 27 kids (14 female, 13 male)
- 8 years old
- Right-handed
- Recordings from 32 electrodes
- Sampling frequency 500 Hz
- Online referenced to left mastoid, recalculated to the average reference offline
- Analyses on peri-stimulus epochs -100 to 1000ms at focus position

8 year olds (condition NEW): ROI statistics



TW 400-600ms
F(1,26)=6,04, p<.05

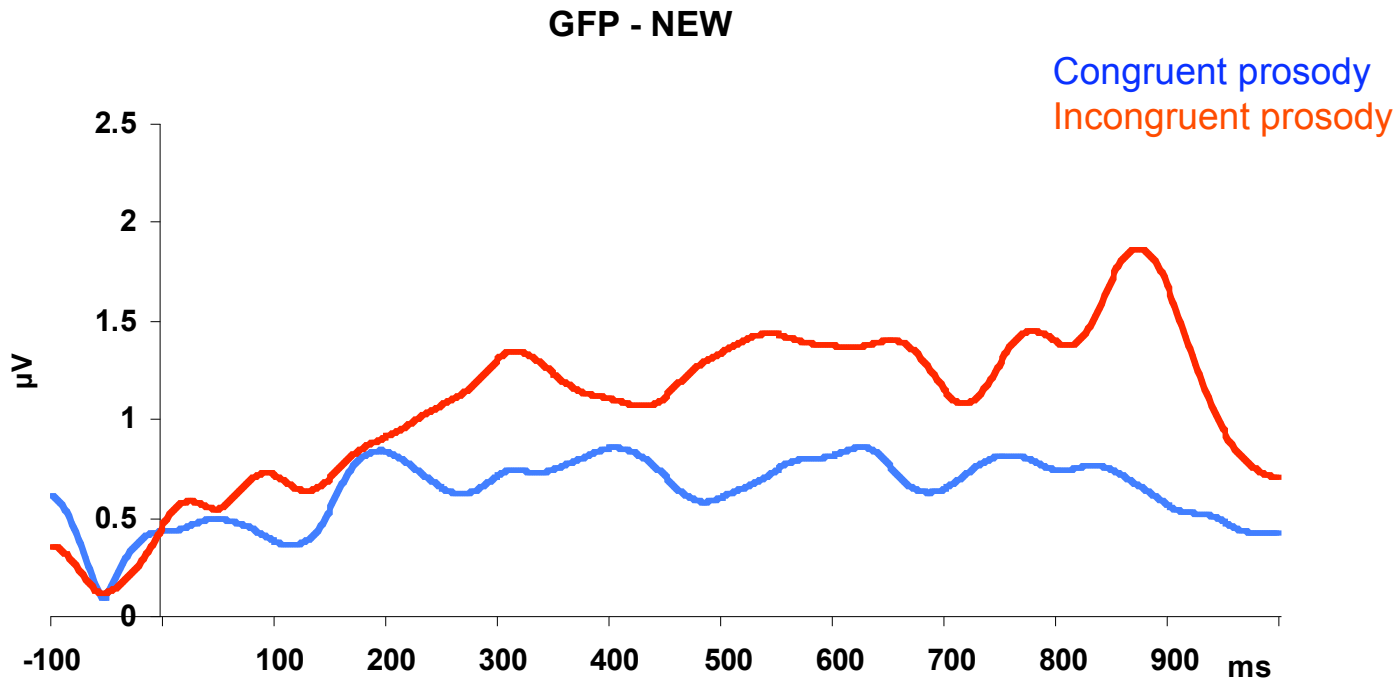
TW 600-800ms
F(1,26)=5,16, p<.05

TW 800-1000ms
F(2,52)=4,32, p<.05

Congruent prosody
Incongruent prosody

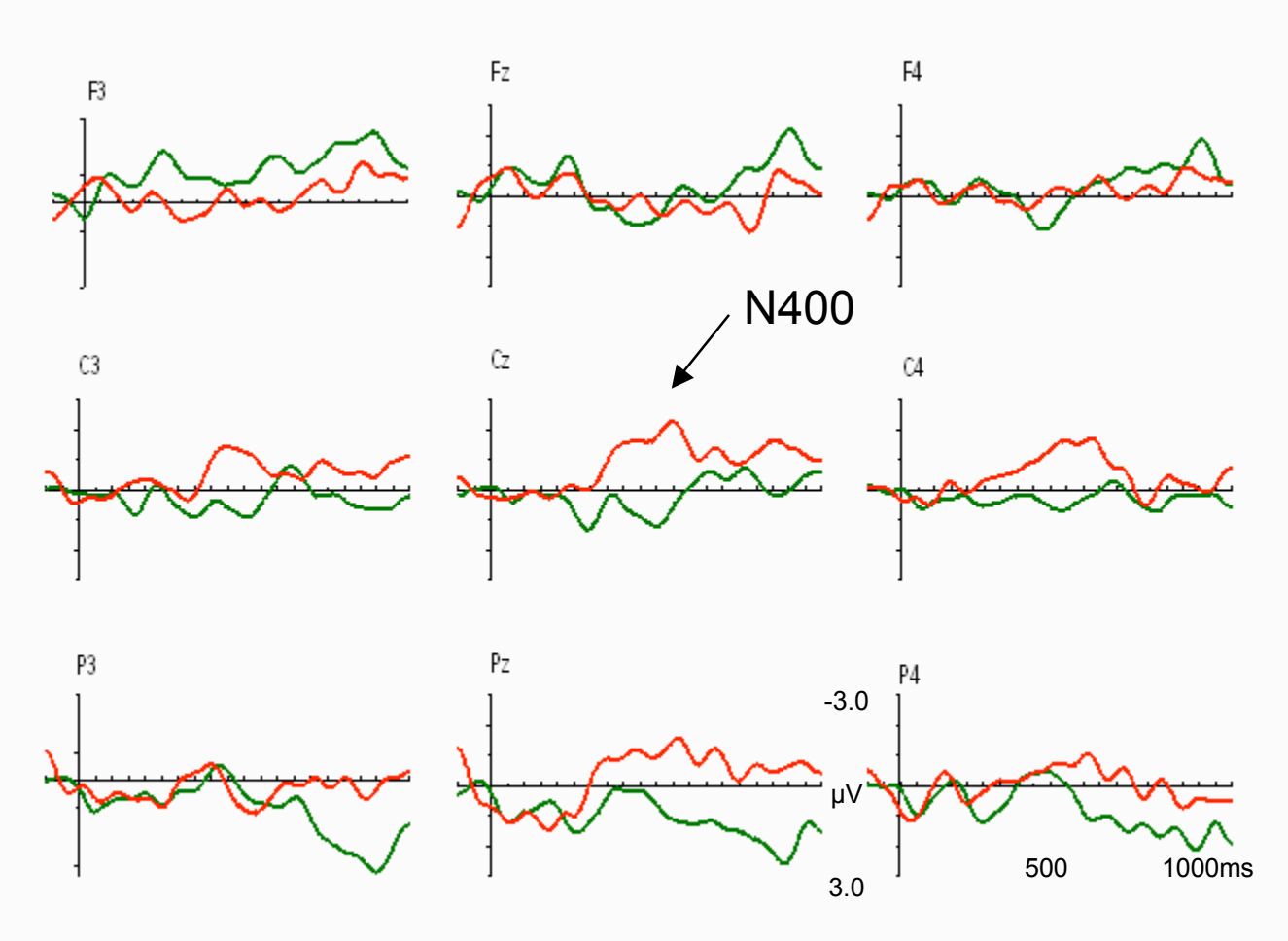
8 year olds (condition NEW): Global electric field analyses

