Temporal dynamics of spoken word recognition: an MEG study

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Theoretical background

## Theoretical background

#### Spoken word recognition

The process that maps the ongoing auditory input into the stored lexical representations in order to retrieve information associated to a specific word (Luce & McLennan, 2005)



- Meaning
- Syntactic role
- Articulatory information
- •••

#### Which types of information?

- Sub-lexical: phoneme / syllable information
- Lexical: word form information and word use information
- Semantic: measure of co-occurrence etc.

#### Where?

 Streams of hierarchically organised brain regions (Hickok & Poeppel, 2007; Poeppel, 2014)

#### In which order?

- Serial processing: sequential activation of the different level of representations (Brodback et al., 2018)
- Parallel processing: overlapping activation already at early stages (Lewis & Poeppel, 2014)



Hickok & Poeppel, 2007; Poeppel, 2014

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Semantic composition



Brodback et al., 2018



Lewis & Poeppel, 2014

The present experiment

Participants: 27 Italian native speakers (12 female, M = 26.7 years, SD = 4.9 years)

Stimuli: 438 italian words 2-4 syllables long

Task: delayed semantic categorization (was the word related to the senses?)

Acquisition: 6 run of MEG continuous recordings (306 channels)

Pre-stimulus	<b>1</b>	Post-stimulus 2.0 s	<b>1</b>	Response max 2.0 s	ITI 0.5-1.0 s
1.5 s					jittered
		"beep"			

Multiple Linear Regression

$$y = \beta_0 * x_0 + \beta_1 * x_1 + \beta_2 * x_2 + \beta_3 * x_3 + \beta_4 * x_4$$

y : MEG signal

β: Event-Related Regression Coefficients (ERRCs) representing the contribution of each predictor in explaining the variance in the MEG recordings.

Betas can be derived using the normal equation:

 $b = (X^{T}X)^{-1}X^{T}y$ 

Predictors:

- First syllable frequency (log token)
- Orthographic Levenshtein Distance
- Frequency (in Zipf's scale)
- Semantic component



#### Binder et al., 2016

#### 1743 participants rated 434 nouns, 62 verbs, 39 adjectives.

"To what degree do you think of a shoe as having a characteristic or defining color?"

Table 5. Example queries for six attributes.					
Attribute	Query	{relation}	{content}		
Colour					
	Noun	having	a characteristic or defining color?		
	Verb	being associated with	color or change in color?		
	Adjective	describing	a quality or type of color?		
Taste		2			
	Noun	having	a characteristic or defining taste?		
	Verb	being associated with	tasting something?		
	Adjective	describing	how something tastes?		
Lower limb		-			
	Noun	being associated with	actions using the leg or foot?		
	Verb	being	an action or activity in which you use the leg or foot?		
	Adjective	being related to	actions of the leg or foot?		
Landmark					
	Noun	having	a fixed location, as on a map?		
	Verb	being	an action or activity in which you use a mental map of your environment?		
	Adjective	describing	the location of something, as on a map?		
Human					
	Noun	having	human or human-like intentions, plans, or goals?		
	Verb	being	an action or activity that involves human intentions, plans, or goals?		
	Adjective	being related to	something with human or human-like intentions, plans, or goals?		



#### PCA on the features space.

Semantic component: the first principal component (~ 20% variance)

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Uniqueness point (UP)

 The point where a string of phonemes corresponds to only one word (Marlsen-Wilson & Welsh, 1978)

Stimulus duration

Estimated UP =

number of graphemes \* orthographic UP

Time window of interest around the UP (time 0)



Cluster permutation test against 0 (p<.05, 10000 perm, 3 neigh) \* = p<.05, \*\* = p<.01, \*\*\* = p<.001



Cluster permutation test against 0 (p<.05, 10000 perm, 3 neigh) \* = p<.05, \*\* = p<.01, \*\*\* = p<.001



\* = p<.05, \*\* = p<.01, \*\*\* = p<.001

0 - 400 ms (FDR corr. p < .05)



Cluster permutation test against 0 (p<.05, 10000 perm, 3 neigh) \* = p<.05, \*\* = p<.01, \*\*\* = p<.001 0 - 330 ms (FDR corr. p < .05)



Cluster permutation test against 0 (p<.05, 10000 perm, 3 neigh) \* = p<.05, \*\* = p<.01, \*\*\* = p<.001 600 – 1000 ms (FDR corr. p < .05)

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#### Results



#### Sub-lexical

Lexical competition

Lexical access

Semantic

Discussion

• Serial processing stages of spoken word recognition (Brodback et al., 2018)

• Hierarchically organised brain regions (Hickok & Poeppel, 2007; Poeppel, 2014).

- Lexical competition vs. lexical selection
- Source level encoding (anatomically defined ROIs)
- Encoding of individual features (e.g., color, shape)

# Thank you









CMeC

