Cue strength and executive function in agreement comprehension

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Agreement Processing

Agreement informs predictions about structure:

The leader of the boys that .... was / were

...were (verb in relative clause)

...was (verb in main clause)
Agreement Attraction

Sometimes these predictions cause ungrammatical sentences to seem OK:

The leader of the boy were very important …

The leader of the boys were very important …

Local plural noun leads to grammaticality illusion

Pearlmutter, Garnsey, & Bock, 1999; Wagers, Lau, & Phillips, 2009
Cue-based retrieval

- **Mechanism:**
  - Encountering verb triggers memory search for plausible controller
  - Local noun retrieved -> Grammaticality illusion

The leader of the boys were very important …
Cues vary by item...

-Word final ‘s’ is an orthographic cue to plurality:
  -Common English representation of morphological pattern
    Boy / Boys

-Sometimes it is not a valid cue:
  Cactus / Cacti
  Dress / Dresses
  Man / Men
Retrieval abilities vary by person...

Working Memory (Reading Span)
• Maintain information in the face of distraction

Inhibitory Control (Stroop)
• Override prepotent reaction

Retrieval (Verb Generation)
• Select among competing alternatives
• Perform lexical access
Question: What affects cued retrieval?

Noun cue
- Encoding (@ noun)
- Retrieval (@ verb)

Plural feature vs transparent orthography?
- Man / cactus / dress?

Reader ability
- Encoding (@ noun)
- Retrieval (@ verb)

Individual differences in...
- Working memory span
- Inhibitory control
- Lexical access/selection among competitors...
Design: Sentences

**Excessive Orthography: dress (+s/+)**

The celebrity who promoted the **dress/dresses** …

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**Reversed Orthography: cactus (+s/-s)**

The landscaper who planted the **cactus/cacti** …

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**Depleted Orthography: man (-s/-s)**

The physician who cured the **man/men** …

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3 (Orthography) x 2 (Local Number)
Design: Sentences

**Excessive Orthography: dress (+s/+s)**

The celebrity who promoted the *dress/dresses* seldom *was/were* seen …

---

**Reversed Orthography: cactus (+s/-s)**

The landscaper who planted the *cactus/cacti* already *was/were* anticipating …

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**Depleted Orthography: man (-s/-s)**

The physician who cured the *man/men* occasionally *was/were* incorrect …

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3 (Orthography) x 2 (Local Number) x 2 (Verb Grammaticality)
Design: Sentences

Excessive Orthography: dress (+s/+s)

I: The celebrity who promoted the dress/dresses seldom was/were seen …
R: The celebrity who promoted the skirt/skirts seldom was/were seen …

Reversed Orthography: cactus (+s/-s)

I: The landscaper who planted the cactus/cacti already was/were anticipating…
R: The landscaper who planted the yucca/yuccas already was/were anticipating…

Depleted Orthography: man (-s/-s)

I: The physician who cured the man/men occasionally was/were incorrect …
R: The physician who cured the boy/boys occasionally was/were incorrect …

3 (Orthography) x 2 (Local Number) x 2 (Verb Grammaticality) x 2 (Matched Control)
Design: Reading Task

Word-by-word self-paced reading
Comprehension probes (of non-critical content)
48 critical sentences + 60 fillers in 8 Lists
Design: ID measures

Working Memory (**Reading Span Score**)
- Number of letters remembered in the face of correctly judged distractor sentences

Inhibitory Control (**Stroop Effect**)
- Incongruent (**RED**) – Congruent (**RED**) Stroop RTs

Retrieval: Lexical Access (**Verb Association Effect**)
- Low (**nebula**) – High Association (**plane**) Nouns

Retrieval: Selection (**Verb Competition Effect**)
- High (**ball**) – Low Competition (**scissors**) Nouns
### At Local Noun/Spillover

Plural > Singular = **plural slowing** at encoding

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**Table: Head Noun, Verb, Local Noun, Spillover, Main Verb, Final Sentence**

| The | Head Noun (singular) | who | Verb (SC-bias) | the | Local Noun | spill over | Main Verb | spill over | Final (3-6 words) |
|-----|----------------------|-----|---------------|-----|------------|GENCY|-------------|-------------|--------------|
| The landscaper | who | planted | the | cactus | already | was | anticipating | the dry summer. |

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**Diagram:**

- Reading time minus control baseline
- Y-axis: Adjusted Reading Time (ms)
- X-axis: Plural Type

- Dresses: Black
- Cacti: Light Blue
- Men: Gray
- Dress: Dark Blue
- Cactus: Light Gray
- Man: Medium Gray
The landscaper who planted the cactus already was anticipating the dry summer.
Cue Encoding Effects

Plural slowing on local noun spillover:

LME on length adjusted reading times for correct trials:
Main Effects of Grammatical Number and Orthography
Noun type (Control/weird) x Grammatical Number x Orthography Interaction

N=119
Cue Encoding Effects

Orthographic cue + plural slowing on local noun spillover:

- Effect driven by slowdown on “cacti” & “dresses” beyond what is predicted by frequency

Effect of Orthographic Cue on encoding

LME on length adjusted reading times for correct trials:

Main Effects of Grammatical Number and Orthography
Noun type (Control/weird) x Grammatical Number x Orthography Interaction

N=119
Cue Encoding IDs

- Slowing on plural noun predicted by Stroop performance
  - Good inhibitory control \( \rightarrow \) Plural slow down

\[ r = -0.23 \]
Cue Encoding IDs x Orthography

Dress & Cactus > Man predicted by… (anything?) – NOPE! (when split by plural type, nothing survives multiple corrections even with disattenuated correlation coefficients) – basically the plural-type manipulation is opaque to IDs
Cue Encoding Summary

1. Noun cue strength
   Encoding:
   - **Plural feature & transparent orthography**?
     • Slow down on atypical plural nouns

2. Reader ability
   Encoding:
   - **Inhibitory Control**
     • Inhibition leads to ability to slow down on **all** plural local nouns
Retrieval Predictions:
Number x grammaticality

<table>
<thead>
<tr>
<th>The Head Noun (singular)</th>
<th>who</th>
<th>Verb (SC-bias)</th>
<th>the</th>
<th>Local Noun</th>
<th>spill</th>
<th>over</th>
<th>Main Verb</th>
<th>spell</th>
<th>over</th>
</tr>
</thead>
</table>
| The landscaper who planted the cactus already was/were anticipating the dry summer.

At Main Verb/Spillover

Grammaticality Illusion:
Singular local noun | Ungrammatical > Plural | Ungrammatical

Reading time on verb
Retrieval Predictions: Number x grammaticality x orthography

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<tr>
<th>The</th>
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<tr>
<td></td>
<td>The landscaper</td>
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<td>the</td>
<td>cactus</td>
<td>already</td>
<td>was</td>
<td>anticipating</td>
<td>the dry summer.</td>
</tr>
</tbody>
</table>

At Main Verb/Spillover

Grammatical Only

Orthographic Only

Both Cues

Reading time on verb

<table>
<thead>
<tr>
<th>Reading time on verb</th>
<th>Dresses</th>
<th>Dress</th>
<th>Cacti</th>
<th>Cactus</th>
<th>Men</th>
<th>Man</th>
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Retrieval effect: Orthographically-weird items

**Illusion of Grammaticality** in verb spillover region

**Local Singular noun + Ungrammatical verb → Increased reading time**

**Illusion of grammaticality** given plural local noun

LME on length-adjusted reading times for correct items:
Main verb: NS
Verb spillover: Main Effects of Grammatical number, Grammatical number-by-grammaticality interaction

\[ N=119 \]
Retrieval effect: Control items

Illusion of Grammaticality in verb spillover region

<table>
<thead>
<tr>
<th></th>
<th>Plural</th>
<th>Singular</th>
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</thead>
<tbody>
<tr>
<td>Excessive (Dress)</td>
<td><img src="image1" alt="Graph" /></td>
<td><img src="image2" alt="Graph" /></td>
</tr>
<tr>
<td>Reversed (Cactus)</td>
<td><img src="image3" alt="Graph" /></td>
<td><img src="image4" alt="Graph" /></td>
</tr>
<tr>
<td>Depleted (Man)</td>
<td><img src="image5" alt="Graph" /></td>
<td><img src="image6" alt="Graph" /></td>
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</tbody>
</table>

Illusion of grammaticality in both sets of items

No effect of noun type (weird vs control)

LME on length-adjusted reading times for correct items:
Main verb: NS
Verb spillover: Main Effects of Grammaticality, Grammatical Number Grammatical Number-by-Grammaticality Interaction

N=119
Retrieval IDs:

- **High WM**: Larger grammaticality illusion
- **Low WM**: Poor retrieval selection
- **Good Selection**: Better retrieval selection
- **Poor Selection**: More prone to grammaticality illusion

**Correlations**:
- **Working Memory**: $r = 0.18$
- **Retrieval Selection**: $r = -0.24$
Hopefully—no effects?
Or—effects of vocabulary size?

NONE! (when split by plural type, nothing survives multiple corrections even with disattenuated correlation coefficients) — again, the plural-type manipulation is opaque to IDs
Retrieval Summary

1. Noun cue strength

   Retrieval:
   - **Plural feature only**
     - Plural features lead to grammaticality illusion, regardless of orthography

2. Reader ability

   Retrieval
   - **Working memory span**
     - Veridical representation of structure?
   - **Retrieval ability**
     - Successfully get correct item
Answer: What affects cued retrieval?

1. Noun cue strength
   Encoding:
   - **Plural feature** & **transparent orthography**?
     * Slow down on atypical plural nouns
   Retrieval:
   - **Plural feature only**
     * Plural features lead to grammaticality illusion, regardless of orthography

2. Reader ability
   Encoding:
   - **Inhibitory control**
     * Inhibition leads to ability to slow down
   Retrieval
   - **Working memory span**
     * Veridical representation of structure?
   - **Retrieval ability**
     * Successfully get correct item
Discussion

• Successful comprehension depends on language input and on the language user
  – Agreement based upon abstract features, not shallow orthography

  – It takes skill to avoid language traps
    • This includes knowing when to slow down (based upon inhibitory control)
    • And remembering structures well (based upon memory capacity)
Thank you!

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