Global field power (GFP)
→ no significant differences



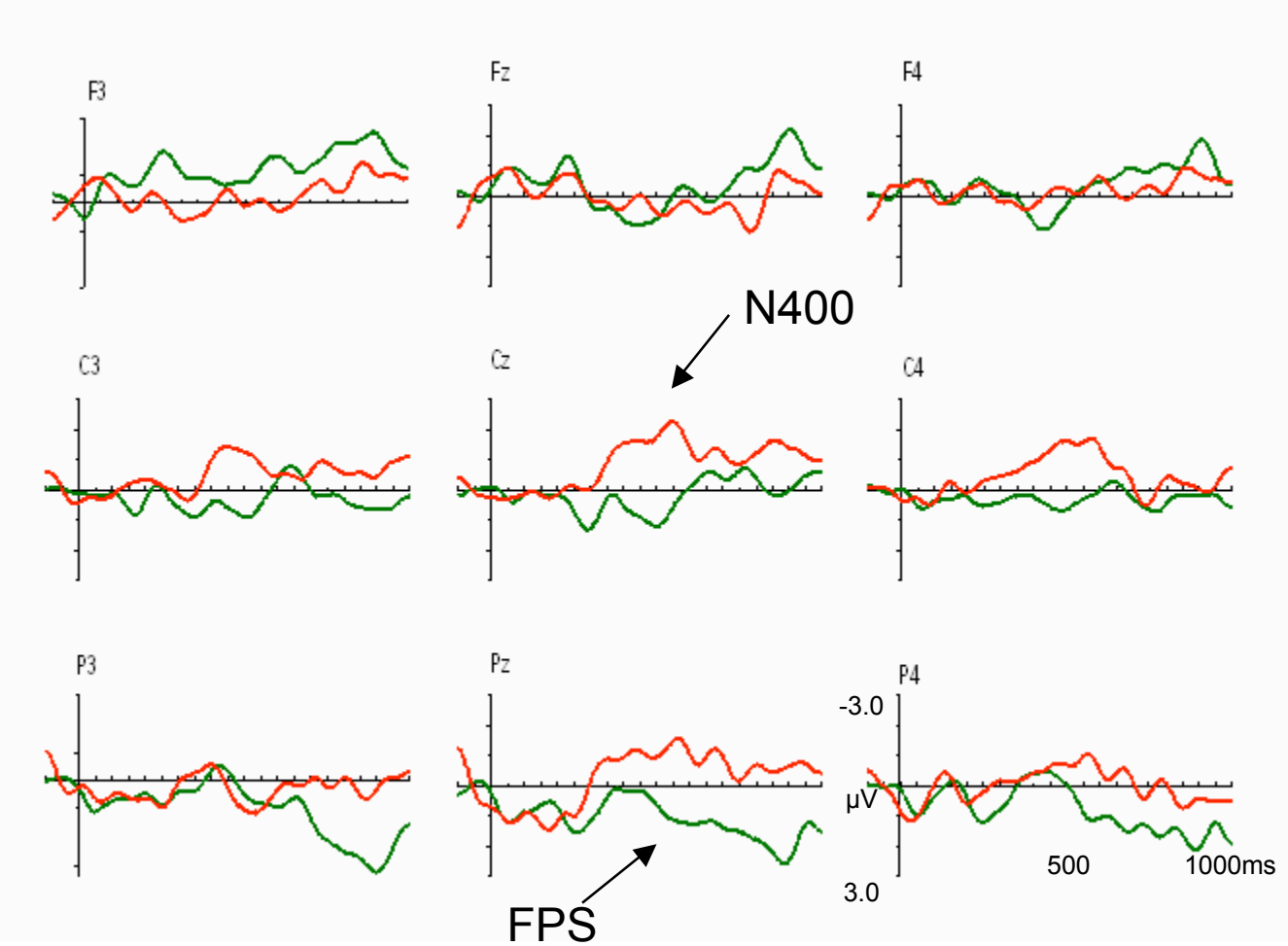
Topographic dissimilarity (DISS) → no significant differences

