Degrees of reanalysis in pragmatically and syntactically motivated dependencies

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Background: Comprehenders incrementally predict the unfolding of the sentence based on different motivations - syntactic licensing, rapid semantic integration, or alignment with pragmatic preferences. Is predictive structure building different when it is motivated by syntactic vs. pragmatic considerations? Keshev & Meltzer-Asscher (2020, henceforth K&MA) investigated the well-known gap prediction on wh-questions (motivated by the syntactic licencing of the dependency) and compared it to prediction of a pronoun following a topic presented in a *regarding*-phrases (which pragmatically require co-reference in following clause, see example in Table 1). On a sentence completion experiment K&MA observed that both cases invite a prediction for co-reference (a gap or pronoun) following the first verb. However, disconfirmation of this prediction, a lexical NP at that position, does not disrupt RTs (on self-pace reading), in the same way. A smaller and belated effect is observed in the *regarding* condition, relative to the classic “filled-gap” effect in the wh-question condition.

The current study: We investigate whether the difference in reanalysis costs of syntactically and pragmatically motivated dependencies reflects different rates of prediction (i.e. lower rates of reanalysis in the *regarding* condition), or a difference in the difficulty of reanalysis (i.e. easier reanalysis the *regarding* condition), using a mixture model analysis of data from K&MA. In addition, we report an experiment manipulating semantic persistence after reanalysis, which tests whether similar factors affect reanalysis costs in pragmatically and syntactically motivated dependencies. Based on our findings, we suggest that effects of prediction failure in pragmatically and syntactically motivated dependencies are not quantitatively, but qualitatively distinct.

Mixture model analysis: We reanalyse the "filled-gap" effect in K&MA's self-paced reading data (Figure 1). We assume that the reaction time (RT) in each trial is drawn from one of two possible distributions: a baseline distribution, comprising the trials in the baseline condition and a subset of the trials in the critical conditions *wh* and *regarding* dependencies); and a reanalysis distribution, comprising the remaining subset of trials, where processing was disrupted. We compared Bayesian models that could have generated the RTs in K&MA’s data. We found Bayes factor evidence for a model which assumes that the reanalysis cost is lower for *regarding* over *wh* dependencies, over model where the difference between the conditions was due to a different probability of drawing from the reanalysis distribution. WAIC values weakly supported this, where the reanalysis cost model was reliably better only relatively to one of the alternatives. See Tables 2-4 for details of the models and the comparison results.

Semantic persistence experiment: Reanalysis costs seem to be affected by the semantic compatibility of the initial interpretation and the globally correct one (Sturt, 2007). In a Hebrew self-paced reading experiment (N=48, 24 experimental sets and 40 filler sentences), we compare the reanalyses costs in *wh* and *regarding* dependencies, and manipulated the compatibility of the pre-reanalysis and post-reanalysis meaning (see Table 2). We observe increased processing costs for where meaning was not preserved after reanalysis only in wh-question (wh-question: $t = 3.82$, $p < .001$, posterior of 42ms [21,64]; *regarding*-dependency: $t = 0.04$, $p > .99$, posterior of 8ms [-17, 30]; interaction: $t = 2.67$, $p = .008$, posterior of 9ms [1,17]). These results suggest that the co-reference prediction in following a topic presentation (*regarding*-dependencies) does not receive a full, committing interpretation, and thus inhibition of the initial analysis is not required to the same degree as in filler-gap dependencies.

Conclusions: Taken together, the results provide evidence that co-reference prediction, motivated by presentation of a pragmatic topic, involve different reanalysis processes and incurs lower costs, relative to gap predictions. We suggest that the parser is less committed to predictions which are not motivated by syntactic licensing of the sentence structure.

Example for the syntactic and pragmatic dependency expectation

<u>*syntactic-motivating*</u> | <u>*pragmatic motivation*</u>

The secretaries checked {which nurse | regarding the nurse if} the patients persuaded

Expected resolution: …persuaded **_/her** to get some rest

Filled-gap design: …persuaded **the agitated doctor** to yell at _/her

Baseline: The secretaries checked whether the patients persuaded the agitated doctor to yell at the nurse

Table 1. Example set, translated from Hebrew, from Keshev and Meltzer-Asscher (2020).

