Gradient Effects in Islands

Experimental and Computational Modeling Results

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WHIT TABOR
Road Map

Introduction
• Grammaticality and acceptability
• Islands: illustration of both extreme, binary-like and gradient effects

Experimental results on islands
  o Acceptability judgment studies
  o Maze Task experiments

Discussion
• Grammar + Processing Account
• A Self-organized sentence processing model (SOSP)
Grammaticality vs. Acceptability

- Acceptability is gradient
- Grammaticality is traditionally considered binary (grammatical vs. ungrammatical)
How can we reconcile gradient effects in acceptability with a (binary) notion of grammaticality?
Grammar + Processing Account

EXTRA GRAMMATICAL MECHANISM
- E.g., Memory

1 Full unacceptability

7 Full acceptability

GRAMMAR
An alternative approach: SOSP

• Both extreme and gradient effects derive from a single mechanism: a (continuous) grammar

→ Self-Organized Sentence Processing Model (SOSP)
SOSP: An Overview

- Each word activates a treelet

```
NP
   Mary
VP
   runs
```
SOSP: An Overview

- Each word activates a treelet
- Each treelet comes with a feature vector (syntactic + semantic features)
- Bonds between treelets are generated through feature match between nodes
SOSP: An Overview

- Each word activates a treelet
- Each treelet comes with a feature vector (syntactic + semantic features)
- Bonds between treelets are generated through feature match between nodes
- However, in SOSP the structure is generated through continuous all-to-all interaction (rather than being limited to perfect grammatical matches)
SOSP: An Overview

• When no optimal bond is available, the system forces the structure to form anyway, allowing the formation of suboptimal structures

→ coercion
Islands

- Islands = Encapsulated syntactic domains out of which *almost* nothing can be extracted (Ross, 1967)

- Islands come in two flavors:

  **STRONG ISLANDS**
  - Subject islands
  - Adjunct islands
  - ...
  - Ban *all* extractions (both D-linked and Non D-linked elements)

  **WEAK ISLANDS**
  - Whether islands
  - Wh-islands
  - Allow *certain* extractions (D-linked elements)
Factorial design for islands

2x2 design:

(i) STRUCTURE TYPE (Non-island vs. Island)
(ii) DEPENDENCY LENGTH (Short vs. Long)

NON-ISLAND, SHORT
Which leader __ thinks the speech interrupted the TV show?

NON-ISLAND, LONG
Which speech does the leader think __ interrupted the TV show?

ISLAND, SHORT
Which leader __ thinks [the appearance of the president] interrupted the TV show?

ISLAND, LONG
Which politician does the leader think [the appearance of __] interrupted the TV show?
Factorial design for islands

2x2 design:

(i) **STRUCTURE TYPE**
    (Non-island vs. Island)

(ii) **DEPENDENCY LENGTH**
    (Short vs. Long)

Predicted: Linear additivity

Actual: Super-additivity
Results
(Sprouse & Messick 2015)

WHETHER ISLAND

<table>
<thead>
<tr>
<th></th>
<th>Non D–linked</th>
<th>D–linked</th>
</tr>
</thead>
<tbody>
<tr>
<td>short</td>
<td></td>
<td></td>
</tr>
<tr>
<td>long</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SUBJECT ISLAND

<table>
<thead>
<tr>
<th></th>
<th>Non D–linked</th>
<th>D–linked</th>
</tr>
</thead>
<tbody>
<tr>
<td>short</td>
<td></td>
<td></td>
</tr>
<tr>
<td>long</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

• All interactions are significant
  → there is an island effect across the board
• The interaction is reduced in D-linked whether islands
1st set of Empirical Facts

All islands (included D-linked whether islands) exhibit an island effect above and beyond processing factors
(Islands ungrammaticality)

D-linking ameliorates without eliminating the island effect
(Gradience)
Experiment 1

2x2x2 design:

(i) STRUCTURE TYPE (Non-island vs. Whether island)
(ii) DEPENDENCY TYPE (D-linked vs. Non D-linked)
(iii) EMBEDDED VERB (Transitive vs. Intransitive)

What do you wonder ....

whether the thief stole __ ?
whether the thief laughed ?

What do you think ....

that the thief stole __ ?
that the thief laughed ?
Experiment 1

N = 96 (English native speakers recruited on AMT)
Task: Acceptability judgments (7 points Likert scale)
Experiment 1: Results

<table>
<thead>
<tr>
<th>Verb Type</th>
<th>Mean acceptability (z-scores)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transitive</td>
<td>Non D-linked</td>
</tr>
<tr>
<td>Intransitive</td>
<td>D-linked</td>
</tr>
</tbody>
</table>

Structure Type
- non island
- island
The processor seems able to form a dependency between a gap inside an island and a filler outside of it (Islands penetrability)
Maze Task: Experiments 2 & 3

The
me
day
extreme
was
sunny.
smile.
Materials

N = 48 (English native speakers recruited on AMT) per experiment

Conditions:
(i) Whether island
(ii) Grammatical control
(iii) Ungrammatical control

Each condition has a corresponding no-extraction condition as a baseline for error rates in easy sentences

Total: 6 conditions
Conditions & Predictions

GRAMMATICAL CONTROL CONDITION (THAT CLAUSE)

Which puzzle do you think that the candidate solved ...

✓ GAP (PP) ... before the interview in Paris?

✗ FILLED GAP (NP) ... the problem before the interview?
Conditions & Predictions

ISLAND CONDITION (WHETHER ISLAND)

Which puzzle do you wonder whether the candidate solved ...

GAP (PP)  ... before the interview in Paris?

