Gradient Selectional Restrictions in HPSG

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Syntactic selectional restrictions

Some **selectional restrictions** are purely **syntactic**, e.g.:

- *Homer **waited*** [$_{\text{PP}}$ *for Marge*].
- *Homer **awaited*** [$_{\text{NP}}$ *Marge*].

Syntactic selectional restrictions are usually **assumed to be hard**, e.g.:

- **Homer **waited*** [$_{\text{NP}}$ *Marge*].
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Aims of this presentation:

- present **evidence that syntactic selectional restrictions may be soft** (“gradient”),
- propose how to **model gradience in HPSG** (based on earlier work),
- especially **gradient selectional restrictions**.

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An **acceptability judgement experiment** (N = 70; F = 24, M = 46; Prolific, LimeSurvey, R):

- we looked at **8 predicates**: *account (for), annoyed (by), ashamed (of), depend (on), familiar (with), speak (about), suffer (from) talk (about)*;
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The **Thermometer Method** was employed, argued to be superior to the standard Likert Scale (Featherston 2008, 2009).

Among the fillers, there were 15 "**standard items**" – 3 sentences for each of the acceptability levels A–E (Featherston 2009, Gerbrich *et al.* 2019).

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kognilab Laboratory of Experimental Philosophy

Robert found but Emma lost two pound coins.

Help: There are two sentences on the scale. Their location on the scale (one at 20, and the other at 30) indicates their respective naturalness scores. Your task is to rate the naturalness of the sentence above, considering the scores of these two sentences.

20
The father fetches the wholemeal bread them.

30
The father fetches the children the wholemeal bread.

Next

Standard Items

A.
- The patient fooled the dentist by pretending to be in pain.
- There's a statue in the middle of the square.
- The winter is very harsh in the North.

B.
- Before every lesson the teacher must prepare their materials.
- Jack doesn't boast about his being elected chairman.
- John cleaned his motorbike with which cleaning cloth?

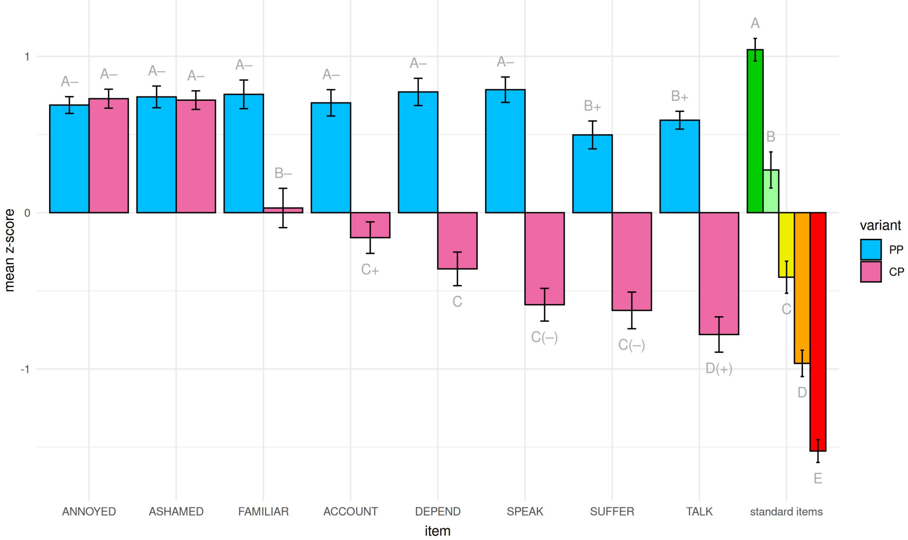
C.
- Anna loves, but Linda hates, eating popcorn at the cinema.
- Most people like very much a cup of tea in the morning.
- The striker fouled deliberately the goalkeeper.

D.
- Who did he whisper that had unfairly condemned the prisoner?
- The old fisherman took her pipe out of mouth and began story.
- Which professor did you claim that the student really admires him?

E.
- Historians wondering what cause is disappear civilization.
- Old man he work garden grow many flowers and vegetable.
- Student must read much book for they become clever.

Experimental Evidence 2

Average z-scores (with 95% confidence intervals):



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Summary of experimental evidence:

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Length and complexity were controlled for, so it is **unlikely that these differences reflect processing**.

This justifies positing the following **hypothesis**:
Syntactic selectional restrictions may be gradient. **Corollary**: **Grammaticality is gradient**.