8 year olds (condition COR): ROI statistics



Congruent prosody
Incongruent prosody

8 year olds (condition COR): ROI statistics

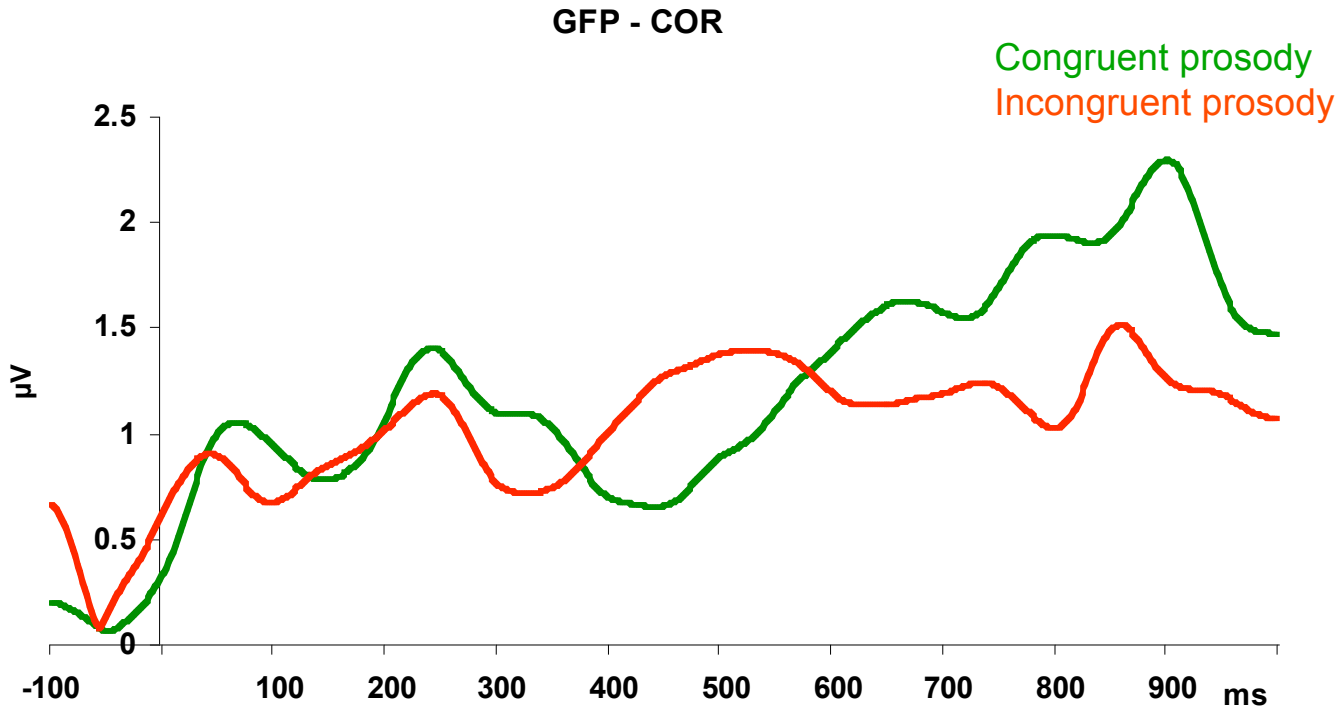


TW 400-600ms
F(1,26)=5,23, p<.05

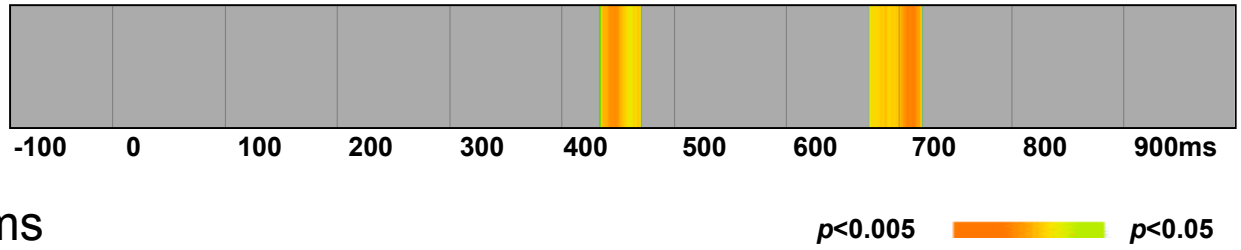
Congruent prosody
Incongruent prosody

8 year olds (condition COR): Global electric field analyses

Global field power (GFP)
→ no significant differences



Topographic Dissimilarity (DISS)
→ differences between 430-470 and 674-720ms

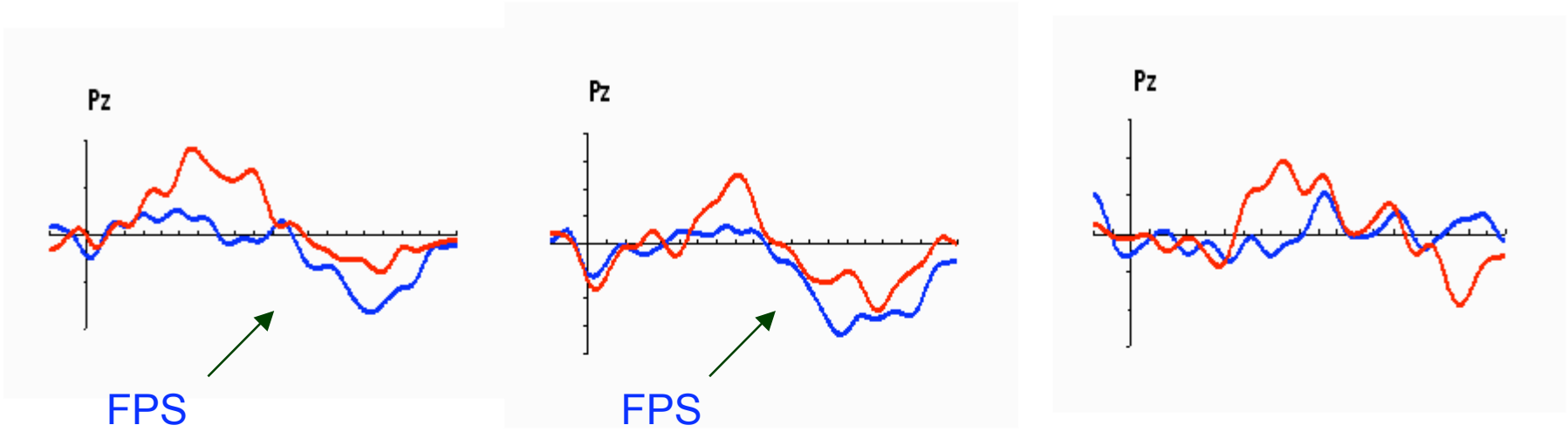


8 year olds summary

- Perceiving novelties with congruent prosody is not accompanied by a brain marker
- The processing of corrections elicits a focus positive shift (FPS) only when the information was realized with adequate prosody (starting at 500ms at centro-parietal electrodes)
    - Reflected in local and global statistic effects

- Detection of a missing accent in condition NEW elicits a negativity followed by a positivity (biphasic N400/P600)
- Detection of a missing accent in condition COR elicits only a negativity (N400)

