

IDENTIFYING EEG MEASURES OF MEMORY AND ATTENTIONAL LOAD IN LANGUAGE PROCESSING

Marten van Schijndel ¹

July 2, 2015

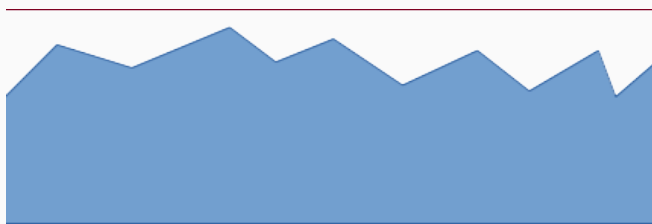
¹Department of Linguistics, The Ohio State University

This is not a neural net talk!

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'Neural' in this talk refers to actual neurons

WHAT IS 'THE CHANNEL'?



Can we measure distinct aspects of 'The Channel'?

Can we measure distinct aspects of 'The Channel'?

Where should we measure?

Can we measure distinct aspects of 'The Channel'?

Where should we measure?

Neural communication occurs over subchannels

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Underpins linguistic communication

Can we measure distinct aspects of 'The Channel'?

Where should we measure?

Neural communication occurs over subchannels

Underpins linguistic communication

Diff neural channels ?= Diff aspects of 'The Channel'

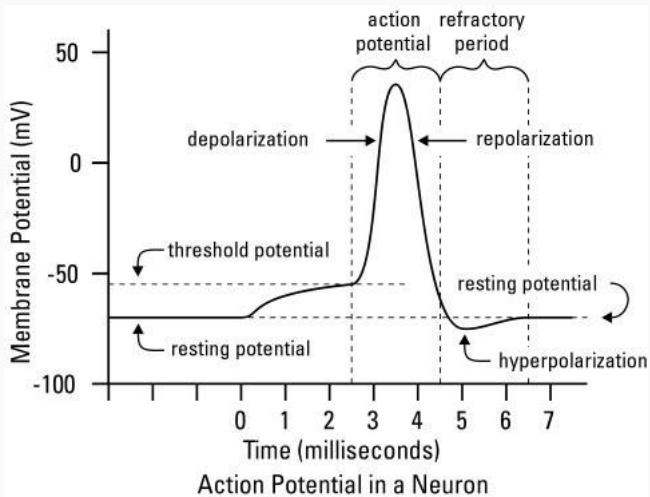
USE EEG

Separately measure attention and memory influences on 'The Channel' via different neural channels

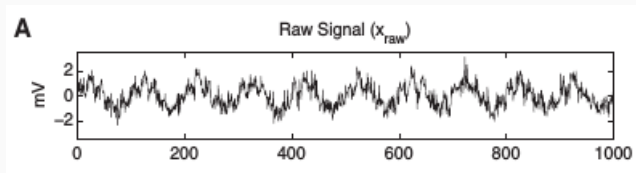
BACKGROUND: WHAT IS EEG?



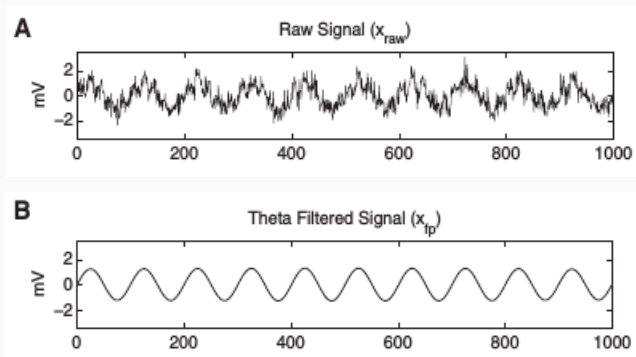
NEURAL FIRING IS NOT CONTINUOUS



FIRING OCCURS IN PARTICULAR FREQUENCY BANDS



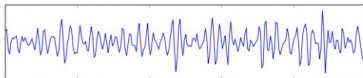
FIRING OCCURS IN PARTICULAR FREQUENCY BANDS



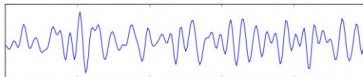
(Tort et al., 2010)

