

Facilitating sentence comprehension by syntactic priming

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Structural priming

Structural priming is the influence of a recently processed sentence structure on the processing of subsequent sentences. Some existing studies found structural priming in sentence comprehension:

- Branigan, Pickering, and McLean (2005): categorical effects on the interpretation of ambiguous sentences.
- Scheepers and Crocker (2004): effects on anticipatory eye movements.
- Arai, van Gompel, and Scheepers (2007): effects on anticipatory eye movements (only in sentences with repeated verbs).
- Traxler (2008): effects reading times, also Traxler and Tooley (2008).

Only the studies by Traxler et al. showed effects of structural priming on on-line processing. Both used ambiguous sentences as stimuli. It is unclear whether the processing of unambiguous sentences can also be primed, nor whether effects on predictive processing lead to reading time facilitation. Thus, the present experiments addressed the following questions:

- Does repetition of syntactic structures facilitate sentence processing, as measured by the self-paced reading task?
- Are there differences in the susceptibility to structural priming between ambiguous and unambiguous sentences?

Experiment 1

Two types of target sentences were used. OVS sentences were temporarily ambiguous (cf. Scheepers & Crocker, 2004); the OVS order is marked in Czech, but not ungrammatical. Sentences with datives were unambiguous. The same verb was used in the prime and target sentence, to replicate conditions under which Arai et al. (2007) found priming effects on structural anticipations.

Experiment 1 stimuli

OVS (ambiguous target)

Matching prime
Skrytou cestu najde kapitán. / (Hidden path)_{acc} finds the captain_{nom}.
Non-matching prime
Starý kapitán najde cestu. / (The old captain)_{nom} finds the path_{acc}.
Target
Štěně postrčí unavený osel u vrat. /
A puppy_{Ambig} pokes the tired donkey_{Nom} at the gate.

Dative (unambiguous target)

Matching prime
Dědeček daroval hračku vnukovi. / Granddad gave toy_{acc} grandson_{dat}.
Non-matching prime
Dědeček daroval vnukovi hračku. / Granddad gave grandson_{dat} toy_{acc}.
Target
Básník daroval kabelku manželce důležitého nakladatele. /
Poet gave purse_{acc} wife_{dat} important publisher_{gen}.

Participants and procedure

A total of 39 native speakers participated in a word-by-word self-paced reading task. Each trial comprised four masked sentences: prime, target, and two fillers. Sentences were followed by a comprehension question.

Analysis

Primary analyses compared total reading times for the region of interest (italicized in the example). Post-hoc analyses were performed for individual words. Mixed-model analysis was used with persons and target sentences as random effects, and condition and trial number as fixed effects. The significance levels were calculated empirically (cf. Baayen, Davidson, & Bates, 2008).

Results

Total mean reading times and the means for individual words:

	Total	Word no.			
		3	4	5	6
OVS					
matched	2906	629	638	445	1133
non-matched	3031	651	659	455	1161
effect	**125	22	21	10	28
Dative					
matched	2900	574	598	619	1053
non-matched	2830	555	583	592	1002
effect	-70	-19	15	-27	-51

The only significant fixed effect of condition was observed for the total reading times in OVS sentences. The region of interest was read faster in the matching condition compared to the non-matching condition ($t = 2.54$, $p = 0.028$). No significant differences were observed for individual words, but the total times for words 3 and 4 in the OVS sentences were faster in the matching condition ($t = 2.88$, uncorrected $p = 0.008$).

No significant effects were observed for the target sentences with datives.

Exp. 1 discussion

- Only ambiguous sentences showed evidence of priming.
- Was this because of the ambiguity or general difficulty? OVS sentences appeared more difficult than the sentences with datives.
- Perhaps priming only occurs in sentences that are hard to read?

Experiment 2

The target sentences were modified so that the OVS sentences were unambiguous, and the sentences with datives were more difficult to process (by moving the “heavy” dative NP to a sentence-internal position). If priming occurred in the modified sentences, it would suggest that difficulty rather than ambiguity makes sentences susceptible to priming.

Experiment 2 stimuli

OVS

Matching prime
Skrytou cestu najde kapitán. / (Hidden path)_{acc} finds the captain_{nom}.
Non-matching prime
Starý kapitán najde cestu. / (The old captain)_{nom} finds the path_{acc}.
Target
Lišku postrčí unavený osel u vrat. /
A fox_{Acc} pokes the tired donkey_{Nom} at the gate.

Dative

Matching prime
Dědeček daroval hračku vnukovi. / Granddad gave toy_{acc} grandson_{dat}.
Non-matching prime
Dědeček daroval vnukovi hračku. / Granddad gave grandson_{dat} toy_{acc}.
Target
Básník daroval manželce důležitého nakladatele kabelku. /
Poet gave (to the wife)_{dat} (of an important publisher)_{gen} (a purse)_{acc}.

Participants, procedure, analysis

A total of 46 native speakers participated. The format of the task was the same as in Experiment 1, as were the analytic procedures. In OVS sentences, the primary observed variable was the reading time for the sentence-initial noun. In sentences with datives, the region of interest was the same as in Experiment 1, i. e. the sequence from first structural difference to the sentence end.

