Looking for the Phonological Mapping Negativity (in all the wrong places)

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Section 1

Introduction

Introduction

Four years ago...

Introduction

Can event-related potential data inform information flow order in speech perception?

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Can event-related potential data inform information flow order in speech perception? i.e. what the extent of top-down mediation is during speech perception.

Introductin

- Interactive models of speech perception (e.g. TRACE)
- Feed-forward / modular models of speech perception (e.g. Cohort model)

Introduction

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- Elman, J. L., & McClelland, J. L. (1988). Cognitive penetration of the mechanisms of perception: Compensation for coarticulation of lexically restored phonemes. Journal of Memory and Language, 27(2), 143-165.

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- McQueen, et al. (2009). No lexical–prelexical feedback during speech perception or: **Is it time to stop playing those Christmas tapes?**. Journal of Memory and Language, 61(1), 1-18.

Elman & McClelland (1988)

Compensation for coarticulation: (Mann & Repp 1981)

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- e.g. Christma/s-ʃ/ more often solved as Christma/s/.

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- e.g. Christma/s-ʃ/ more often solved as Christma/s/.
- Effect stronger at phoneme boundary.

Elman & McClelland (1988)

Christma**/s-**ʃ/ **/t-k/**capes

Elman & McClelland (1988)

Christma/**s-ʃ**/ /**t-k**/capes

Cool, huh?

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Event-related potentials

Event-related potentials (**ERP**) are measured brain responses that are direct result of a **sensory**, **cognitive** or motor event (**Luck 2005**)

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Event-related potential components are measured with electro-encephalography (**EEG**) equipment.

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Event-related potentials

- Mismatch Negativity (**MMN**)

* Originanly named Phonological Mismatch Negativity

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- Phonological Mapping***** Negativity (**PMN**)

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- **N400**

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- **N400**
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MMN

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In the auditory domain, a deviant stimulus can be identified by differences in pitch, duration, stress and frequency range (Erlbeck et al., 2014)

N400

The N400 (Kutas & Hillyard 1980) is part of the normal brain response to words and other meaningful stimuli.

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nurse

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- Other paradigms include cloze-probability mismatch (e.g. Connolly and Phillips 1994)

Phonological Mapping Negativity

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However, while some studies (e.g. Connolly and Phillips 1994) have linked the PMN to phonological mapping during the lexical selection stage of speech perception..

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Others (e.g. Newman & Connolly) report that the PMN is a **marker of acoustic and pre-lexical information**.

Connolly and Phillips (1994)

Event-Related Potential Components Reflect Phonological and Semantic Processing of the Terminal Word of Spoken Sentences:

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- The piano is out of

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Event-Related Potential Components Reflect Phonological and Semantic Processing of the Terminal Word of Spoken Sentences:

- The piano is out of tune (no mismatch)

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- The piano is out of pizza

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- The piano is out of pizza (N400 and PMN)

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- The piano is out of tune (no mismatch)
- The piano is out of tuna (N400)
- The piano is out of pizza (N400 and PMN)
- ...

Newman et al. (2003)

Phoneme deletion task to study the PMN:

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Delete /k/ from the word “clap”

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- aap

Newman et al. (2003)

Phoneme deletion task to study the PMN:

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- lap
- aap
- dog

Phonological Mapping Negativity

Lewendon et. al (2020) suggest that the possibility exists that the PMN is an extension of either the Mismatch Negativity (**MMN**) or **N400** components

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Lewendon et. al (2020) also report that the majority of the literature on the PMN is characterized by contradictory findings and methodological limitations, e.g.

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  - Some studies report discovering the PMN in frontal and central sites, ohers in parietal / mid-line / evenly spread across the scalp.

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  - Few trials (usually < 40)

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- Methodological limitations:
  - Few participants (usually < 10)
  - Few trials (usually < 40)
  - Confounding variables

Research questions

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- **Is the PMN in response to acoustic, phonetic, phonological, lexical mapping and mismatch, none or a combination of all?**

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- **Is any other ERP component found in response to acoustic, phonetic and phonological mismatch in place of / together wih the PMN?**

Research questions

Why the PMN..

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- The PMN might play an important role in future investigations of architectures of grammar (placed in between acoustic and lexical processing)

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Why the PMN.. and why now?