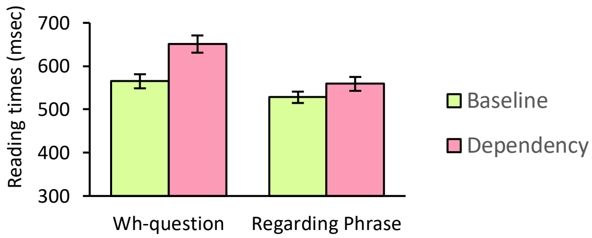

Figure 1. Results of Keshev and Meltzer-Asscher (2020). Mean RTs (+/-SE) in the *filler-gap* and *baseline* conditions at the critical word, and in the *regarding* and *baseline* condition at the spillover region (where contrasts were observed).

M0a: Same as baseline	RTwh ~	(1-P) ·	$LogNormal(\mu_1, \sigma_1)$ +	P ·	$LogNormal(\mu_1 + \Delta, \sigma_3)$
	RTregarding ~		$LogNormal(\mu_2, \sigma_2)$		
M0b: Same as wh	RTwh ~	(1-P) ·	$LogNormal(\mu_1, \sigma_1)$ +	P ·	$LogNormal(\mu_1 + \Delta, \sigma_3)$
	RTregarding ~	(1-P) ·	$LogNormal(\mu_2, \sigma_2)$ +	P ·	$LogNormal(\mu_2 + \Delta, \sigma_4)$
M1: Different reanalysis probability	RTwh ~	(1-$\mathbf{P_1}$) ·	$LogNormal(\mu_1, \sigma_1)$ +	$\mathbf{P_1}$ ·	$LogNormal(\mu_1 + \Delta, \sigma_3)$
	RTregarding ~	(1-$\mathbf{P_2}$) ·	$LogNormal(\mu_2, \sigma_2)$ +	$\mathbf{P_2}$ ·	$LogNormal(\mu_2 + \Delta, \sigma_4)$
M2: Different reanalysis cost	RTwh ~	(1-P) ·	$LogNormal(\mu_1, \sigma_1)$ +	P ·	$LogNormal(\mu_1 + \mathbf{\Delta_1}, \sigma_3)$
	RTregarding ~	(1-P) ·	$LogNormal(\mu_2, \sigma_2)$ +	P ·	$LogNormal(\mu_2 + \mathbf{\Delta_2}, \sigma_4)$
M3: Different probability & cost	RTwh ~	(1-$\mathbf{P_1}$) ·	$LogNormal(\mu_1, \sigma_1)$ +	$\mathbf{P_1}$ ·	$LogNormal(\mu_1 + \mathbf{\Delta_1}, \sigma_3)$
	RTregarding ~	(1-$\mathbf{P_2}$) ·	$LogNormal(\mu_2, \sigma_2)$ +	$\mathbf{P_2}$ ·	$LogNormal(\mu_2 + \mathbf{\Delta_2}, \sigma_4)$

Table 2. The compared models. M0a: A null hypothesis model where there is no reanalysis in the regarding condition. M0b: A null hypothesis model where reanalysis in regarding and wh-conditions has the same probability and cost. M1: the probability reanalysis is different, but the cost is the same. M2: the probability of reanalysis is the same, but the cost is different. M3: both probability and cost of reanalysis are different.

Parameter		Prior	Comments
P	Probability of reanalysis	Beta(1,1)	When two probability terms were used P_2 had to be smaller than P_1
μ	Mean RT for the baseline conditions (on the log-scale)	Normal(6,0.5)	
σ	Variance of RTs	half Normal(0,0.5)	All variance parameters had the same prior
Δ	Cost of reanalysis (addition for the mean RT on reanalysis trials, on the log-scale)	half Normal(0,0.5)	When two cost terms were used Δ_2 had to be smaller than Δ_1

Table 3. Parameters and their priors.