FIRING OCCURS IN PARTICULAR FREQUENCY BANDS

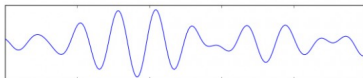
Comparison of EEG Bands



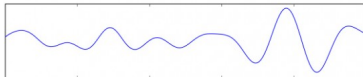
Gamma: 30-100+ Hz



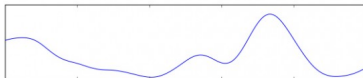
Beta: 12-30 Hz



Alpha: 8-12 Hz



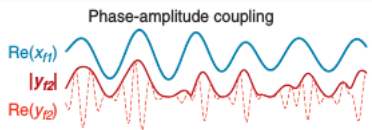
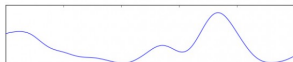
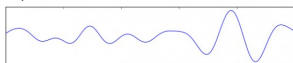
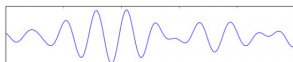
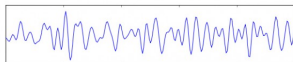
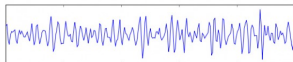
Theta: 4-7 Hz



Delta: 0-4 Hz

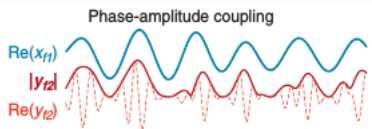
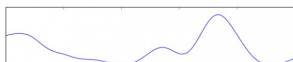
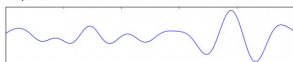
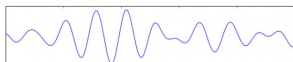
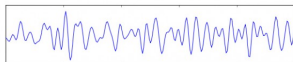
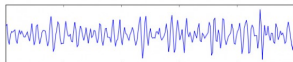
FIRING FREQUENCIES INTERACT TO ENCODE INFORMATION

Comparison of EEG Bands



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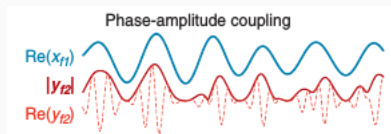
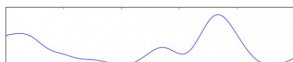
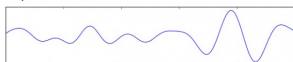
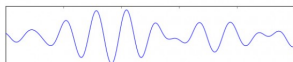
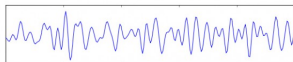
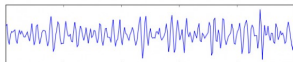


Example interactions:

- δ, γ : Bottom-up perceptions

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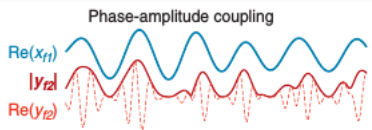
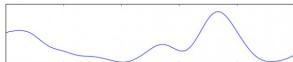
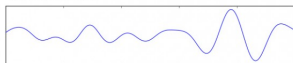
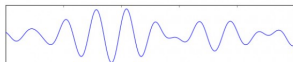
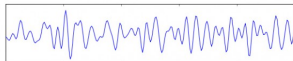
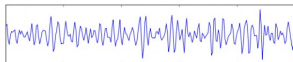


Example interactions:

- δ, γ : Bottom-up perceptions
- δ, β : Top-down predictions

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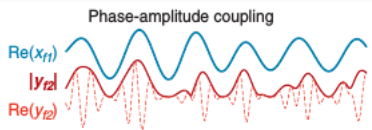
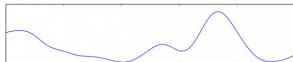
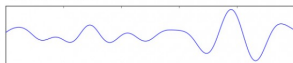
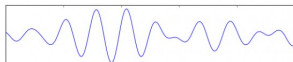
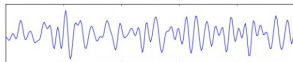
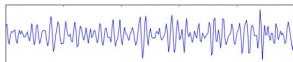


Example interactions:

- δ, γ : Bottom-up perceptions
- δ, β : Top-down predictions
- α, γ : Attentional salience ranking

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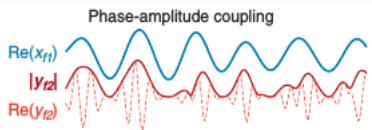
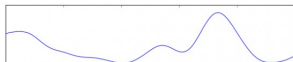
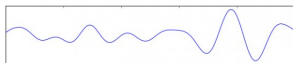
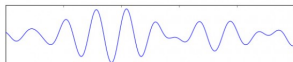
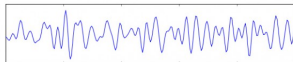
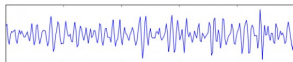


Example interactions:

- δ, γ : Bottom-up perceptions
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- θ, γ : Working memory encoding

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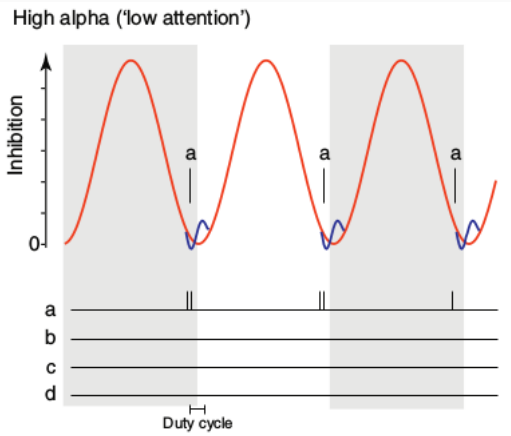


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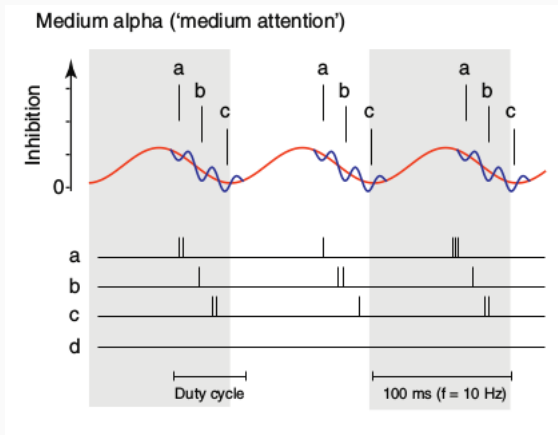
Do these translate to language?

ALPHA ATTENTIONAL CODING

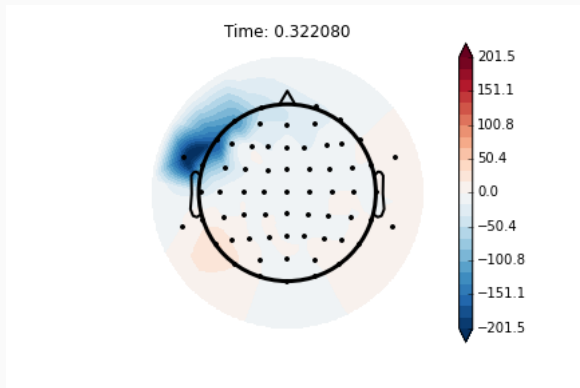


Jensen et al., (2012)

ALPHA ATTENTIONAL CODING



Jensen et al., (2012)

EEG $d_2 - d_1$ (6 subjects)

Dual task paradigm:
Combine linguistic memory task with
non-linguistic, non-memory task

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A4: Use the driving simulator!

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A4: Use the driving simulator!
With EEG?

Dual task paradigm:
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Dual task paradigm:

Combine linguistic memory task with
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How to dual task with EEG?

Dual task paradigm:

Combine linguistic memory task with
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How to dual task with EEG?

Only affect the 'attentional' channel



Little & Woollacott (2015)



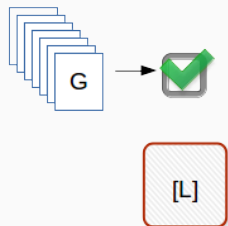


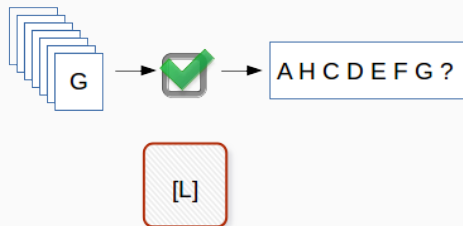


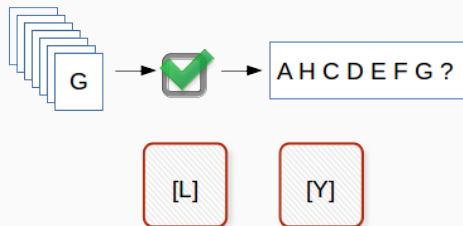


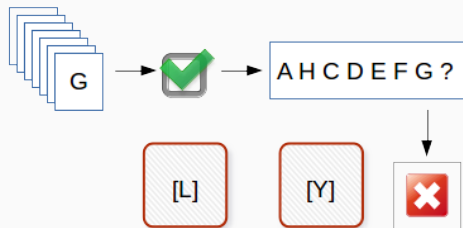












Conditions:

Ling: 0 vs 2 embedding

Task: Solo (no beep) vs Dual (beep)

Focus: Ling vs Alt

Ling-solo vs $\left\{ \begin{array}{l} \text{Ling-dual} \\ \text{Alt-dual} \end{array} \right.$

Stimuli

2 embeddings:

Either both A will V1 and B will V2 or S2.