- The PMN might play an important role in future investigations of architectures of grammar (placed in between acoustic and lexical processing)
- Clinical studies have used the PMN as a marker of phonological processing abilities (Robson et al. 2017). However, it is not clear what processes sexactly the PMN stands for.

Section 2

Methods

Experimental design

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Three neuro-imaging experiments designed to introduce new contexts in which to probe the elicitation of the PMN ERP component.

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Three neuro-imaging experiments designed to introduce new contexts in which to probe the elicitation of the PMN ERP component.

Experiments **1**, **2** (and **3**) were designed to simultaneously work independently while also being fully comparable.

Equipment & Processing

Hardware:

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Hardware:

- 64 active pin-type **BioSemi** electrodes

Equipment & Processing

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- 64 active pin-type **BioSemi** electrodes
- 6 (EX1 to EX6) face electrodes

Equipment & Processing

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- 64 active pin-type **BioSemi** electrodes
- 6 (EX1 to EX6) face electrodes
- BiooSemi hardware (e.g. receiver)

Equipment & Processing

Software:

Equipment & Processing

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- BioSemi Actiview

Equipment & Processing

Software:

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- Neurobehavioral Systems' **Presentation**

Equipment & Processing

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- MATLAB (2018b; 2019a; 2019b)

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- MATLAB (2018b; 2019a; 2019b)
- EEGLAB (Delorme & Makeig 2004)
- ERPLAB (Lopez-Calderon & Luck, 2014)

Equipment & Processing

Software:

- BioSemi Actiview
- Neurobehavioral Systems' **Presentation**
- MATLAB (2018b; 2019a; 2019b)
- EEGLAB (Delorme & Makeig 2004)
- ERPLAB (Lopez-Calderon & Luck, 2014)
- R (4.1) (R Core Team 2021)

Equipment & Processing

EEG pre-processing:

Equipment & Processing

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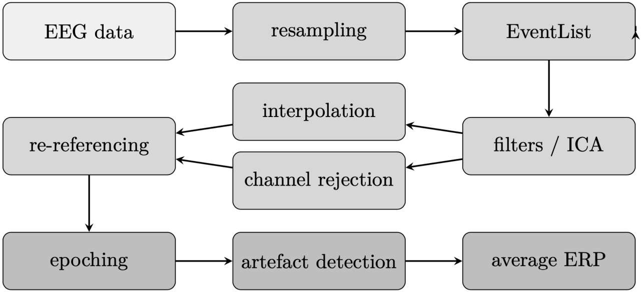

Equipment & Processing

EEG pre-processing:

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EEG pre-processing:

- Offline average reference

Equipment & Processing

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- Offline average reference
- 512 Hz sampling frequency

Equipment & Processing

Statistical analyses:

Equipment & Processing

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- Exploratory channel-level multivariate testing with package `ERP` (Causeur et al. 2020) and the Adaptive Factor Adjustment (AFA) procedure (Sheu et al. 2016)

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Statistical analyses:

- Exploratory channel-level multivariate testing with package `ERP` (Causeur et al. 2020) and the Adaptive Factor Adjustment (AFA) procedure (Sheu et al. 2016)
- Mean amplitude modelling with mixed-effect models & package `lme4` (Bates et al. 2015)

Equipment

Data visualisation:

Equipment

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- Grand-Average / difference ERP plots with `ggplot2` (Wickham 2016)

Equipment

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- Grand-Average / difference ERP plots with `ggplot2` (Wickham 2016)
- Cubic spline interpolation scalp maps with package `akima` (Akima and Gebhardt 2020)

Reproducibility

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Data, code and model summaries are freely available on GitHub at the repository `mcanzi/phd_codedata`

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PhD thesis has been submitted and will be available through open access following thesis defense (in August) and corrections.

Section 3

Experiment 1

Procedure

- Participants were trained to learn three pairs of tri-syllabic nonce words in a computerized training phase (e.g. pitabu dipida)

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- During EEG data collection, stimuli were played back to participants during a passive listening task, however..

