Morpheme by Morpheme: The Processing of French Verbs

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Thesis Advisor: Fanny Meunier

Nice, December 3rd 2015.
0. How language can be?

1. Verbal morphology

2.1. Study 1: Pseudoverbs

2.2 Study 2: Frequency effects

2.3 Study 3: Priming effects

4. Discussion

5. Future perspectives
How language can be?

### Representation

- Prosody
- Syllable
- Phonology
- Orthography

### Level

- /i l, r e v e ’ n E/
- Il revenait.

### Processes

1. Primary acoustic analysis
2. Identification of phonemes
3. Identification of word form
4. Identification of word category
5. Identification of lemma and morphologic information
6. Integration of semantic and morphosyntactic information
7. Processes of reanalysis and repair

### ERP

- Phase 0: N100 (100ms)
- Phase 1: ELAN (150-200ms)
- Phase 2: LAN/N400 (300-500ms)
- Phase 3: P600 (600ms)

### Neuroanatomical

- Articulatory network: pMTG, TP, anterior insula (left dominant)
- Sensorimotor interface: Parietal-temporal Spt (left dominant)
- Spectrotemporal analysis: Dorsal STG (bilateral)
- Phonological network: Mid-post STS (bilateral)
- Combinatorial network: pMTG, pSTS (left-dominant)
- Lexical interface: pMTG, pSTS (weak left-hemisphere bias)

### References

Mental Lexicon

Empiricism Vs. Rationalism

Word List
aimer
aimons
aimions...

Mental Lexicon

Morphemes
aim
\[\sum_i\]
ons

Empiricism
Association (experience)

Rationalism
Symbolic combination

Colorless green ideas sleep furiously.
Morphology!

The dog.
Two dogs.

Oh, conjugation. We have: en hund, hunden, två hundar, hundarna

...Den HUND, EINEN HUND, DEM HUND, EINEM HUND, DES HUNDES, EINES HUNDES, DEN HUNDEN, DER HUNDEN!

Bollocks. Ughh...

This are even worse than I had imagined...

Language parameter
Recursively
Creativity
Production

koirasi, koirani, koiransa, koiramme, koiranne, koirani, koiransi, koiransa, koirammen, koiranne, koirassani, koirassasi, koirassansa, koirassamme, koirassanne, koirastani, koirastasi, koirastansa, koirastamme, koirastanne, koirastani, koirallerasi, koiralleransa, koiralleramme, koiralleranne, koiranani, koiranasi, koiranansa, koiranamme, koirananne, koiri=yes, koiralessi, koiralessensa, koiralessamme, koiralessanne, koiralessani, koirattasi, koirattansa, koirattamme, koirattanne, koirineni, koirinesi, koirinensa, koirinamme, koirinanne

"whimper"
Morphological Models

- **Whole-Word Access (WWA):** whole-word representations (Jackendoff, 1975; Manelis & Tarp, 1977)

- **Obligatory Decomposition (OD):** representation in morphemic and lexical levels (Taft, 1979)

- **A-Morphous Morphology:** word and paradigm representation and processing (Anderson, 1992)

- **Distributed Morphology (DM):** underspecification, syntax all-the-way-down, late insertion (Halle & Marantz, 1993)

- **Augmented Address Model (AAM):** whole-word access or morphemic activation (Caramazza, Laudanna, & Romani, 1988)

- **Lexeme-Morpheme Base Morphology (LMBM):** lexicalist hypothesis (Beard, 1995)

- **Race Model (RM):** parallel whole-word and morphemic activation (Baayen, Dijkstra & Schreuder, 1997)

- **Words and Rules (W&R):** regular and irregular words in a declarative/procedural system (Pinker, 1999; Pinker, & Ullman, 2002)

- **Minimalist Morphology (MM):** structured combinatorial constituents, early insertion (Wunderlich, 1996)

- **Connexionnist models (PDP):** interaction between orthography, phonology, and semantics in hidden units (Rumelhart, & McClelland, 1982)

- **Supralexical Morphology:** early whole word and late morphemic processing (Grainger, & Giraudo, 2001)

- **Naive Discriminative Learning (NDL):** direct mapping from form onto meaning without specific representations (Baayen et al., 2011)
# Romance Languages Review

