First-language attrition in the online revision of ungrammaticality

ERP evidence challenging the “critical period” view

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& Karsten Steinhauer
Background

- Neurobiological ‘critical period’ for L2 learning is still controversial

- AoA effects = Maturational constraints on brain plasticity
  - L1 is “hard-wired” and stable from early years of life
  - L2 must rely on “non-native-like” processing mechanisms

- Differences in the brain due to late age-of-acquisition (AoA) or low levels of proficiency / exposure?

[AoA and proficiency often confounded]
Proficiency vs. Age-of-acquisition

- Late L2 learners at very high proficiency levels:
  - Do exist
  - Show indistinguishable processing patterns from native-speakers e.g., Bowden et al., 2014; Friederici, Steinhauer & Pfeifer, 2002; Osterhout et al., 2006; Rossi et al., 2006; Steinhauer, White & Drury, 2009; White, Genesee & Steinhauer, 2012

- Proficiency found to be critical factor in modulating brain’s responses to language - even in monolingual speakers e.g., Pakulak & Neville, 2010

- AoA effects despite high proficiency, especially in cases of cross-linguistic differences and “difficult” L2 features (e.g., long-distance dependencies) → argument in favor of maturational constraints e.g., Clahsen & Felser, 2006
The special case of “attriters”

- Immigrants immersed in a new language in adulthood
  - Shift from monolingual L1 environment to L2 environment
  - Highly-proficient in predominantly-used L2
  - Limited/no exposure in native-L1

→ **Attrition** = shift in dominance and negative changes in L1 due to predominant use of L2  
  (see Schmid & Köpke, 2007; Schmid, 2011)
New light on an old problem

- Brain mechanisms underlying L1 processing:
  - Stable and “native-like” despite “attrition symptoms”, due to hard-wiring within maturational limits on neuroplasticity?
  - OR different from non-attriting native-speakers?
    → Evidence of ongoing neuroplasticity in adulthood

- Long history of behavioral studies on L1 attrition
- Neurocognitive approach still relatively unexplored (especially in morpho-syntax)
M. Schmid et al. ERP study

- **German gender agreement** in L2ers and attriters

- **Paradigm:**
  - **Correct:**
    - *Das* (neut) *Gras* (neut)
    - *The* (neut) *grass* (neut)
  - **Violation:**
    - *Der* (masc) *Gras* (neut)
    - *The* (masc) *grass* (neut)
M. Schmid et al. ERP study

L1 monolingual (Control group)
Correctness: p < .001

L1 attriters (L2: English)
Correctness: p < .001

Late L2 learners
No gender in L1
Corr × Hemi: p < .01

Late L2 learners
Gender in L1

... das / * der frische Gras ...
... the_fresh / * the_max fresh grass ...
M. Schmid et al. (cont.)

Conclusion:
- Critical period for late L2 learners’ morpho-syntax, but attriters = monolingual L1 (no evidence for late plasticity)

Potential Critique:
- Das\textsubscript{(neut)} Gras\textsubscript{(neut)} *Der\textsubscript{(masc)} Gras\textsubscript{(neut)}
- Paradigm tests **online availability of lexically stored noun gender**, not just morpho-syntactic processing (→ e.g., Lemhöfer et al., 2014, JoCNS)
- Focus exclusively on P600 (more subtle diffs in attriters?)
Current study

- Grammatical processing in the L1
- Reading study using event-related potentials (ERPs)
- Local and non-local number agreement (subject-verb-modifier)

**Research Qs:**

- Do Attriters differ from non-attriting native-speakers in detection and/or repair of number-agreement errors in real-time sentence comprehension?
- Are differences modulated by L1 proficiency?
2 groups of native-Italian speakers

- "Attriters" (first generation immigrants; n = 24)
  - Italian (L1) + English (late, high-proficient L2)
  - Born in Italy (fully acquired standard-Italian)
  - Immigrated to Canada in adulthood (> 28 yrs; LoR:12 yrs)
  - Unanimously reported Italian proficiency had changed:
    - Accessing intended words (semantic intrusions, false friends)
    - Non-native grammar constructions (influenced by English)

- Control: Italian native-speakers in Italy (n = 30)
Proficiency

Several L1-Italian measures
- Written C-test (Kras, 2008)
- Written Error-detection test (designed for this study)
- Verbal semantic fluency
- Reading-fluency (designed for this study, based on Woodcock-Johnson et al., 2001)

Attriters scored lower but not significantly-different from Controls

Effects of proficiency on ERPs were analyzed with proficiency “subgroups” (median split) and continuous measure (scores)