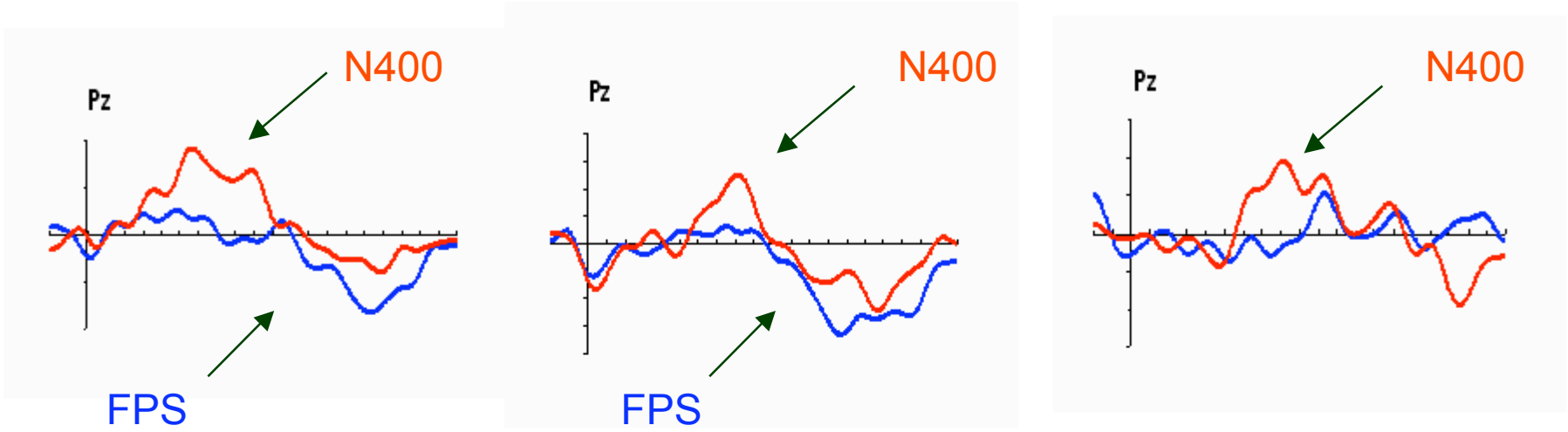
Discussion: Condition NEW



Adults 12 years 8 years

Congruent prosody
Incongruent prosody

Discussion: Condition NEW



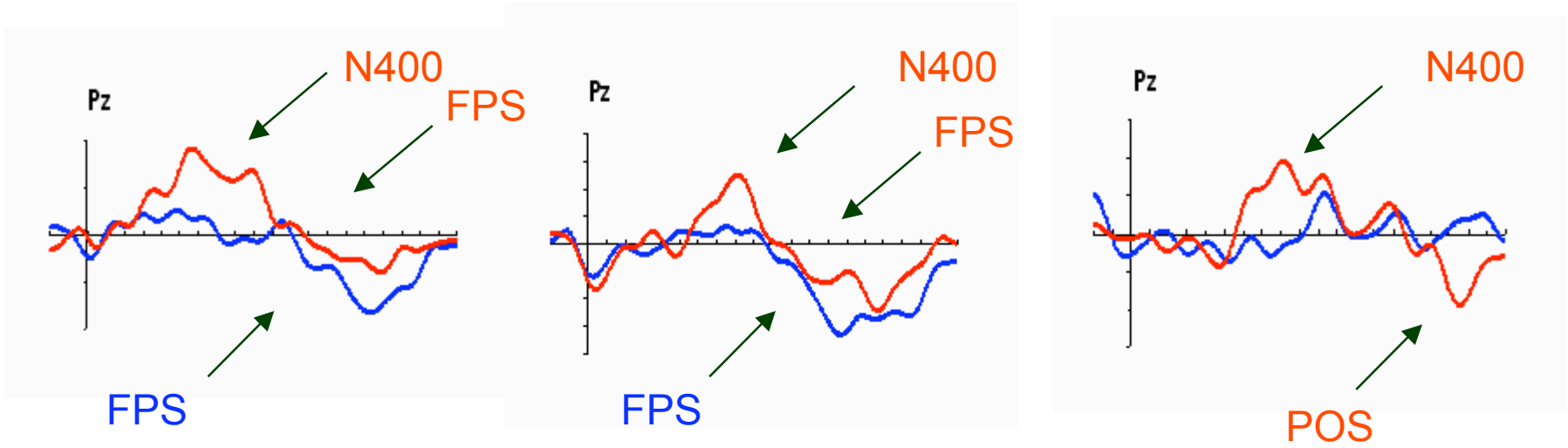
Adults

12 years

8 years

Congruent prosody
Incongruent prosody

Discussion: Condition NEW



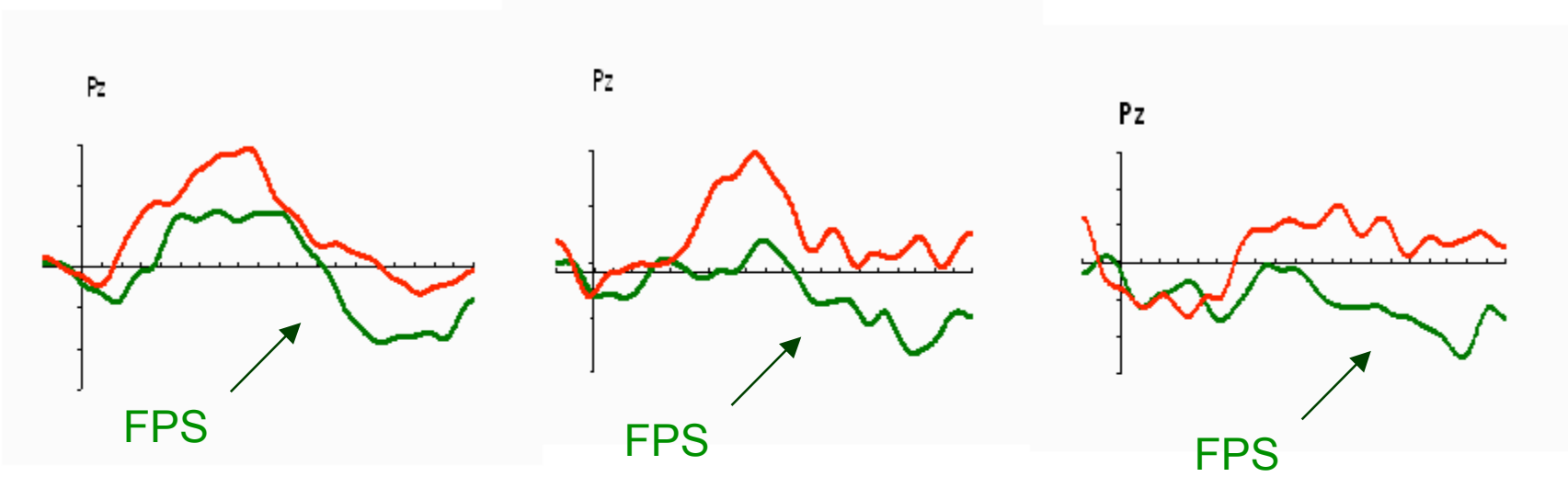
Adults

12 years

8 years

Congruent prosody
Incongruent prosody

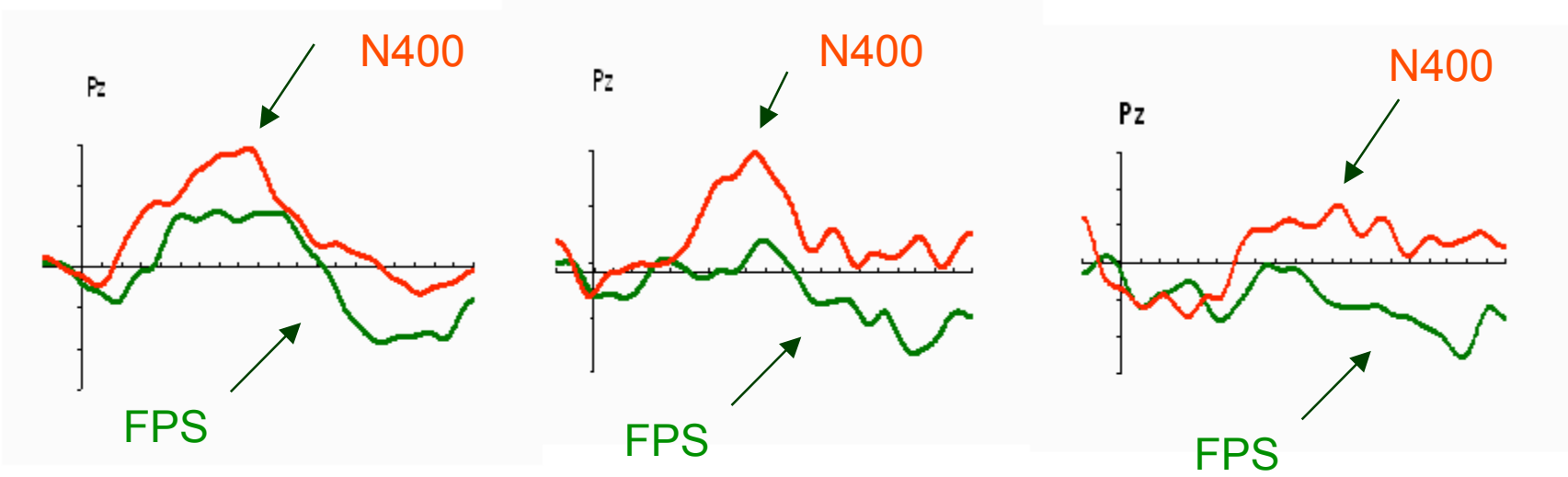
Discussion: Condition COR



Adults 12 years 8 years

Congruent prosody
