Inhibition Accumulates Over Time in Bilingual Language Mixing
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How do bilinguals control language selection?

Influential proposal: 2 kinds of inhibition (Grosz, 1986)

1) Global-language-wide/inhibition
- Applied to the dominant language to facilitate non-dominant language production
- Must be released before switching back into dominant language
- Examples: asymmetric switch cost —switching into dominant language is often easier than switching into non-dominant language (Moses & Aker, 1999)
- Can also explain reversal dominance effect — overall faster RT in non-dominant language (a fickle pattern of data that is hard to predict) (Davies & Phillips, 2013)

2) Local (word-specific) inhibition
- Translation equivalents (e.g., dog & perro) laterally inhibit each other at the lemma level
- Not well-supported by evidence — translation equivalents often facilitate each other (as in picture-word interference) (Cara, Mosco, & Caramazza, 1999; Hall, 2011)

How long does inhibition persist?

Grosz (1986): “[Previous episodes of] suppression may [continue to] exert their effects, since it takes time for the effects of prior inhibition to be overcome.”

- Consistent with observed block order effects
- Performance in a dominant-language block is worse following a non-dominant-language block (Yu, Liu, Moen, & Koehl, 2011; Van Assche, Duyck, & Gollan, 2013)

If inhibition persists, it may accumulate over time.

The present study: Determine whether inhibition accumulates

Strategy: On each picture naming trial, take into account all previous pictures named & languages used in same block

- Logic: Every instance of non-dominant language production may negatively impact dominant language production at all later trials
- Previous trials divided into 3 bins to index different mechanisms: repetition priming, lateral inhibition, and language-wide inhibition

Method

Participants: 416 Spanish-English bilinguals in 4 experiments:
- 3 exps. in Kleinman & Gollan (2016) (n=210)
- 1 unpublished exp. (n=120) → >0.05% picture naming trials

Materials: 20 block-and-white pictures (across participants)
- Each participant only named 9 unique pics

Design: 2 or 3 critical blocks (order fully counterbalanced)
- 2 single-language blocks (100)
- English-only & Spanish-only
- 1 cued switching block (n=416)
- Switch rate: 33% (100) or 50% (100)
- 176 trials per block (9 pics presented 12x)

Trial structure:

<table>
<thead>
<tr>
<th>Variant</th>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>550 ms</td>
<td>550 ms</td>
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<tr>
<td></td>
<td>150 ms</td>
<td>150 ms</td>
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<tr>
<td></td>
<td>250 ms</td>
<td>250 ms</td>
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<tr>
<td></td>
<td>3500 ms or voice</td>
<td>3500 ms or voice</td>
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<tr>
<td></td>
<td>850 ms</td>
<td>850 ms</td>
</tr>
</tbody>
</table>

For comparison with other experiments, a more standard analysis of the same data is shown in the next section using a much coarser measure of trial number that does not distinguish between three components.

Results — Standard analysis

Reported RT (ms) for each condition & block quarter (i.e., the 1st, 3rd, 6th, 9th) 33% of trials within each block. Error bars ±95% CI.

Summary

1) Language-wide inhibition accumulates over time:
- Asymmetric: Naming any pic in the non-dominant lang. slowed dom lang production, but not vice-versa
- Inhibitory effect increased in force throughout the block
- Did not interact with switch costs
- Distinct from shorthand inhibition that gives rise to asymmetric switch costs

2) Lateral inhibition exists, and likewise accumulates:
- Symmetric: Naming any pic in either language slowed subsequent naming in the other language
- Asymmetric inhibition in from naming non-target pics
- Should not interact with switch costs
- Major mechanism of language control only revealed through modeling of trial number components
- Symmetry could indicate automatic mechanism that biases a word over its translation equivalent to facilitate “bottom-up” selection (Kleinman & Gollan, 2016)

3) Reversed dominance effects emerge over time:
- Over time, more repetition priming for nondominant lang. + more inhibition of dom lang → reversed dominance
- Indicates why this pattern is so fickle: In a short block and/or with few repetitions, not enough time for asymmetric effects to accumulate/dominance to reverse

Conclusions

Most research into bilingual language switching has assumed that bilinguals switch between several different static states — essentially, language activation profiles — that remain constant. Our results show instead that the states themselves change continuously over time as bilinguals employ persistently cumulative inhibition at both language-wide & lemma levels.

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References

Costa, A., Miozzo, M., & Caramazza, A. (1999). Lexical selection in bilinguals: Do different static states — essentially, language activation profiles — that remain constant. Our results show instead that the states themselves change continuously over time as bilinguals employ persistently cumulative inhibition at both language-wide & lemma levels.