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Supporting Corpus Evidence 1

The number of occurrences of predicate plus *that* in English Web 2021 and the number of **true combinations of the predicate with its CP dependent among a 100-hit random sample**:

Predicate	Hits	Sampled	True Positives
annoyed	501	100	**93**
ashamed	4,551	100	**85**
familiar	316	100	**48**
account	7,975	100	3
depend	534	100	**15**
speak	17,636	100	**10**
suffer	11,603	100	1
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Some **examples** for ***depend***:

1. *No matter what management does in the States, we always have to* ***depend*** [$_{\text{CP}}$ *that they are building it to our specs, which isn't always the case*].
2. *They respect each other's role and* ***depend*** [$_{\text{CP}}$ *that each wolf in the pack will live up to their individual responsibility*].
3. *…and you may* ***depend*** [$_{\text{CP}}$ *that we will endeavor to be your guard*].

Some for ***talk***:

4. *Some of us old timers were out at Avis Collier's Store not long ago and were* ***talking*** [$_{\text{CP}}$ *that we hadn't been to a Serenading Party for about 40 years or better*].
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Gradient grammaticality in HPSG 1

Formally, an **HPSG grammar** is a **set θ of closed formulae** ("constraints") δ_i (Richter 2004, 2024: 173).

A **gradient HPSG grammar** (cf. Şenşekerci 2024) is:

- a **set θ of $\langle \delta_i, w_i \rangle$ pairs** such that:
  - δ_i is a **closed formula** ("constraint"), and
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Some **scenarios**:

violations	burden for the model
no violations	0
a single object violates a single constraint δ_j	w_j
two objects violate δ_j and another violates δ_k	$2 \cdot w_j + w_k$

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where $\mathrm{Viol}(\delta_i)$ is the set of model objects violating δ_i.

This **does not take into account** the sometimes reported ***under*additive effect of multiple violations**, in particular, "**floor effects**".

A formula that does:

$$\mathrm{B(I)} = 1 - \prod_{\langle \delta_i, w_i \rangle \in \theta} (1 - w_i)^{|\mathrm{Viol}(\delta_i)|}$$

Examples:

- - model I_1 with **three weighty violations** worth 0.7, 0.8, and 0.9
  - $\mathrm{B(I_1)} = 1 - (1 - 0.7) \cdot (1 - 0.8) \cdot (1 - 0.9) = 0.994 \approx 1.0$
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Assume for simplicity that idiosyncratic **syntactic selectional restrictions** are directly **encoded in lexical entries**, e.g.:

- $\mathrm{LE}_{depend} \stackrel{df}{\equiv} \begin{bmatrix} \textsc{phon} \ \langle \textit{depend} \rangle \\ \ldots \\ \textsc{arg-st} \ \langle \mathrm{NP}[\textsc{nom}], \mathrm{PP}[\textit{on}] \rangle \end{bmatrix}$

Such lexical entries are built into **a larger "lexicon" constraint**, e.g., the **Word Principle** (Höhle 1994, Richter 2024: 101):

- $\textit{word} \rightarrow (\mathrm{LE}_{depend} \vee \mathrm{LE}_{Marge} \vee \mathrm{LE}_{wait} \vee \ldots)$

Problem:
How to say that the 2nd argument of *depend* may be a CP[*that*], but with some penalty?

Non-starter:
A weight attached to the Word Principle above only reflects the general penalty for using an out-of-vocabulary word.

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Such lexical entries are built into **a larger "lexicon" constraint**, e.g., the **Word Principle** (Höhle 1994, Richter 2024: 101):

- $\mathit{word} \rightarrow (\mathrm{LE}_{\mathit{depend}} \vee \mathrm{LE}_{\mathit{Marge}} \vee \mathrm{LE}_{\mathit{wait}} \vee \ldots)$

Problem:
How to say that the 2nd argument of *depend* may be a CP[*that*], but with some penalty?

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A weight attached to the Word Principle above only reflects the general penalty for using an out-of-vocabulary word.

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Gradient selectional restrictions in HPSG 1

Two solutions:

1. one based on the assumption that there is a **dichotomy between hard and soft selectional restrictions**,
2. another **not making such an assumption**.

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- note the lack of an NP in the 2nd argument (a hard constraint), e.g.:
- **Justin Bieber can* ***depend*** [$_{\mathrm{NP}}$ *the fact* [$_{\mathrm{CP}}$ *that his fans still love his early songs*]].
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- $\left\langle \begin{bmatrix} \textsc{phon}\ \langle depend \rangle \\ \textsc{arg-st}\ \langle \boxed{1}, \boxed{2} \rangle \end{bmatrix} \longrightarrow \neg\boxed{2}\left[\ldots|\textsc{head}\ \ complementiser\right],\ \ 0.28 \right\rangle$ ($\boxed{2}$ is not a CP)

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Gradient selectional restrictions in HPSG 2

Solution 2 (more general, preferred):

- **lexical entries do not mention syntactic selectional restrictions** at all, only the number of arguments – or not even this, given some linking theory (Davis *et al.* 2024), e.g.:
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But not any PP or CP will do, e.g.:

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Additional – fine-grained – **lexical and morphosyntactic constraints** are needed, e.g.:

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    (If $\boxed{2}$ is a PP, then it is a PP[*on*].)
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Again, such constraints could be stated at the level of **word classes**, within **linking rules**.