Incongruent prosody

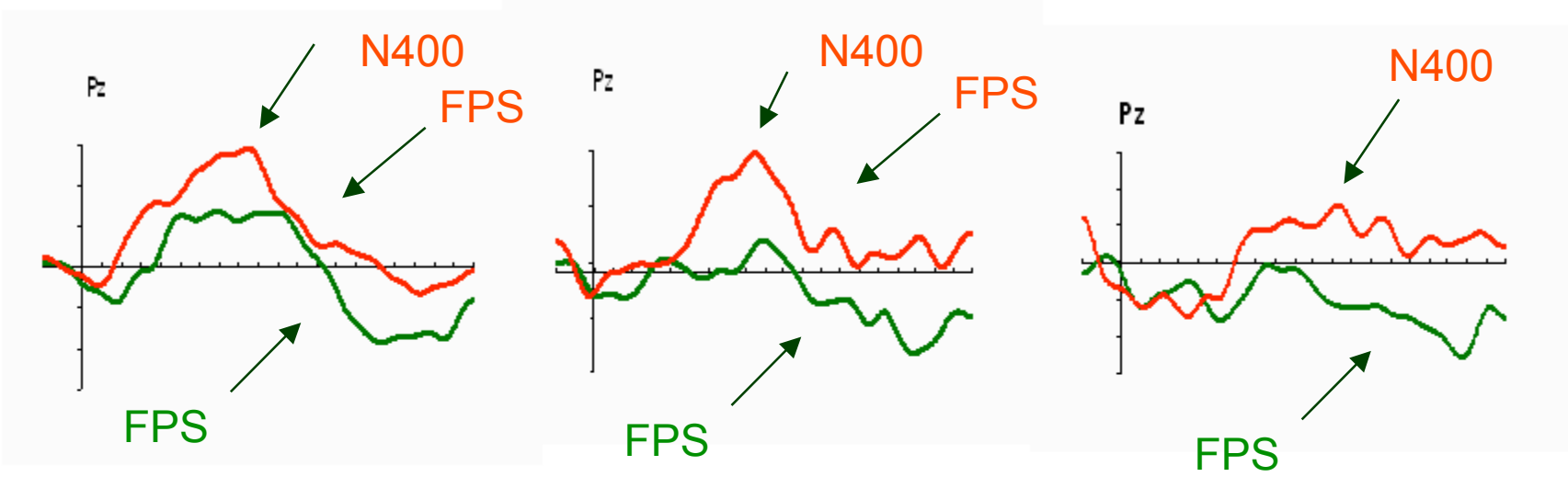
Discussion: Condition COR



Adults 12 years 8 years

Congruent prosody
Incongruent prosody

Discussion: Condition COR



Adults 12 years 8 years

Congruent prosody
Incongruent prosody

Conclusion

- Discourse perception in 12 year olds reveals a similar brain response pattern as in adults
  - Most apparent for correction focus (classical local ERP analyses and global topographic analyses converge)

- 8-year-olds still strongly diverge from the adult-like pattern
  - Most apparently when processing novelty focus

Outlook

- Investigation of the brain response pattern for 5 year olds

- Further topographic analyses and neural source estimation

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Thanks to Sylvia Stasch and Kristiane Werrmann in Leipzig for data recording.

Thanks to Denis Brunet for the EEG analysis software:

http://brainmapping.unige.ch/cartool.php

(see also Murray, Brunet, Michel; BTOP 2008, for the ratio of the analyses)

Thanks to the inventors of Skype!