<table>
<thead>
<tr>
<th>Language</th>
<th>Reference</th>
<th>Results and Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catalan</td>
<td>Rodriguez-Fornells et al., 2001</td>
<td>Lexical and combinatorial access by different morphological structures (Dual-mechanism), but Oltra-Massuet (1999) (DM)</td>
</tr>
<tr>
<td>Italian</td>
<td>Orsolini, &amp; Marslen-Wilson, 1997</td>
<td>Productivity and lexical specificity (Full-decomposition), but Say, &amp; Clahsen (2002) (W&amp;R)</td>
</tr>
<tr>
<td>Portuguese</td>
<td>Verissimo, &amp; Clahsen, 2009</td>
<td>1st class = structured root-based, 3rd class/vowel change = structured stem-based (Dual-mechanism), but Bassani, &amp; Lunguinho (2011) (DM)</td>
</tr>
<tr>
<td>French</td>
<td>Meunier, &amp; Marlen-Wilson, 2004 Kilani-Schoch, &amp; Dressler, 2005 Bonami et al., 2008</td>
<td>1st class = fully-regular, 2nd class = fully-regular, 3rd class = allomorphy and idiosyncrasy structured morpheme-based (full-decomposition)</td>
</tr>
</tbody>
</table>
## French Verbal Inflection

- How verbs are represented and processed in the mental lexicon?
- How words are activated and accessed?
- How verbal stems and inflectional suffixes are processed?

<table>
<thead>
<tr>
<th>Person</th>
<th>Present</th>
<th>Simple Past</th>
<th>Imperfect</th>
<th>Future</th>
<th>Conditional</th>
<th>Subjunctive</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st sg</td>
<td>parl-e</td>
<td>parl-ai</td>
<td>parl-ai-s</td>
<td>parl-e-r-ai</td>
<td>parl-e-r-ai-s</td>
<td>parl-e</td>
</tr>
<tr>
<td>2nd sg</td>
<td>parl-e-s</td>
<td>parl-as</td>
<td>parl-ai-s</td>
<td>parl-e-r-as</td>
<td>parl-e-r-ai-s</td>
<td>parl-e-s</td>
</tr>
<tr>
<td>3th sg</td>
<td>parl-e</td>
<td>parl-a</td>
<td>parl-ai-t</td>
<td>parl-e-r-a</td>
<td>parl-e-r-ai-t</td>
<td>parl-e</td>
</tr>
<tr>
<td>1st pl</td>
<td>parl-ons</td>
<td>Parl-à-mes</td>
<td>parl-i-ons</td>
<td>parl-e-r-ons</td>
<td>parl-e-r-i-ons</td>
<td>parl-i-ons</td>
</tr>
<tr>
<td>2nd pl</td>
<td>parl-ez</td>
<td>Parl-à-tes</td>
<td>parl-i-ez</td>
<td>parl-e-r-ez</td>
<td>parl-e-r-i-ez</td>
<td>parl-i-ez</td>
</tr>
<tr>
<td>3th pl</td>
<td>parl-ent</td>
<td>Parl-è-r-ent</td>
<td>parl-ai-ent</td>
<td>parl-e-r-ont</td>
<td>parl-e-r-ai-ent</td>
<td>parl-ent</td>
</tr>
</tbody>
</table>

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</thead>
<tbody>
<tr>
<td>1st sg</td>
<td>boi-s</td>
<td>bu-s</td>
<td>buv-ai-s</td>
<td>boi-r-ai</td>
<td>boi-r-ai-s</td>
<td>boiv-e</td>
</tr>
<tr>
<td>2nd sg</td>
<td>boi-s</td>
<td>bu-s</td>
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</tr>
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<td>3th sg</td>
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<td>bu-t</td>
<td>buv-ai-t</td>
<td>boi-r-a</td>
<td>boi-r-ai-t</td>
<td>boiv-e</td>
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<td>Bû-mes</td>
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<td>boi-r-ont</td>
<td>boi-r-ai-ent</td>
<td>boiv-ent</td>
</tr>
</tbody>
</table>
**Study 1: Pseudoverbs**

**Objective**
Investigate the morphological decomposability of the French verbs and the processing of different morphological structures.

**Questions**

a. Which is the cognitive cost (RT) for processing the different morphemes?

b. Is there a difference in function of the number of suffixes?

c. Which is the morphological processing hierarchy?