See Schmid 2011 book for methodological considerations
Number agreement and ERPs

LAN (left-anterior negativity): Early detection of morphosyntactic violation (Kaan, 2002; Osterhout & Mobley, 1995)

OR

LTN (left-temporal negativity)  
Weber-Fox & Neville, 1996; Steinhauer et al., 2010)

Figure source: Review paper by Molinaro, Barber & Carreiras, 2011 in Cortex
Number agreement and ERPs

Early frontal positivity ("frontal P600"): Integration difficulties with previous context
(Barber & Carreiras, 2005; Kaan & Swaab, 2003; Molinaro, Vespignani et al., 2008; Molinaro et al., 2011)

Figure source: Review paper by Molinaro, Barber & Carreiras, 2011 in Cortex
Number agreement and ERPs

**P600:** Repair and re-analysis
**Larger for costlier repair**
(Carreiras, Salillas & Barber, 2004; Mancini et al., 2009; Molinaro, Vespignani et al., 2008; Silva-Pereyra & Carreiras, 2007)

*Figure source: Review paper by Molinaro, Barber & Carreiras, 2011 in Cortex*
**N400:** associated with accessing lexical-information / expectancy-based mismatches

*Figure source: Review paper by Molinaro, Barber & Carreiras, 2011 in Cortex*
Number agreement and ERPs (cont.)

- However, not all agreement studies make distinction between early/frontal positivity and late/posterior P600
  - Different underlying neurocognitive processes?

- Cross-linguistic differences in “cues”:
  - **Italian**: Rich morphological system; relatively free word-order (subject can follow verb)
  - **English**: Less-detailed number-marking system; word-order constrains subject interpretation

  - Expectancy-based negativities may be less likely in Italian
  - What do attriters rely on if exposure/dominance shifting to L2?
### Experimental design

<table>
<thead>
<tr>
<th>S-V-M agr.</th>
<th>x</th>
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- Based on Molinaro et al., 2011 (JML, Experiment 2)
- Number of noun counterbalanced (half sing, half plur)
- Intervening noun (fabbrica) always inanimate and feminine
On the **VERB**:

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### On the MODIFIER: Repair based on verb?

| xxx | Il lavoratore torna dalla fabbrica sporco di grasso.  
The worker$_{sg}$ returns$_{sg}$ from the factory dirty$_{sg}$ with grease. |
|-----|--------------------------------------------------------------------------------------------------|
| xyx | Il lavoratore tornano dalla fabbrica sporco di grasso.  
The worker$_{sg}$ return$_{pl}$ from the factory dirty$_{sg}$ with grease. |
| xyy | Il lavoratore tornano dalla fabbrica sporchi di grasso.  
The worker$_{sg}$ return$_{pl}$ from the factory ?dirty$_{pl}$ with grease. |
| xxy | Il lavoratore torna dalla fabbrica sporchi di grasso.  
The worker$_{sg}$ returns$_{sg}$ from the factory dirty$_{pl}$ with grease. |

- Molinaro et al.: **Number of verb overrides number of noun** when violation is detected on the verb (→ repair) and sentence follows verb number.
## On the **MODIFIER**: Repair based on verb?

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<th>Note</th>
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| xxx     | *Il lavoratore torna dalla fabbrica sporco di grasso.*  
The worker$_{sg}$ returns$_{sg}$ from the factory dirty$_{sg}$ with grease. | |
| xyx     | *Il lavoratore tornano dalla fabbrica sporco di grasso.*  
The worker$_{sg}$ return$_{pl}$ from the factory dirty$_{sg}$ with grease.  
→ **P600 effects when modifier clashes with verb number** | |
| xyy     | *Il lavoratore tornano dalla fabbrica sporchi di grasso.*  
The worker$_{sg}$ return$_{pl}$ from the factory dirty$_{pl}$ with grease.  
→ **NO P600 in previous study; Repair based on verb number** | |
| xxy     | *Il lavoratore torna dalla fabbrica sporchi di grasso.*  
The worker$_{sg}$ returns$_{sg}$ from the factory dirty$_{pl}$ with grease.  
→ **Not tested in previous study; P600 expected** | |
Behavioral results: Acceptability ratings (on a scale 1-5)
Il lavoratore | *tornano
*return
Torna
returns

The worker | torna

22 ERPs on verb

CONTROLS

- Small LTN (300-500ms)
- T5
- FZ
- P600 (650-1200ms)
- PZ

Frontal pos. (550-650ms)
ERPs on verb

**CONTROLS**
- Small LTN **T5** (300-500ms)

**ATTRITERS**
- Broad N400 **(300-500ms)**
- Broad N400 **(300-500ms)**
- Broad N400 **(300-500ms)**

**EEG**
- **FZ**
- **CZ**
- **PZ**

Il lavoratore | *tornano*
---|---
The worker | *return*
Il lavoratore | *torna*
The worker | returns
CONTROLS

