Garden-path dead-ends contextualized

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We are subjected to imperfect sentences daily because of speech errors, a noisy environment, imperfect turn-taking in conversations, or simply ambiguous language [1,2]. To assist in comprehension, we use context to predict upcoming speech and resolve ambiguity. In this study, we focus on the relationship between ungrammaticality, semantic fit, and linguistic ambiguity, asking ourselves the following question: Can the strength of semantic fit between a verb and noun phrase (NP) override the phrase structural or lexical demands of a verb?

Garden-path (GP) sentences can cause lingering misinterpretations even once the initial ambiguity is resolved [3]; though what happens when a GP cannot be successfully resolved to a grammatical form is less clear, especially when semantic constraints favor a grammatical interpretation. We define these GPs as GP dead-ends, sentences where a misparse cannot be resolved due to grammatical constraints; in our study, these constraints arise from a missing argument required by an obligatorily transitive verb (see (1)-(4) next page).

In (1), the NP *the computer* initially gets misinterpreted as the object of *fixed*; the parser realizes it has been garden-pathed upon getting to *hummed*. However, due to the obligatory transitivity of *fixed*, reanalysis should be impossible. In our study, we hypothesize that there will be an interaction between grammaticality and plausibility; plausible ungrammatical sentences, strengthened by semantic constraints and context, will be accepted more than implausible ungrammatical sentences, in line with the idea of good-enough processing [4-6]. Our hypothesis also hinges on the idea of a cooperative speaker [7] who does their best to come up with a sensible interpretation. Alternatively, the plausibility of the critical noun could create a tug-of-war for the phrase between the two clauses, leading to longer reading times (reflected in eye movements) as the parser resists letting go of the initial attractive parse [8,9].

We used a 2 x 2 design ([un]grammaticality x [im]plausibility) to investigate the effects of context on the parsing of GP dead-ends. Plausibility was manipulated locally by varying how well the critical NP (the NP following the subordinate clause verb) could serve as a potential object of the subordinate verb (V1). For the control conditions, sentences were rendered grammatical by adding *them* after V1, satisfying the verb's argument structure. Context sentences provided a clear referent for *them*. After conducting a norming study to verify our intuitions of plausibility, we conducted an acceptability judgment study (Exp.1) to see whether our manipulations had an effect on people's explicit judgments of acceptability. After reading the contextual and critical sentences, displayed together, participants (N = 79) were asked to judge the acceptability of sentences (40 critical/40 filler) on a scale of 1 (unacceptable) to 5 (acceptable). An ordinal mixed effects model found statistically significant effects of grammaticality and plausibility, but no interaction (Fig. 1). This finding suggests that participants are sensitive to the grammatical status of the sentences and the plausibility of the critical NP, but plausibility did not modulate evaluations of grammaticality.

In Exp. 2, we conducted an eye-tracking study. 40 participants read the same set of sentences as in Exp.1. Participants read each sentence one at a time and then received a Y/N comprehension question that pertained to either the context or critical sentence. The questions about the critical sentence queried the main clause and, importantly, never asked about aspects of the sentence that related to the verb argument structure. A linear mixed-effects model looking at go-past reading times at the critical disambiguating verb (V2) showed a critical interaction: As can be seen in Fig. 2, the plausibility of the NP rendered the ungrammatical dead-end GP sentence as easy to process as the grammatical controls. This result suggests that plausibility can dupe the parser into treating the sentence as grammatical, or at least interpretable.

These experiments support two conclusions. First, we see a dissociation between patterns of data for acceptability judgments and reading times, suggesting they tap into different processes. More importantly, our results indicate that grammaticality is a graded phenomenon that can be pushed around by semantic constraints. Our findings provide further evidence for good-enough and noisy channel views of parsing that posit comprehenders' ability to normalize less than optimal input.