**Method**

- **Subjects:** N=36, 18 women, mean age 21.48, Fr L1
- **Experience:** lexical decision task in visual modality
- **Study:** 5 cond. of structure X 2 cond. operations
  1) 50 only suffix (OS)
  2) 50 only base (OB)
  3) 50 existent morphological legal (EML)
  4) 50 inexistent morphological legal (IML)
  5) 50 morphological illegal (MI)

[Diagram of morphological structures]

- EML VP
  - v
  - T
  - Agr
  - parl i/o ons
  - [imp]/[pre] [1p]

- OB VP
  - v
  - X
  - parl ou
  - [?] [?]

- OS VP
  - X
  - T
  - Agr
  - fech i/o ons
  - [?][imp]/[pre] [1p]

- IML VP
  - v
  - T
  - Agr
  - parl i/o t
  - [imp]/[pre] [3s]

- MI abrou

**Processing of the French verb by lexical decomposition**

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2Laboratoire sur le Langage, le Cerveau et la Cognition (L2C2, CNRS UMR5304)
Study 1: Pseudoverbs

**Predictions**
Whole Word Access (WWA) (Manelis & Tharp, 1977):
(EML) < MI = OB = OS = IML

Obligatory Decomposition Model (OD) (Taft, 1979):
MI = OB < OS < (EML) < IML

Augmented Addressed Model (AAM) (Caramazza et al., 1988):
MI < (EML) < OB = OS < IML

**Discussion**
MI = OB < EML = OS < IML
✓ WWA immediately rejected.
✓ AAM rejected because OB ≠ OS, list size and frequency.
✓ OD prediction! MI do not allow decomposition being promptly rejected; OB decomposed with fast suffix rejection; OS long base list; IML inhibited, recombination crashes; EML decomposed and recombined.
✓ EML and OS = operation affect.
Study 2: Frequency effects

**Objective**
Investigate the stem representation of French verbs in function of the surface and base frequencies (Taft, 1979).

**Surface frequency (SF)**
aime=52, aimez=18

**Base frequency (BF)**
aime+aimez+aimons...
52+18+6+...=795

**Hypothesis**
- **H0**: SF effect/no BF effect = whole word recognition.
- **H1a**: SF and BF effects = word decomposition. Morphophonological and Irregular stem allomorphs have different representations.
- **H1b**: no BF effect = Morphophonological and Irregular stem allomorphs have an abstract representation.

**Method**
- **Subjects**: N=32, 16 women, mean age 20.31, Fr L1
- **Experience**: lexical decision task in visual modality
- **Study**: 4 verb types, 4 conditions
- **Stimuli**: 320 experimental verbs, 320 pseudoverbs

<table>
<thead>
<tr>
<th>+BF</th>
<th>-BF</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>+SF</strong></td>
<td><strong>-SF</strong></td>
</tr>
<tr>
<td>Regular</td>
<td>entrait</td>
</tr>
<tr>
<td>Morpho. e/E</td>
<td>répétait</td>
</tr>
<tr>
<td>Morpho. o/O</td>
<td>adorais</td>
</tr>
<tr>
<td>Irregular</td>
<td>buvaient</td>
</tr>
</tbody>
</table>
Study 2: Frequency effects

Discussion

- **Regulars** = fully-combinatorial
- **Morphophonological** = phonological underspecified representation (late insertion) (Zhou & Marslen-Wilson, 1999)
- **Idiosyncratic** = different stem representations (Aronoff, 1994)
- **SF effect** = recombination between stem and affixes (Taft, 1979)
- **BF effect** = decomposition evidence
- **Visual modality** = contribute to decomposition (Rastle & Davis, 2008)
- Obligatory decomposition model (Taft, 2004; Halle & Marantz, 1993); revised dual-route model (Baayen; Dijkstra & Schreuder, 1997)
Morphological Decomposition

Regulars
- "aime": aim-e
- "aimons": aim-e-ons

Irregulars
- "vois": voi-s
- "verra": ve-rra

Morphophon.
- "achète": achète
- "achetons": achèt-e achet-on

Veuillez noter que les exemples sont en français et que "achèt-e" et "achet-on" sont des formes verbales irrégulières."
Study 3: Priming effects

Romance languages verbal system inherited from Latin (Dubois, 1967)

