Evidence of first-language attrition in the brain

Kristina Kasparian
Francesco Vespignani
& Karsten Steinhauer
Background

- Long history of claims and debates surrounding idea of a *Critical Period* for language-learning
  - Maturational limits on brain’s ability to change (plasticity)
  - First-language (L1) is “hard-wired” in early years of life
  - Second-language (L2) must rely on different systems than those used for the L1
- Increasing evidence of neural plasticity (even in adulthood) has cast doubt on claim

→ Controversial!
The *neurocognitive* perspective

- **Behavioral methods** focus on *linguistic performance*
  - **Q:** Is it possible to reach a native-like level in a second language when it was learned after the “critical period”?

- **Neuro methods** focus on the *underlying systems* involved in language learning/processing
  - **Q:** If a late-learner *does* reach a high level of L2 proficiency, *does the brain do so in the same way as early learners?*
    - Same processes, in same areas?
    - Same speed/automaticity?
    - Different compensatory strategies?
A confound with “age”...

- A number of studies have shown that late-learners differ from native-speakers in linguistic performance and/or neurocognitive processes.

- However, late age of acquisition often confounded with low proficiency level (and low exposure).

→ Differences in the brain because the L2 was learned LATE or because speakers are not fully proficient in the L2?
Aims

(1) To tease apart age-effects from proficiency effects in “minority-language speakers” or “attriters”

- Low exposure and declining proficiency in early-L1
- High exposure and proficiency in late-L2

→ Are they native-like in linguistic abilities and in how the brain processes their L1, despite limited use?
Aims

(2) To study the neurocognitive aspects of language attrition (= loss or decline) which are still unexplored
Minority language speakers

- Italian native speakers (born in Italy)
- Immigrated to Montreal in adulthood
- Had fully acquired standard-Italian
- Dominant in English (limited use of Italian)
- ALL of them report changes to Italian, for example:
  - Confusing words and trouble finding words in Italian
  - Transferring English words when speaking Italian
  - Italian grammar influenced by English grammar
Groups

- “Attriters” (minority language speakers)
  - Italian (non-dominant L1) + English (late, high-proficient L2)
- Bilingual controls
  - English (L1) + Italian (late, highly proficient L2)
- Italian native-speakers in Italy
- English native speakers
<table>
<thead>
<tr>
<th>MEASURE</th>
<th>ATTRITERS (n=19) Mean (SD)</th>
<th>ITALIAN NATIVES (n=30) Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at testing</td>
<td>37.8 (7.9)</td>
<td>31 (7.3)</td>
</tr>
<tr>
<td>Age at immigration</td>
<td>27.8 (6.9)</td>
<td>----</td>
</tr>
<tr>
<td>Length of residence</td>
<td>10.6 (5.0)</td>
<td>----</td>
</tr>
<tr>
<td>Age 1\textsuperscript{st} exposure English</td>
<td>16 (4.72)</td>
<td>----</td>
</tr>
<tr>
<td>C-test (written production)</td>
<td>94.8 (3.9)</td>
<td>96.3 (4.4)</td>
</tr>
<tr>
<td>Error correction test (written comprehension)</td>
<td>87.6 (5.1)</td>
<td>90.0 (5.1)</td>
</tr>
<tr>
<td>Semantic verbal fluency</td>
<td>20.4 (3.7)</td>
<td>23.4 (5.5)</td>
</tr>
<tr>
<td>Reading fluency</td>
<td>72.7 (15.4)</td>
<td>71.2 (13.2)</td>
</tr>
<tr>
<td>Working memory</td>
<td>5.5 (1.2)</td>
<td>5.5 (1.1)</td>
</tr>
<tr>
<td>MEASURE</td>
<td>ATTRITERS (n=19) Mean (SD)</td>
<td>ITALIAN NATIVES (n=30) Mean (SD)</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-----------------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>Age at testing</td>
<td>37.8 (7.9)</td>
<td>31 (7.3)</td>
</tr>
<tr>
<td>Age at immigration</td>
<td>27.8 (6.9)</td>
<td>---</td>
</tr>
<tr>
<td>Length of residence</td>
<td>10.6 (5.0)</td>
<td>---</td>
</tr>
<tr>
<td>Age 1st exposure English</td>
<td>16 (4.72)</td>
<td>---</td>
</tr>
<tr>
<td>C-test (written production)</td>
<td>94.8 (3.9)</td>
<td>96.3 (4.4)</td>
</tr>
<tr>
<td>Error correction test</td>
<td>87.6 (5.1)</td>
<td>90.0 (5.1)</td>
</tr>
<tr>
<td>(written comprehension)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Semantic verbal fluency</td>
<td>20.4 (3.7)</td>
<td>23.4 (5.5)</td>
</tr>
</tbody>
</table>