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- Participants were tested on their knowledge of the experimental stimuli in a computerized task
- During EEG data collection, stimuli were played back to participants during a passive listening task, however..
  - In 33% of total trials (400 total trials), the first syllable of the second nonce-word of each pair would be manipulated to break expectations

Stimuli

pitabu

Stimuli

pitabu dipida

Stimuli

pitabu dipida

pitabu

Stimuli

pitabu dipida

pitabu **ba**pida

Stimuli

pitabu dipida

pitabu **ba**pida

pitabu

Stimuli

pitabu dipida

pitabu **ba**pida

pitabu **bu**pida

Stimuli

pitabu dipida

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- Stimuli were synthesized using Mac OS Text-to-Speech

Stimuli

pitabu dipida

pitabu **ba**pida

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- Stimuli were synthesized using Mac OS Text-to-Speech
- Vowel, syllable and word length were controlled for (each syllable was 200 ms long)

Stimuli

pitabu dipida

pitabu **ba**pida

pitabu **bu**pida

- Stimuli were synthesized using Mac OS Text-to-Speech
- Vowel, syllable and word length were controlled for (each syllable was 200 ms long)
- Speaker and pitch contours were the same for all stimuli.

Participants

22 Participants (F = 13) took part to the experiment.

- 22 right-handed adults

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- 22 right-handed adults
- 22 BrE speakers

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- Age (M = 22, 18-25)

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Participants

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- 22 right-handed adults
- 22 BrE speakers
- Age (M = 22, 18-25)
- Normal or corrected to normal vision and hearing
- No reported use of psychoactive medications

Results

Cubic-spline interpolation scalp maps. Mean amplitude betweeen 280 and 320 ms post-stimulus onset.

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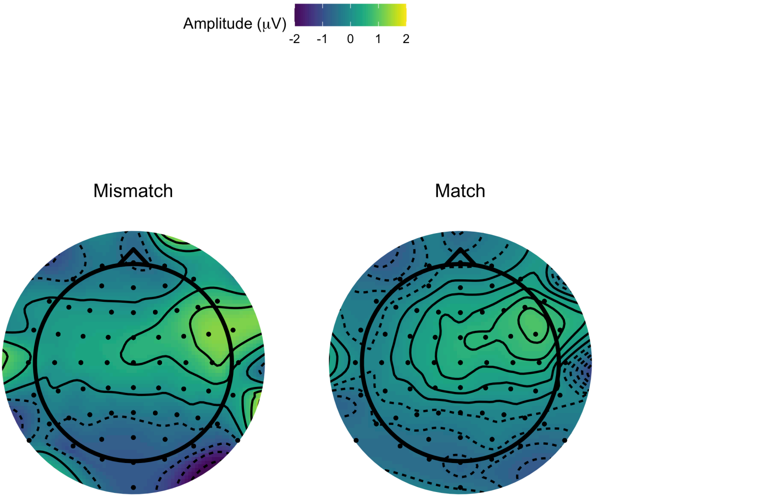

Other effects

- Small negative effect between 150-200 ms for mismatch condition (fronto-cenral)

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- Bigger positive effect between 500-700 ms for mismatch condition (centro-parietal)

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- Bigger positive effect between 500-700 ms for mismatch condition (centro-parietal) (**P600?**)

Discussion

No instance of **PMN** (in any of its expected forms) was found)

Discussion

Possible explanations:

Discussion

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- PMN is more ”higher-level” than previously theorized

Discussion

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- PMN is more "higher-level" than previously theorized
- Methodological limitations of Exp. 1

Section 4

Experiment 2

Stimuli

Same nonce words as **Experiment 1**

Procedure

di +

Procedure

di + (500 ms pause) +

Procedure

di + (500 ms pause) + pi +

Procedure

di + (500 ms pause) + pi + (500 ms pause) +

Procedure

di + (500 ms pause) + pi + (500 ms pause) + da

Procedure

di + (500 ms pause) + pi + (500 ms pause) + da

(4 s pause)

Procedure

di + (500 ms pause) + pi + (500 ms pause) + da

(4 s pause)

dipida

Procedure

However, in 33% of total trials

di

Procedure

However, in 33% of total trials

di pi

Procedure

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di pi da

Procedure

However, in 33% of total trials

di pi da

bapida

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- ~~Methodological limitations of Exp. 1~~

Section 5

General Discussion

Thank you!

Special thanks to my supervisors **Dr Wendell Kimper**, **Dr Patrycja Strycharczuk** and to all the RAs: Hui Chen, Lauren Forrest, Chloe Gornall, Tristan Hill, Yuerong Shen, Ellen Symonds, Xinrong Wang, Ziyun Zhang

References

Questions?