**Stem:** form after inflectional suffix stripping (Aronoff, 1994)

**Theme vowel (Th):**
conjugational (class, group) vowel merged with the root in theme (stem) formation

<table>
<thead>
<tr>
<th>Language</th>
<th>á</th>
<th>ë</th>
<th>ë</th>
<th>ì</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latin</td>
<td>amārē</td>
<td>prendērē</td>
<td>vidērē</td>
<td>audīrē</td>
</tr>
<tr>
<td>Spanish</td>
<td>amar</td>
<td>prender</td>
<td>ver</td>
<td>oír</td>
</tr>
<tr>
<td>Portuguese</td>
<td>amar</td>
<td>prender</td>
<td>ver</td>
<td>ouvir</td>
</tr>
<tr>
<td>Italian</td>
<td>amare</td>
<td>prendere</td>
<td>vedere</td>
<td>udire</td>
</tr>
<tr>
<td>Catalan</td>
<td>amar</td>
<td>prendere</td>
<td>veure</td>
<td>sentir</td>
</tr>
<tr>
<td>French</td>
<td>aimer</td>
<td>prendre</td>
<td>voir</td>
<td>ouïr</td>
</tr>
</tbody>
</table>
Study 3: Priming effects

Questions

• Is there a Th morpheme representation in French? Root? Stem?

• How stems from specific micro-classes are represented and processed:
  a) 1st: [-er]/eE,
  b) 3rd: [-ir]/[-dre]/[-ire]/[-indre] (80%)

• How the morphological and phonological/prosodic systems interact in French?

Main Objective
• Investigate if the Th is represented in the French mental lexicon

Secondary Objectives
• Explore which structures, nodes, and morphemes are stored in the French mental lexicon
• Study how verbal morphological is influenced by the phonological/prosodic systems
**Target:** 1st plural present inflected form [-ons]

**Prime predictions:**
- **Identity** = same target (full priming)
- **Control** = different infinitive (no priming)
- **Test** = target infinitive (?)

**Stimuli:**
- 6 verb types, 3 conditions
- Experimental: 126 pair of verbs
  (21 per verb type)
- Fillers: 294 pairs
  (84 w-w, 210 w-p (84 phono., 126 unrel.))

<table>
<thead>
<tr>
<th>Verb Type</th>
<th>Control</th>
<th>Test</th>
<th>Identity</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) 1st e/E</td>
<td>peser</td>
<td>lever</td>
<td>lèvent</td>
<td>LEVENT</td>
</tr>
<tr>
<td>b) 1st [-er]</td>
<td>aimer</td>
<td>parler</td>
<td>parlons</td>
<td>PARLONS</td>
</tr>
<tr>
<td>c) 3rd [-ir]</td>
<td>ouvrir</td>
<td>dormir</td>
<td>dormons</td>
<td>DORMONS</td>
</tr>
<tr>
<td>d) 3rd [-dre]</td>
<td>prendre</td>
<td>vendre</td>
<td>vendons</td>
<td>VENDONS</td>
</tr>
<tr>
<td>e) 3rd [-ire]</td>
<td>construire</td>
<td>écrire</td>
<td>écrivons</td>
<td>ECRIVONS</td>
</tr>
<tr>
<td>f) 3rd [-indre]</td>
<td>paindre</td>
<td>joindre</td>
<td>joignons</td>
<td>JOIGNONS</td>
</tr>
<tr>
<td>g) Control(MP)</td>
<td>brûler</td>
<td>apprécier(S)</td>
<td>administe(O)</td>
<td>ADMIRONS</td>
</tr>
</tbody>
</table>

**Experiment1:** cross-modal priming

**Subjects:** N=54, 27 women, mean age 21.82, French as L1

**Experiment2:** masked priming

**Subjects:** N=54, 27 women, mean age 22.51, French as L1
**Study 3: Hypothesis**

**Predictions on Prime Types**
- **Full priming**: Identity = same representation
- **No priming**: Control = different representation
- **Partial priming** = different but linked representations

**H0**: no priming in Test Condition:
  a) verb not decomposed: [word]
  b) whole-word representation

**H1**: full priming in Test Condition:
  a) verb completely decomposed: [[[√][Th]][[T][Agr]]]
  b) rule-based stem
  c) phonological abstract representation e/E

**H2**: partial priming in Test Condition:
  a) verb partially decomposed [[Stem][[T][Agr]]]
  b) stem allomorphic storage
  c) phonological representation e/E
Study 3: Results