→ Do ERPs reveal more than behavioral proficiency measures?
Lexical (vocabulary) access in online comprehension of Italian

Experiment 1
Research questions

- Is there evidence of **lexical attrition in online** (= real-time) comprehension of Italian (L1)?
- Does evidence support participants’ anecdotal reports of “confusing words” in Italian?
Design

- Pairs of nouns differing in final vowel, but different meaning
e.g. cappello (hat) vs. cappella (chapel);
mento (chin) vs. menta (mint)

- Sentence contexts for each word (48 pairs = 96 contexts)

- **3 conditions:**
  - Correct (each word in pair occurs in its proper context)
  - Swap (words in pair are switched: cappella in cappello context)
  - Mismatch (word from another pair: menta in cappello context)

- Balanced design: Each target word occurs in each condition

- Reading study

- **Task:** Acceptability judgment (rating 1-5)
What do ERPs tell us?

- Specific language processes trigger identifiable and replicable brain wave patterns
- **The “N400”**
  - Elicited when a semantically anomalous word is detected
  - The more implausible or anomalous the word, the larger the N400

![Graph showing N400 wave pattern](image)

*Experiment 1: Kutas, Lindamood & Hillyard, 1984*
ERP components

- Specific language processes trigger identifiable and replicable brain wave patterns
- **The “P600”**
  - Re-analysis of interpretation
  - Conflict monitoring

Bourguignon et al., 2012
Predictions

- **Italian native-speakers**
  - Classic **N400** for mismatch and swap
  - Followed by small **P600** (re-analysis)

- **Attriters (immigrants)**
  - If words are confused, swap error may go undetected
    - **N400 only for mismatch** condition
    - **Smaller/no N400 for swap** condition
  - Followed by large **P600**: “second thought” – more conflict monitoring
Mismatch: To cover his head, the fisherman wears the mint of wool.
Swap: To cover his head, the fisherman wears the chapel of wool.
Correct: To cover his head, the fisherman wears the hat of wool.
Mismatch: To cover his head, the fisherman wears the mint of wool.
Swap: To cover his head, the fisherman wears the chapel of wool.
Correct: To cover his head, the fisherman wears the hat of wool.
Attrition – a continuum?

- A closer look at the minority group reveals 2 subgroups
  - Higher proficiency range in Italian
  - Lower proficiency range in Italian
    (→ more likely candidates of attrition)

- Do their ERP patterns differ, on a continuum from native-like → mild attrition effects → strong attrition?
Attriters with higher Italian (L1) proficiency

Experiment 1
Attriters with lower Italian (L1) proficiency

Sign. N400 only for mismatch

P600
Experiment 1

Swap vs. Correct

N400

Natives

HP Attriters

LP Attriters

P600
Discussion

- A different pattern of processing in attriters, especially lower-range of Italian (L1) proficiency
  - “Swap” not readily detected (less automatic processing)
  - Large P600 - “second thought” after they miss it initially
- First-ever ERP evidence of attrition in vocabulary access!
- Striking experimental support for “confusing words” in their native language!
Morphosyntactic (grammar) processing in online comprehension of Italian

Experiment 2
Research questions

- Is there evidence of **attrition in morphosyntax** (although studies suggest grammar less vulnerable)?
- Do attriters **interpret and process** Italian differently than native controls due to **interference** from English?
Design

- **Relative clauses: Cross-linguistic differences**
  - **In grammaticality**
    - 4 word orders are possible in Italian
    - 2/4 are impossible/ungrammatical in English
  - **In cue strength**
    - Italian speakers rely on semantic cues
    - English speakers rely on word-order

- Strong agent-patient relationships (e.g. policeman/arrests/thief)
- Task: Acceptability judgment (1-5)