FILLED GAP (NP)  ... the problem before the interview?
**Conditions & Predictions**

**UNGRAMMATICAL CONTROL (TRANSPOSED THAT CLAUSE)**

*Which puzzle do you* **that think** *the candidate solved ...*

**GAP (PP)**  
*... before the interview in Paris?*

**FILLED GAP (NP)**  
*... the problem before the interview?*
"DO" QUESTIONS

Do you think that the candidate solved ...

✗ GAP (PP) ... before the interview in Paris?

✓ FILLED GAP (NP) ... the problem before the interview?
Results:
Non D-linked whether islands

<table>
<thead>
<tr>
<th>Sentence type</th>
<th>Proportion of PP continuations</th>
</tr>
</thead>
<tbody>
<tr>
<td>THAT what</td>
<td>82%</td>
</tr>
<tr>
<td>THAT do</td>
<td>9%</td>
</tr>
<tr>
<td>WHETHER what</td>
<td>31%</td>
</tr>
<tr>
<td>WHETHER do</td>
<td>10%</td>
</tr>
<tr>
<td>TRANSPOSED what</td>
<td>73%</td>
</tr>
<tr>
<td>TRANSPOSED do</td>
<td>14%</td>
</tr>
</tbody>
</table>
Results:
D-linked whether islands

Sentence type
Proportion of PP continuations

<table>
<thead>
<tr>
<th>Sentence type</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>THAT which</td>
<td>91%</td>
</tr>
<tr>
<td>THAT do</td>
<td>8%</td>
</tr>
<tr>
<td>WHETHER which</td>
<td>78%</td>
</tr>
<tr>
<td>WHETHER do</td>
<td>8%</td>
</tr>
<tr>
<td>TRANSPOSED which</td>
<td>90%</td>
</tr>
<tr>
<td>TRANSPOSED do</td>
<td>10%</td>
</tr>
</tbody>
</table>
Desiderata

- Islands ungrammaticality
- Gradient effects in islands
- At least some islands are penetrable
1. Theory of grammar:
   Subjacency

2. Theory of processing:
   Cue-based memory model (ACT-R)
   (e.g., McElree 2000; Lewis and Vasishth 2005; Van Dyke and McElree 2006; McElree 2006)
Cue-based memory model

- Processing long-distance dependencies requires a retrieval mechanism.
- This mechanism is cue-based (e.g., McElree 2000; Lewis and Vasishth 2005; Van Dyke and McElree 2006; McElree 2006).
- Retrieval is sensitive to interference.
Cue-based retrieval

Hofmeister and Vasishth (2014):

• semantically and syntactically more complex targets are retrieved faster than simpler ones

(1) The congressman interrogated the general who a lawyer for the White House advised __ to not comment on the prisoners

(2) The congressman interrogated the victorious four star general who a lawyer for the White House advised __ to not comment on the prisoners
A similar mechanism could be argued to be at play in islands:

(1) *What* do you wonder whether the engineer built __ ?

(2) *Which building* do you wonder whether the engineer built __ ?

- If retrieval is facilitated in conditions with richer targets, retrieval should be easier in (2) than in (1)
- Since acceptability ratings increase when retrieval is easier (Hofmeister et al. 2010, 2013), this account predicts higher acceptability ratings for D-linked over non D-linked whether islands
Challenge for a memory-based processing theory

Challenge:

If D-linking facilitates retrieval for whether islands, it should facilitate it across island types

(1) *Who does the leader think [the appearance of __ ] interrupted the TV show?

(2) *Which politician does the leader think [the appearance of __ ] interrupted the TV show?
In SOSP, the structure is generated through continuous all-to-all interaction.

When no optimal parse can be generated, the system forces the structure to form anyway (coercion).

```
S
  /  \
/    \  
|      |  
|      |   
NP     VP
[+N]   [+Sg]

NP
[+N, +Sg, +Human, +Animate, ...]

Mary

VP
[+V, +Pl, ...]
sleep
```
Simulation Results

**Mean judgment (z-scores)**

<table>
<thead>
<tr>
<th>Dependency length</th>
<th>Non D–linked</th>
<th>D–linked</th>
</tr>
</thead>
<tbody>
<tr>
<td>short</td>
<td>mean</td>
<td>mean</td>
</tr>
<tr>
<td>long</td>
<td>mean</td>
<td>mean</td>
</tr>
</tbody>
</table>

**Structure**
- non–island
- island

---

**Subject**
- short
- long

---
Two parsing options:

1. respecting the island constraint at the cost of failing to propagate the filler
   - *Non-D-linked whether islands*
   - *Subject islands*

2. propagating the filler at the cost of *coercing* the structure to behave in a “non-island manner”
   - *D-linked whether islands*
D-linked whether island

Which car do you wonder whether John bought?

Facts:
1) Intermediate acceptability ratings
2) Participants often posit a gap inside a D-linked whether island (Maze task experiment + intransitive data)

→ coercion
Which car do you wonder *whether* John bought?

Which car do you think *that* John bought?
Which car do you wonder whether John bought?
Non D-linked whether island

What do you wonder whether John bought?

Facts:
1) Very low acceptability ratings
2) Participants rarely posit a gap inside a Non-D-linked whether island (Maze task experiment + intransitive data)

→ Slash propagation fails most of the time
→ Coercion fails most of the time
Non D-linked whether island
Subject islands

For subject islands, the coercion mechanism fails because of the absence of a similar-enough grammatical structure:

*What do you think [the speech by __ ] interrupted the TV show?

What do you think [the speech by the president] interrupted __?
Subject islands
Conclusions

1. Grammar + memory-based processing theory

Empirical facts:
- islands are ungrammatical
- islands badness can be alleviated (gradient effects)
- sometimes the dependency inside the island is established

Accounts of gradience:

1. Grammar + memory-based processing theory
2. SOSP
I also thank Emily Kaplan, Melissa Rayment, Augden Shaw and Panat Taranat for assistance with data collection.