Exp.1 – Cross-modal

Exp.2 - Masked

Full priming = -ER, -IR, -DRE, e/E
[-er]/[-ir]: Th representation; same morphological structure
[-dre]: no Th representation
e/E: abstract phonological representation (Marslen-Wilson, & Zhou, 1999)
Completely decomposed
Differences in mc productivity

Partial priming = -IRE, -INDRE
Different stem representations or morphological operations

No priming = CONTROL(MP)
## Study 3: Verbal Structure Representation

<table>
<thead>
<tr>
<th>1st Class</th>
<th>3rd Class (rules)</th>
<th>3rd Class (allom.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-er</td>
<td>-ir</td>
<td>-ire</td>
</tr>
<tr>
<td><strong>Target</strong></td>
<td><strong>Prime</strong></td>
<td><strong>Target</strong></td>
</tr>
<tr>
<td>[parler]_{Inf}</td>
<td>[parle]<em>{Theme} [r]</em>{T}</td>
<td>[dormir]_{Inf}</td>
</tr>
<tr>
<td>[parl]<em>{Root} [e]</em>{Th}</td>
<td>[parlons]<em>{1p pre} [parl]</em>{Root} [ons]_{Agr}</td>
<td>[dormons]<em>{1p pre} [dorm]</em>{Root} [ons]_{Agr}</td>
</tr>
<tr>
<td>e/E</td>
<td>-dre</td>
<td>-indre</td>
</tr>
<tr>
<td>[lever]_{Inf}</td>
<td>[leve]<em>{Theme} [r]</em>{T}</td>
<td>[vendre]_{Inf}</td>
</tr>
<tr>
<td>[lev]<em>{Root} [e]</em>{Th}</td>
<td>[lEvent]<em>{3p pre} [lev]</em>{Root} [ent]_{Agr}</td>
<td>[vendons]<em>{1p pre} [vend]</em>{Root} [ons]_{Agr}</td>
</tr>
</tbody>
</table>

- **full priming**
- **partial priming**
Word and Paradigm Vs. Item and Process

Paradigm

joindre
joignons

Process

joindre
joignons

joind-
joign-
joind-re
joign-ons

joix-
joind-re
joign-ons
French Verbs in the Mental Lexicon

**Metrical Phonology**
Halle, & Idsardi, 1996

```
<table>
<thead>
<tr>
<th>e/E</th>
<th>*</th>
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</tbody>
</table>

relèves relevons relèverons
```

```
| [-ire] | * |
|        | * |
|        |   |

écrits écrivons
```

```
| [-indre] | * |
|          | * |
|          |   |

rejoins rejoignons
```

**1st class [er]**

- jeter -> jEttent
- appeler -> appEllent
- lever -> lEvent
- adorer -> adOrent

```
| √/e/ - > √/E/ / [stress] |
| √/o/ - > √/O/ / [stress] |
|                            |
```

**2nd class [ir]/[ss]**

- finir -> finissons

```
| √<ir> - > √<iss> / _ V[stress] |
|                                |
```

**3rd class [XrX]**

- dormir -> dort
- prendre -> prenons

```
| √<g> - > √<ge> / _ V[stress] |
| √<c> - > √<ç> / _ V[stress] |
|                            |
```

** Auxiliary Verbs **
être, avoir, aller

**Modal Verbs**
pouvoir, vouloir

Kilani-Schoch & Dressler (2006)
General Discussion

- French verbs are obligatory completely decomposed for morpheme processing

- All 3 verb classes are fully-combinatorial

- Unlike other Romance languages (Spanish, Catalan, Italian, and Portuguese), French has a single combinatorial mechanism

- Th representation, and consequently, root and structure representations in stem formation

- Allomorphic stem representations, or alternatively, morphological operations in stem allomorphy

- French verbs are first decomposed in stem and inflectional suffixes; and after, the stem is decomposed in root and Th, with minimal morphemic activation

- Stems are defined by allomorphy and morphophonological rules driven by suffixal morphemes, phonology, and prosody

Perspectives

- Rule processing (cost)

- Suffix processing: productivity, relative entropy

- Morphological processing time-course (EEG)

“There is always a minimal computation”

(Chomsky, 1965)
Thank you for
the attention!
Bibliography