*Competition Model (MacWhinney & Bates, 1989)*
## Stimuli

<table>
<thead>
<tr>
<th></th>
<th>V-NP</th>
<th>Subject/Object</th>
<th>Translation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>V-NP</td>
<td>subject</td>
<td>Il gatto che caccia i topi corre nel giardino.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(The cat that chases the mice runs in the garden)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>O</td>
<td>S</td>
</tr>
<tr>
<td>2</td>
<td>V-NP</td>
<td>object</td>
<td>I topi che caccia il gatto tremano di paura.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(The mice that chases the cat tremble with fear.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S</td>
<td>O</td>
</tr>
<tr>
<td>3</td>
<td>NP-V</td>
<td>subject</td>
<td>Il gatto che i topi caccia corre nel giardino.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(The cat that the mice chases runs in the garden.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S</td>
<td>O</td>
</tr>
<tr>
<td>4</td>
<td>NP-V</td>
<td>object</td>
<td>I topi che il gatto caccia tremano di paura.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(The mice that the cat chases tremble with fear.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>O</td>
<td>S</td>
</tr>
<tr>
<td>Stimuli</td>
<td>1. V-NP subject</td>
<td>Il gatto che <em>caccia</em> i topi corre nel giardino.</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>(The cat that chases the mice runs in the garden)</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. V-NP object</td>
<td>I topi che <em>caccia</em> il gatto tremano di paura.</td>
<td>✗</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>(The mice that chases the cat tremble with fear.)</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. NP-V subject</td>
<td>Il gatto che i topi <em>caccia</em> corre nel giardino.</td>
<td>✗</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>(The cat that the mice chases runs in the garden.)</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. NP-V object</td>
<td>I topi che il gatto <em>caccia</em> tremano di paura.</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>(The mice that the cat chases tremble with fear.)</em></td>
<td></td>
</tr>
</tbody>
</table>
Predictions

- Italian native-speakers
  - All conditions are grammatical, but #2-3 are unpreferred
  - Reliance on semantic cues → N400
Predictions

- Italian native-speakers
  - All conditions are grammatical, but #2-3 are unpreferred
  - Reliance on semantic cues $\rightarrow$ N400

- Attriters
  - If following Italian grammar $\rightarrow$ same patterns as controls
  - If transfer from L2-English grammar $\rightarrow$ little/no reliance on semantic cues (no N400) and #2-3 should be perceived as strong grammatical violations (LAN, P600)
Online acceptability ratings

Experiment 2

V-NP subj  V-NP obj  NP-V subj  NP-V obj
V-NP subject vs. object: Italian natives

Il gatto che caccia i topi corre nel giardino.
(The cat that chases the mice runs in the garden)
I topi che caccia il gatto tremano di paura.
(The mice that chases the cat tremble with fear.)
No evidence of any N400: No reliance on semantic cues
Stronger grammatical violation effect (larger P600)
### Experiment 2

#### Online acceptability ratings

<table>
<thead>
<tr>
<th>Group</th>
<th>V-NP subj</th>
<th>V-NP obj</th>
<th>NP-V subj</th>
<th>NP-V obj</th>
</tr>
</thead>
<tbody>
<tr>
<td>Italy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minority</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
NP-V subject vs. object: Italian natives

Il gatto che i topi caccia corre nel giardino.  
(The cat that the mice *chases* runs in the garden)

I topi che il gatto caccia tremano di paura.  
(The mice that the cat *chases* tremble with fear.)

→ Mild garden-path effect, rather than outright grammatical violation
NP-V subject vs. object: Attriters

Il gatto che i topi caccia corre nel giardino.
( The cat that the mice chases runs in the garden)
I topi che il gatto caccia tremano di paura.
( The mice that the cat chases tremble with fear)

Different pattern: Early negativity instead of early positivity
Experiment 2

Subject vs. Object

NATIVES

P3a
0.300 .. 0.450 s

P600
0.450 .. 0.700 s

P600
0.700 .. 1.000 s

ATTRITERS

N400
0.300 .. 0.450 s

LAN
0.450 .. 0.700 s

P600
0.700 .. 1.000 s
Discussion

- For relative-clause word orders that are ungrammatical in English (but possible in Italian), **attriters give lower ratings AND process sentences differently when reading in Italian**

$\Rightarrow$ **L2-dominance affects grammar in the native L1**
Conclusions

- First evidence of attrition effects using ERPs
- Dominant and highly-proficient L2 influences L1 in both vocabulary and grammar
- Online measures such as ERPs provide crucial information about attrition, as some effects may not be revealed in behavioral tasks
- Evidence of ongoing brain plasticity, even in adulthood
- The “downside” of brain plasticity – L1 not privileged
THANK YOU!
Acknowledgements

- **Funding:**
  - K. Kasparian: Vanier Canada Graduate Scholarship, Richard H. Tomlinson Fellowship, Michael-Smith Foreign Study Supplement
  - K. Steinhauer: Canada Research Chair, NSERC Discovery grant

- **Supervision:**
  - Dr. Karsten Steinhauer (McGill)
  - Dr. Francesco Vespignani (Uni Trento)

- **Valuable feedback:**
  - Dr. John Drury
  - Dr. Eleonora Rossi
  - Dr. Monika Schmid

- **Research assistants:** Kristina Maiorino, Paolo Zandomeneghi, Filippo Vicari, Lucia D’Arienzo, Linna Jin