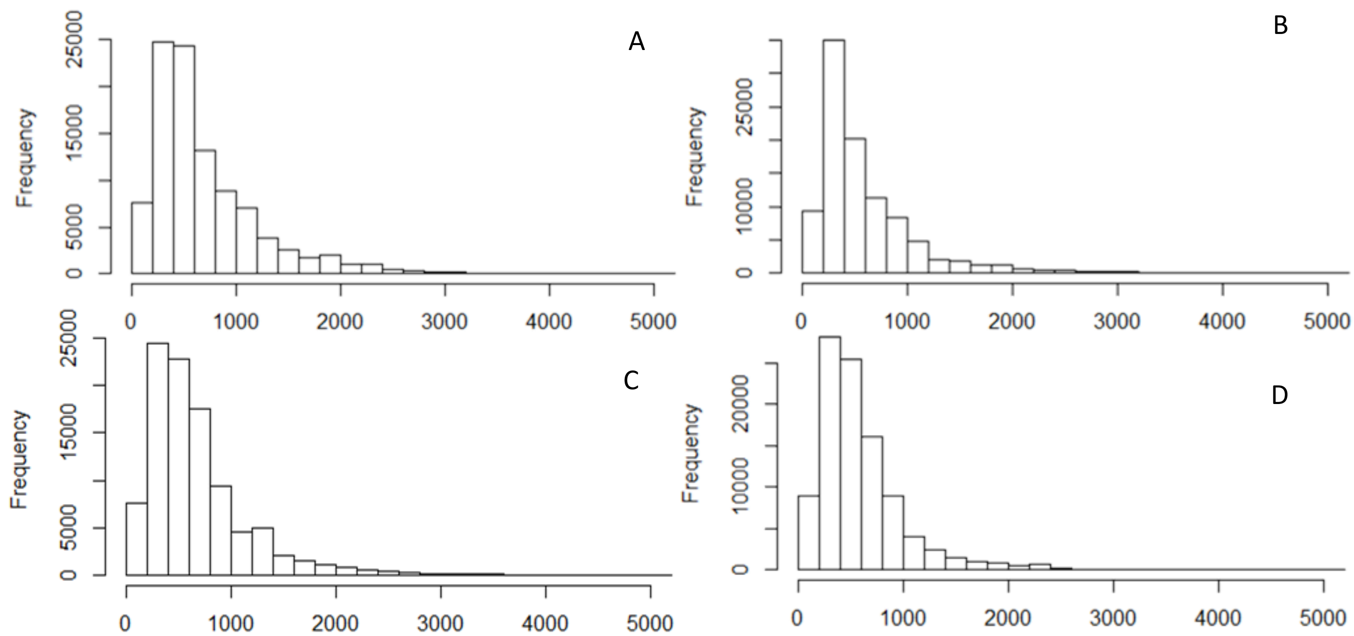

Figure 2. Simulating RTs from the prior distributions for the A: wh-condition on the reanalysis cost model (M2); B: regarding condition on the reanalysis cost model (M2); C: wh-condition on the reanalysis probability model (M3); D: regarding condition on the reanalysis probability model (M3).

	dWAIC	dSE	Bayes Factor in favour of M2
M0a	-11.67	7.75	1e6
M0b	-1.48	2.52	23
M1	-2.77	2.83	1736
M3	-1.18	0.47	20

Table 4. Results of the WAIC and BF model comparison. Evidence for M2 are shaded in grey**.**

Condition	**Example**	**Compatibility**
Syntactic dependency	*Dan nixeš et eyzo toxnit ha-menahel baxar* Dan guessed ACC which plan the-manager chose {***levatel* | *lehagšim***} *letovat ha-xevra* {to-cancel | to-execute} for-good the company	Choosing a plan ~ choosing to execute a plan ≠ choosing to cancel a plan
Pragmatic dependency	*Dan nixeš legabey ha-toxnit im ha-menahel baxar* Dan guessed regarding the-plan if the-manager chose {***levatel* | *lehagšim***} *ota letovat ha-xevra* {to-cancel | to-execute} it for-good the company	

Table 5. Example set for the semantic persistence experiment.

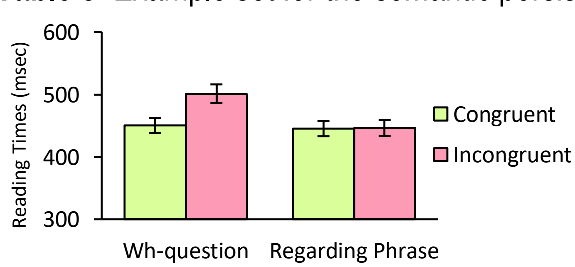

Figure 3. Mean RTs (+/-SE) in the semantic persistence experiment.

References: Keshev & Meltzer-Asscher (2020) The effects of syntactic pressures and pragmatic considerations on predictive dependency formation. *Language, Cognition, & Neuroscience.* Sturt (2007). Semantic re-interpretation and garden path recovery. *Cognition*.