Thematic roles' alignment with grammatical functions facilitates sentence processing

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Alignment between prominence scales is important in language use (e.g., [1], [2], [3], [4], [5]). For example, [3] found that Agent-Theme verbs (e.g., *kick*) are harder and less frequent in passives than Object Experiencer (OE) verbs (e.g., *frighten*). This is possibly because passives of Agent-Theme verbs misalign grammatical function (GF) and thematic role hierarchies, with the higher ranked role Agent in a lower ranked GF Oblique, while passive OE verbs align both (see exs. (1a–b,f)), assuming the GF hierarchy *Subject* $>$ *Object/Oblique* and thematic hierarchy *Experiencer* $>$ *Stimulus*. However, the thematic roles invoked by Agent-Theme verbs and OE verbs differ, creating a confound for this approach. To address this, the present study contrasts Subject Experiencer (SE) (e.g., *fear*) verbs with OE verbs: these both invoke the same (or at least more comparable) thematic roles, Experiencer and Stimulus, facilitating comparisons.

We test the hypothesis that alignment between thematic role prominence and GF prominence facilitates processing, extending [2] by using self-paced reading with comprehension questions, while adding a factor of SENTENCE VOICE (active/passive). Crucially, the GF prominence of arguments exactly reverses in passives compared to actives—active objects become passive subjects, while active subjects become passive obliques. We thus predict OE verbs will be more difficult than SE verbs in active sentences, as the former places the higher ranked thematic role in a lower ranked GF, while the latter aligns both. In contrast, this pattern should flip in passive sentences, as the GF assigned to each thematic role is reversed. See exs. (1c–f).

72 native English-speaking subjects from the authors' university read 32 sentences like those in (2) and 56 filler items of various types in an online word-by-word SPR task. Pairs of OE and SE verbs selected from [6] were matched for overall length and lemma frequency (ps > 0.05). Items were constructed such that each subject saw all 32 verbs once, but not in the same carrier sentence. After each sentence, subjects answered a comprehension question. For the critical items, comprehension questions were constructed such that consistently successfully answering them meant understanding the verb and how it assigned its thematic roles to its arguments.

Log RTs were calculated by region (fig. 1). LMEMs were fit to test significance (p values given by `lmerTest` [7]). In the critical and spillover regions, the predicted interaction between sentence voice and verb type was found ($\hat{\beta}_{crit}$ = -0.12, t = -2.65; $\hat{\beta}_{spill}$ = -0.25, t = -5.58). Planned comparisons in the spillover region revealed faster RTs in active SE sentences than in active OE sentences ($\hat{\beta}$ = 0.15, t = 5.57), and slower RTs in passive SE sentences than in passive OE sentences ($\hat{\beta}$ = -0.1, t = -3.65). (In the critical region, the expected difference was found in passives ($\hat{\beta}$ = -0.1, t = -3.032), but not actives ($\hat{\beta}$ = 0.02, t = 0.83).) To ensure summing RTs to create comparable analysis regions did not introduce artifacts, we did a word-by-word analysis: the interaction (and no main effects) was found at the first post-verbal word ($\hat{\beta}$ = -0.28, t = -4.54), with pairwise comparisons finding the same pattern as above. For question accuracy (fig. 2), a logistic regression found an interaction between sentence voice and verb type ($\hat{\beta}$ = 1.98, z = 10.29); planned comparisons showed more accurate responses for active SE sentences than for active OE sentences ($\hat{\beta}$ = -1.01, z = -6.34), and vice versa in passives ($\hat{\beta}$ = 0.93, z = 6.59). This was not due to low accuracy overall—χ^2 tests determined whether subjects' total accuracy (including fillers) was greater than chance (50%). No subjects were excluded by this criterion.

These results show that alignment of thematic role and GF hierarchies facilitates sentence processing. Distinct but similar results have been established in sentence production by [2], who found that misalignment of GF and thematic role prominence affects early eye-movement measures with active SE and OE verbs, with competition evident in early looks to subject/object referents; the present results show that this effect is not production-specific, bolsters it with evidence from passives, and show that misalignment induces not only competition, but also cost.