Negativity
300-500ms

Frontal pos.
550-650ms

P600
650-1000ms

Late P600
1000-1200ms

ATTRITERS

Negativity
300-500ms

Frontal pos.
550-650ms

P600
650-1000ms

Late P600
1000-1200ms
ERPs on verb: Discussion

- Controls and Attriters **differed** on **amplitude + scalp distribution of negativity**
- Frontal positivity indistinguishable in both groups (thus differences in negativity *not* due to component overlap)
- Why the smaller LTN/N400 in Controls?
  - In Italian, subject-verb number mismatch does not immediately signal a violation (subject may be post-verbal, **unlike in English**)
  - More robust N400 in Attriters suggests **influence of English syntax**
- **Longer P600 in L1 Controls** associated with more elaborated morphosyntactic re-analysis / repair processes
  - Attriters engage in **less-elaborated sentence-repair** than Controls?
  - To be examined further on the modifier...
**XXY condition: Proficiency effects**

**HIGH**

- **Fz**
  - N400:
  - Negativity: 300-500 ms

- **Cz**
  - Positivity by 600 ms
  - Negativity: 500-600 ms

- **Pz**
  - Large P600 (600-1300 ms)
  - P600: 600-900 ms
  - Late P600: 1000-1300 ms
**XXY condition: Proficiency effects**

**HIGH**
- Negativity: 300-500 ms
- N400
- Positivity begins earlier
- Large P600

**LOW**
- Negativity: 500-600 ms
- N400
- Late P600: 1000-1300 ms
- Smaller P600
**Group effects on late P600**

(a) By Proficiency

- **High Proficiency**
- **Low Proficiency**

(b) By Group

- **Controls**
- **Attriters**

**Early P600**: Diagnosis of anomaly
Larger with higher proficiency

**Late P600**: Re-analysis/repair of anomaly;
Larger in non-attriting natives

Again: shorter P600 in attriters!
Repair condition **XYY** vs. clash **XYX**

**CONTROLS**

Somewhat larger P600 in **xyx** compared to **xyy** is in line with Molinaro et al.'s (2011) ‘Repair hypothesis’ - but only in CONTROLS

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Repair condition **XYY** vs. clash **XYX**

**CONTROLS**

- **P600 for** \(xyx\) (\(xyy\) similar to correct)

**ATTRITERS**

- **P600 for** \(xyx\) and \(xyy\)

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\[\begin{array}{l}
\text{xxx} & \text{The worker}^{(sg)} \text{ returns}^{(sg)} \text{ from the factory} | \text{dirty}^{(sg)} \text{ with grease.} \\
\text{xyx} & \text{The worker}^{(sg)} \text{ *return}^{(pl)} \text{ from the factory} | \text{*dirty}^{(sg)} \text{ with grease.} \\
\text{xyy} & \text{The worker}^{(sg)} \text{ *return}^{(pl)} \text{ from the factory} | \text{?dirty}^{(pl)} \text{ with grease.}
\end{array}\]
ERPs on modifier: Discussion

- **Proficiency effects:**
  - Lower L1 proficiency = smaller, less frontal and longer-lasting N400 followed by smaller P600

- **Group effects:**
  - Like on verb, shorter P600 in Attriters (only early P600 until 900 ms)
  - Trend towards larger P600 in xyy (“repair condition”) than Controls
  - Suggestive of “shallower” repair-processes in Attriters

- **Attrition more than just L1-proficiency variation**
  - Amount of L1-exposure predicted native-like P600 responses (larger early and late P600 with more L1-exposure)
General discussion

- Differences in amplitude, timing and scalp distribution between two groups of native-speakers
- On ERPs (online) but not behaviorally (offline)
- 3 distinct phases of positivities reflecting different neurocognitive processes (differentially affected by proficiency and “attrition”)

Next steps:
- Bilingual control groups
  - Examine data from English-Italian late learners (L2)
  - Test Italian-English late bilinguals still dominant in L1
- Longitudinal studies (in attriters)
  - Do ERP differences show up as behavioral differences?
Take-home messages

- ERP evidence of L1-attrition in grammar
- Proficiency impacts processing patterns, even in L1
- Evidence of ongoing neuroplasticity, even in adulthood
- The “downside” of neuroplasticity – L1 is not stable
- ERPs are more complex than just ‘presence’ vs. ‘absence’ of P600s.
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