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What is the **meaning of weights**?

Ideally:

- they are **neurocognitively real**, i.e.,
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- so there may be individual differences;
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Practically:

- the **weights reflect results of a particular experiment** on a population sample,
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Normalizing weights

Ideally, different experimental methodologies (Likert Scale, Magnitude Estimation, Thermometer Method, etc.) should result in similar weights.

So there should be a **normalizing procedure** mapping specific experimental results to a normalized scale of weights, e.g., $[0, 1]$.

Here, **the simplest normalizing procedure** (to be verified by future experiments):

- **suppose** that:
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  - the **estimated judgement drop** caused by a violation of constraint δ_i is β_i,
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- **in the experiment above**:
  - the **experimental scale** is (practically) $[10, 40]$ (Thermometer Method),
  - the mixed effects model coefficient reflecting **the drop from the grammatical PP condition to the CP condition** for *depend* is 8.44,
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Summary and conclusion

A number of researchers have argued for **gradient grammaticality**, e.g., Chomsky 1965, Keller 2000, Sorace and Keller 2005, Featherston 2005, Häussler and Juzek 2016, Lau *et al.* 2017, . . . , Przepiórkowski *et al.* 2025; see also Francis 2022.

Our experiments **contribute to this mounting evidence**:

- predicates readily combining with PPs expressing propositions ("P the fact that...")
- differ in their acceptance of CPs (primary vessels of propositions).

Our **technical HPSG contribution**:

- a general approach to gradience in HPSG (based on Şenşekerci 2024),
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Also:

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Limitations and outlook

There are various **limitations** of this early-stage work, including:

- we assumed that certain selectional restrictions are syntactic, but **distinguishing between semantic and syntactic selectional restrictions is often difficult**;
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Thank you for your attention!

Motto

*The current **disconnect between theoretical investigations** of language structure **and psycholinguistic studies** is an unfortunate feature of our discipline. Because **HPSG** comports so well with what is known about processing, it **could serve as the basis for a reconnection between these two areas of study**.*

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Experimental Evidence 4

Another experiment (*familiar, depend, speak, talk*).

Acceptability judgement experiment (Prolific, LimeSurvey, R;
N = 79: N_{uk} = 40, N_{us} = 39; F = 41, M = 38).

4 × 9 = 36 **experimental items** of the form:

- V [$_{CP}$ *that* NP$_i$...] CP
- V [[$_{PP}$ P NP$_i$] *and* [$_{CP}$ *that* Pron$_i$...]] PP & CP
- V [$_{PP}$ P [NP$_i$ *and* [$_{NP}$ *the fact* [$_{CP}$ *that* Pron$_i$...]]]] PP

For example:

- **CP** condition:
  Justin Bieber can depend [$_{CP}$ *that* [$_{NP}$ *his fans*]$_i$ *still love his early songs*].
- **PP & CP** condition:
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Thermometer method and **standard items**, as before.

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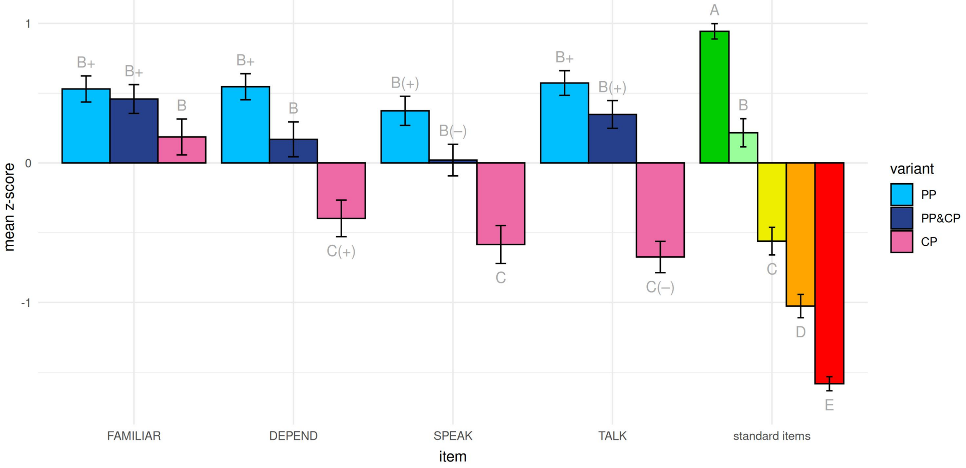
Experimental Evidence 5

Average z-scores (with 95% confidence intervals):



Experimental Evidence 6

Results:

- **for all predicates**, the acceptability of PP & CP is lower than that of PP (and higher than that of CP);
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