(1) a. Active, Ag-Th (aligned):
Subject > Object
Agent > Theme

b. Passive, Ag-Th (misaligned):
Subject > Oblique
Agent > Theme

c. Active, SE (aligned):
Subject > Object
Experiencer > Stimulus

d. Active, OE (misaligned):
Subject > Object
Experiencer > Stimulus

e. Passive, SE (misaligned):
Subject > Oblique
Experiencer > Stimulus

f. Passive, OE (aligned):
Subject > Oblique
Experiencer > Stimulus

(2) a. Active, Subject Experiencer||Object Experiencer:
That's the actor// that the director// particularly// appreciates||bothers// because of//
his dramatic emotional bearing.
(critical region; spillover)

b. Passive, Subject Experiencer||Object Experiencer:
That's the director// that the actor// is particularly// appreciated||bothered by// because of//
his dramatic emotional bearing.
(critical region; spillover)

(3) Comprehension question:
a. Who appreciates||bothers someone?
the actor the director

b. Who is appreciated||bothered?
the actor the director

Analysis regions are delimited by "//"; participants did not see these in the sentences. Subject||Object experiencer conditions are indicated by vertical pipes ("||"); participants saw only one of these in a given sentence, and no vertical pipes. Question voice and the position of the correct answer were balanced within items. Participants read sentences one word at a time, pressing the space bar to replace the current word with the next word in the center of the screen.

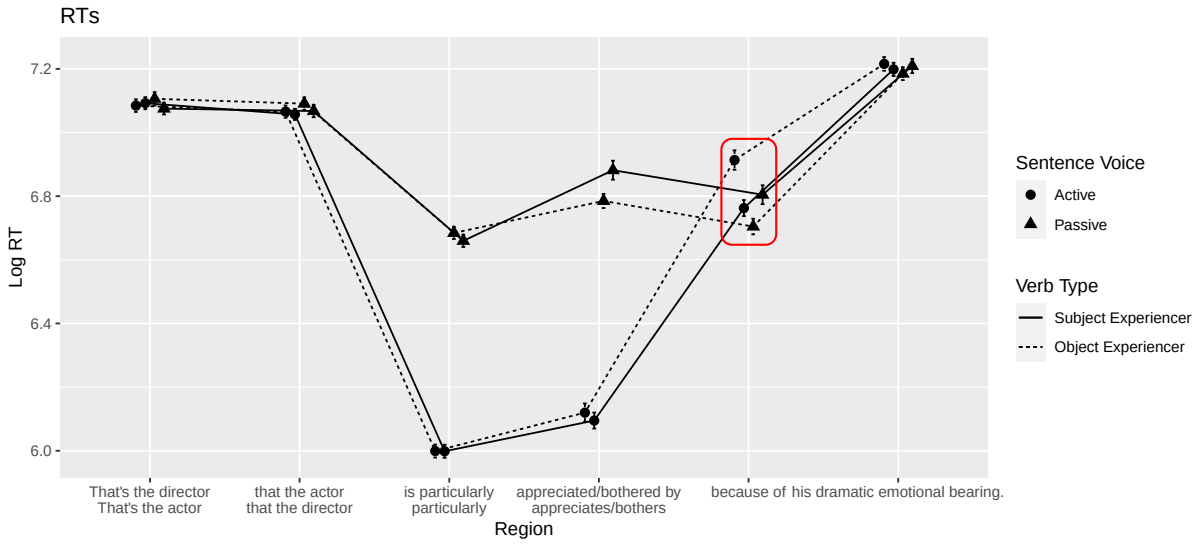

Figure 1: Log RTs by Region and Condition

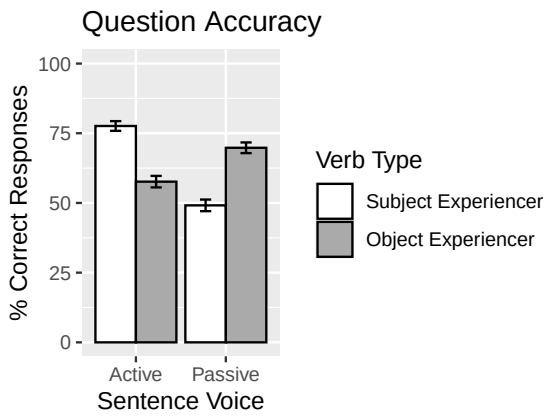

Figure 2: Question Accuracy by Condition
No effects of question voice were found;
results are plotted collapsed across those conditions.

[1] Wagers & Pendleton (2016). Structuring expectation: Licensing animacy in relative clause comprehension. *WCCFL 33*. **[2]** Do & Kaiser (2019). The syntax-to-semantics mapping in real-time language production: A view from psych verbs. *LSA 93*. **[3]** Gennari & MacDonald (2009). Linking production and comprehension processes: The case of relative clauses. *Cognition*. **[4]** Gattei et al. (2017). Prominence in Spanish sentence comprehension: An eye-tracking study. *Lang Cogn Neurosci*. **[5]** Bornkessel & Schlesewsky (2006). The extended argument dependency model: A neurocognitive approach to sentence comprehension across languages. *Psychol Rev*. **[6]** Levin (1993). *English Verb Classes and Alternations*. **[7]** Kuznetsova et al. (2017). lmerTest package: Tests in linear mixed effects models. *J Stat Softw*.