Results

Mean reading times are reprinted in the table. For comparison with Experiment 1, mean times for all words in OVS targets are reported.

	Total	Word no.					
		1	2	3	4	5	6
OVS							
matched	664	554	610	553	432	1138	
non-matched	706	571	631	557	436	1114	
effect	42	17	21	4	4	-24	
Dative							
Total							
Word no.							
3							
4							
5							
6							
matched	3062	585	620	574	1186		
non-matched	3027	572	588	566	1222		
effect	-35	-13	-32	-8	36		

Analyses revealed no significant effects of experimental condition in either type of sentences. In OVS sentences, this was the case for individual words as well as for the total reading time for the whole sentence, and for the total reading time for the OV sequence (initial two words).

Experiment 3

The design of Experiments 1 and 2 did not make it possible to compare the priming effects in ambiguous and unambiguous sentences directly. Experiment 3 was designed to allow for this comparison, combining target sentence ambiguity and priming as factors in a 2 × 2 design. The experiment exploited the dative-accusative morphological ambiguity in one class of Czech nouns.

Matching prime
Dědeček daroval hračku vnukovi. / Granddad gave toy_{acc} grandson_{dat}.
Non-matching prime
Dědeček daroval vnukovi hračku. / Granddad gave grandson_{dat} toy_{acc}.
Ambiguous target
Pán odeslal hospodyně výplatu na konto. /
man sent maid_{DatAccAmbig} money_{Acc} to account.
Unambiguous target
Pán odeslal sluhovi výplatu na konto. /
man sent servant_{Dat} money_{Acc} to account.

Participants, procedure, results

A total of 37 volunteers participated in the experiment. The procedure was similar to Experiments 1 and 2. Analyses examined the effects of prime type, target ambiguity and their interaction. The primary region of interest was the reading time for the region from word 3 to the sentence end. Follow-up analyses examined individual words.

	Total	Word no.			
		3	4	5	6
Amb. primed	2237	535	524	408	669
Amb. unprimed	2269	562	515	409	718
Unamb. primed	2213	523	523	403	689
Unamb. unprimed	2124	538	497	401	631

No significant effect of prime type or interaction with target ambiguity was found in the region of interest. Ambiguous targets were read more slowly than unambiguous ones ($p = 0.04$). Faster reading times of unambiguous stimuli were also found on the third word (the ambiguous noun, $p = 0.028$) and, marginally, on the fifth word ($p = 0.051$). There was a significant interaction between priming and target ambiguity on the sentence-final word ($p = 0.037$): the effect of priming was opposite in the two ambiguity conditions. This is in line with the original hypothesis that priming is stronger in ambiguous sentences.

Discussion

Experiment 3 successfully manipulated target sentence ambiguity. The effects of priming only show in the significant interaction between priming and target ambiguity, which was observed on the sentence-final word. The results suggest that structural priming may be stronger in garden-path sentences, but the effects are not robust. The overall difficulty of the task may have contributed to the weak results.

Conclusions

The results indicate that structural ambiguity may be an important factor determining susceptibility of sentences to structural priming.

- Unambiguous sentences did not undergo priming, even though the verb was repeated.
 - Previously, priming effect in English sentences with datives was shown for predictive processing (Arai et al., 2007).
 - Present results suggest that predictive processing effects may not lead to reading facilitation.
- Structural priming occurred in garden-path OVS sentences even in the absence of verb repetition.
 - Effect disappeared when the ambiguity was removed.
 - No previous reports found structural priming of comprehension in unambiguous sentences (except for anticipations).
- Priming of on-line parsing appears to be possible only in ambiguous sentences.

Possible implications

Evidence for the revision stage?

The distinction between ambiguous and unambiguous sentences, if confirmed, could support the two-stage accounts of parsing.

- It looks like priming facilitates revisions but not first-pass parsing.
- If the distinction proves to be robust, it would support the existence of two separate processing stages, each susceptible to different influences.

References

- Arai, M., van Gompel, R. P. G., & Scheepers, C. (2007). Priming ditransitive structures in comprehension. *Cognitive Psychology*, 54, 218–250.
- Baayen, R., Davidson, D., & Bates, D. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language*, 59, 390–412.
- Branigan, H. P., Pickering, M. J., & McLean, J. F. (2005). Priming prepositional-phrase attachment during comprehension. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 31, 468–481.
- Scheepers, C., & Crocker, M. W. (2004). Constituent order priming from reading to listening: A visual-world study. In M. Carreiras & C. Clifton (Eds.), *The on-line study of sentence comprehension: Eyetracking, ERP, and beyond* (pp. 167–185). New York: Psychology Press.
- Traxler, M. J. (2008). Lexically independent priming in online sentence comprehension. *Psychonomic Bulletin & Review*, 15, 149–155.
- Traxler, M. J., & Tooley, K. M. (2008). Priming in sentence comprehension: Strategic or syntactic? *Language and Cognitive Processes*, 23, 609–645.



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