Either both G will V1 and B will V2 or S2.

0 embeddings:

Now today, A will V1 and B will V2 or S2.

Now today, A will V3 and B will V2 or S2.

2 embeddings:

Entweder werden zuerst die Pflanzlinge umgesetzt und dann gedeiht der Garten oder der Baum trägt keine Früchte.

Entweder werden zuerst die Pflanzlinge umgetopft und dann gedeiht der Garten oder der Baum trägt keine Früchte.

0 embeddings:

Meistens werden sorgfältig die Pflanzlinge umgesetzt und dann gedeiht der Garten oder der Baum trägt keine Früchte.

Meistens werden sorgfältig die Pflanzlinge umgetopft und dann gedeiht der Garten oder der Baum trägt keine Früchte.

8 topic domains

~12 coordinator pairs / domain = 96 stimuli

2 versions of each stimulus (0,2)

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96 fillers

>50% shorter than test stimuli

50% begin with N coord

8 topic domains

~12 coordinator pairs / domain = 96 stimuli

2 versions of each stimulus (0,2)

96 fillers

>50% shorter than test stimuli

50% begin with N coord

Comprehension variants for each item/filler

66% change content word

33% change coordinator

Timing

450 ms / word

~ 10 words / sentence

(96 stimuli + 96 fillers)

6 seconds for comprehension+feedback (50%)

1 second for alt feedback (66%)

~30 second break after each domain

~30 minutes + setup + cleanup

Hypotheses and Conclusion

- α, γ (Attentional salience ranking)
ling-solo-0 < ling-dual-0 = alt-dual-0

- α, γ (Attentional salience ranking)
ling-solo-0 < ling-dual-0 = alt-dual-0
- θ, γ (Working memory encoding)
ling-solo-0 < ling-solo-2

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- Can we see the effects independently?
ling-solo-0 $<_{a < m}$ ling-dual-2

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- Can we see the effects independently?
ling-solo-0 $<_{a < m}$ ling-dual-2
- α power (Inhibition)
alternate task regions > focused task region

- Younger vs Older Subjects
- English vs German

Open questions:

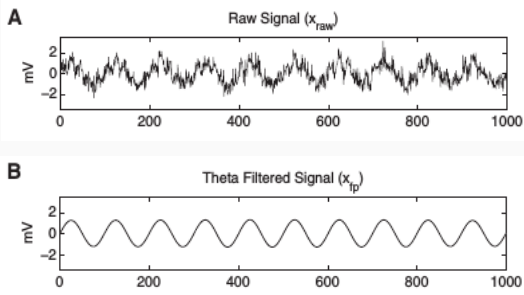
- Focus change? Just in pilot?
- 1-2-3 beeps?
- Easy vs Hard beeps?

Any questions or suggestions?

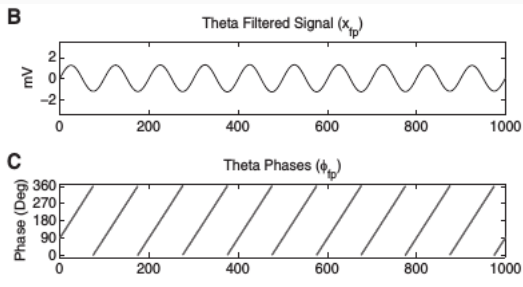
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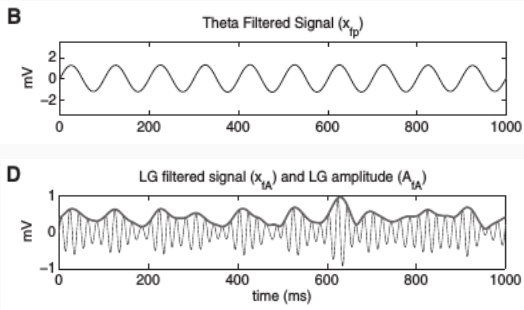
COMPUTING MODULATION INDEX (MI)



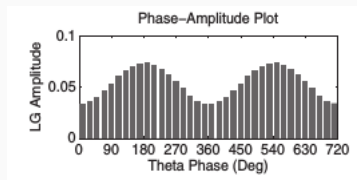
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