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Example stimuli

1. Mary worked at an electronics store and her main responsibility was to repair various broken parts. While Mary **fixed *the computer* *hummed*** in the corner. (+PL, -GR)
2. Mary worked at an electronics store and her main responsibility was to repair various broken parts. While Mary **fixed them *the computer hummed*** in the corner. (+PL, +GR)
3. Mary worked at an electronics store and her main responsibility was to repair various broken parts. While Mary **fixed *the client* *hummed*** in the corner. (-PL, -GR)
4. Mary worked at an electronics store and her main responsibility was to repair various broken parts. While Mary **fixed them *the client hummed*** in the corner. (-PL, +GR)

Exp.1 results - Ordinal mixed effects model with maximal random effects

Model formula : rating ~ Plausibility * Grammaticality + (1 + Plausibility * Grammaticality | Participant) + (1 + Plausibility * Grammaticality | Item)

Coefficients	*Estimate*	*SE*	*z-value*	*p*
Plausibility	.51	.2016	2.522	0.012 *
Grammaticality	-1.94	.22	-8.95	<0.001 ***
Grammaticality x Plausibility	-.27	.18	-1.47	0.14

Exp. 2 results - Linear mixed effects (with by-participant random effects)

Model formula : gopast ~ grammaticality * plausibility + (1 | subj_num)

Coefficients	*β*	*SE*	*t*	*p*
(Intercept)	516.93	19.65	26.30	<.001 ***
Grammaticality	-36.59	12.16	-3.01	0.003 **
Plausibility	-44.95	12.17	-3.69	<.001 ***
Grammaticality x Plausibility	28.88	12.17	2.37	.018 *

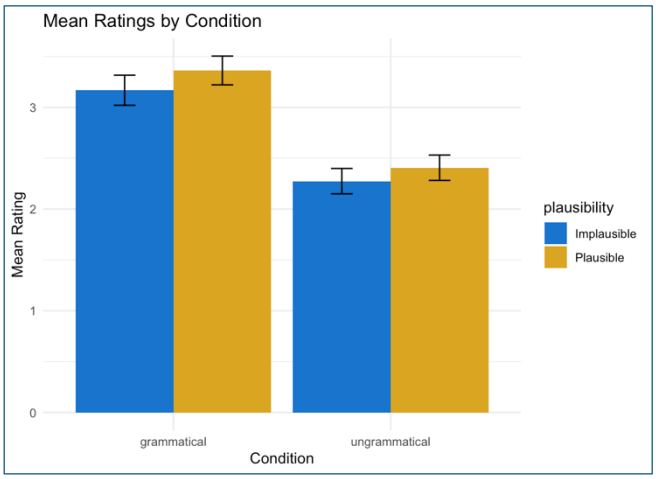

Figure 1 : Mean ratings by condition (Exp. 1)

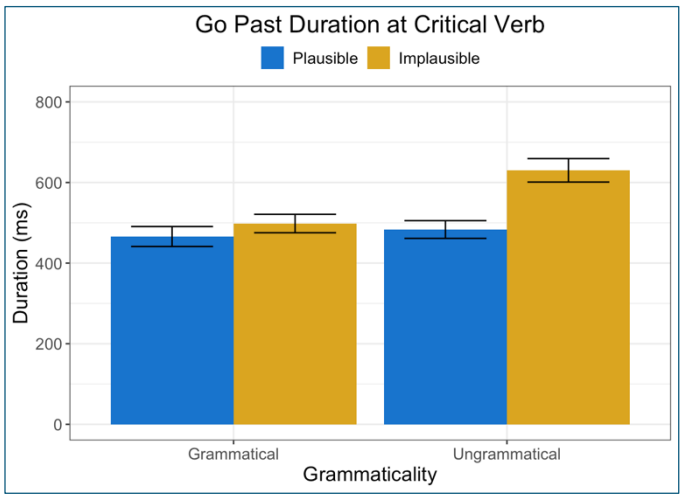

Figure 2 : Go-past times at V2 (Exp. 2)

[1] Corps et al., “Early Preparation during Turn-Taking.”; [2] Gibson, Bergen, and Piantadosi, “Rational Integration of Noisy Evidence and Prior Semantic Expectations in Sentence Interpretation.”; [3] Christianson et al.,“Thematic Roles Assigned along the Garden Path Linger.” [4] Ferreira, Bailey, and Ferraro, “Good-Enough Representations in Language Comprehension.” [5] Sturt, “Semantic Re-Interpretation and Garden Path Recovery.” [6] Pickering, “Plausibility and Recovery From Garden Paths: An Eye-Tracking Study.” [7] Grice, H. P. “Logic and conversation” [8] Tabor, Galantucci, and Richardson, “Effects of Merely Local Syntactic Coherence on Sentence Processing.” [9] Fodor, J. D., & Inoue, A.. “Attach anyway”.

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