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Adaptation to complex cues in sentence comprehension

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Language processing strongly relies on predictive mechanisms which have been shown to adapt to reliable cues [1,2,3,4,5,6]. We demonstrate syntactic adaptation to a complex, but highly reliable, cue (Tense+Verb Type). Since adaptation is methodologically relevant for methods that require large number of trials (e.g. ERP) we present a follow up study designed to attenuate reliability of the cue. **Background.** A number of recent offline and online studies have investigated the parser's preference for a Relative Clause (RC) or Pseudo Relative (PR) interpretation under ambiguity. Contrary to RCs (1a), PRs (1b) match English eventive Small Clauses (2b) in that they are only available in selected environments (e.g. under perceptual, but not stative verbs) and require Matching Tense between matrix and embedded verb.

(1) a. Ho $[_{V'}$ visto $[_{DP}$ l' $[_{NP}$ uomo $[_{RC}$ che correva]]]]] b. Ho $[_{V'}$ visto $[_{PR}$ l'uomo che correva]]
(2) a. I.have $[_{V'}$ seen $[_{DP}$ the $[_{NP}$ man $[_{RC}$ that ran]]]] b. I.have $[_{V'}$ seen $[_{SC}$ the man running]]

Across languages and techniques, the results consistently show a strong parsing preference for PRs over RCs [7,8,9]. PR-availability was manipulated in two acceptability/eye-tracking studies in French [9], with a Matrix-Verb-Type(perceptual vs. stative)*Tense(Match vs. Mismatch) design (Table 1). The results show lower acceptability and longer fixation durations at the disambiguating region (embedded verb) for Tense Mismatch under perceptual, but not under stative verbs. In French a perceptual main verb provides a PR compatible environment, however the tense mismatch with the embedded verb forces an RC reading that is not required when the tense matches. Hence, lower acceptability and longer reading times for this contrast support the hypothesis that PRs are preferred over RCs [10,7]. **Experiment 1:** Two aspects of the study in [10] can lead to adaptation: i. ¾ of the target sentences are unambiguous RCs, which can lead to structural priming effects, and ii. a highly reliable cue potentially leading to adaptation: the prediction of a PR is voided when perceptual verbs are in the present tense. Specifically, we expect an interaction between Tense (Mis)match and Verb Type to be significantly stronger in the first compared to second half of an experiment with a sufficiently large number of items (i.e., 60). We test for these effects using an acceptability judgment experiment. *Design:* 2*(V-Type: perceptual vs. stative)*2(Tense: match vs. mismatch). 32 native speakers of Italian rated 180 sentences for acceptability on a scale of 1 (completely unacceptable) to 10 (completely acceptable). The stimuli consisted of 60 experimental sentences, 30 grammatical and 90 ungrammatical unrelated fillers. Results show a 3-way interaction (t=-3.60) between V-Type*Tense*Half(1^{st} vs. 2^{nd} half of the experiment), with a steep improvement in the acceptability of Tense Mismatch under Perceptual verbs, which is rated as acceptable as Tense Match by the end of the experiment (fig 1,2). The interaction between V-Type and Tense is present in the first half (t=5.61), but eliminated in the second half (t=1.72) of the experiment. In line with previous results, the globally PR-compatible condition consistently receives the highest scores and does not show any learning effect. While all RC-conditions show improvement through the study, this effect is strongest for RCs under perceptual verbs, i.e. in locally ambiguous PR/RC environments. We attribute these changes to adaptation to a reliable cue: perceptual verbs in the present tense exclusively introduced RCs, rather than the preferred PRs, in the present experiment. **Experiment 2:** To try to offset adaptation, we reduced reliability of the cue by replacing 15 of the 30 grammatical fillers in Exp 1 with 15 sentences containing a perceptual verb in the present tense followed by an unambiguous PR (Table 2), bringing the overall PR:RC ratio up to 2:3 and to 1:1 under present tense perceptual verbs. As predicted, results (N= 30) show a 2-way interaction between V-Type and Tense (t=4.73), but no 3-way interaction with Half (t=1.68). While the learning effect is still present numerically (possibly because of the overall PR:RC ratio), it is no longer significant (fig 3,4). **Discussion:** Complex cues (combination of a specific tense marking with a specific class of verbs) can lead to adaptation when highly reliable. The results are relevant for ERP, which require a large number of trials per condition, increasing the chance of adaptation and null results.

VERB TYPE	TENSE	**Sample Sentence**	
Perceptual	*Match*	a. Max ha visto la ragazza che spingeva la signora. *Max **saw** the girl that **pushed** the lady.*	PR/RC
	Mismatch	b. Max vede la ragazza che spingeva la signora. *Max **sees** the girl that **pushed** the lady.*	RC-Only
Stative	*Match*	c. Max era sposato con la ragazza che spingeva la signora *Mas **was** married to the girl that **pushed** the lady.*	RC-Only
	Mismatch	d. Max è sposato con la ragazza che spingeva la signora. *Max **is** married to the girl that **pushed** the lady.*	RC-Only

Table 1: Example of experimental stimuli (English translation only)

VERB TYPE	TENSE	**Sample Filler Sentence**	
Perceptual	*Match*	Max vede Maria che spinge la signora. Max **sees** Mary that **pushes** the lady. *`Max sees Mary pushing the lady'*	PR-Only

Table 2: Example of one of the 15 unambiguous PR sentences used as fillers in Experiment 2

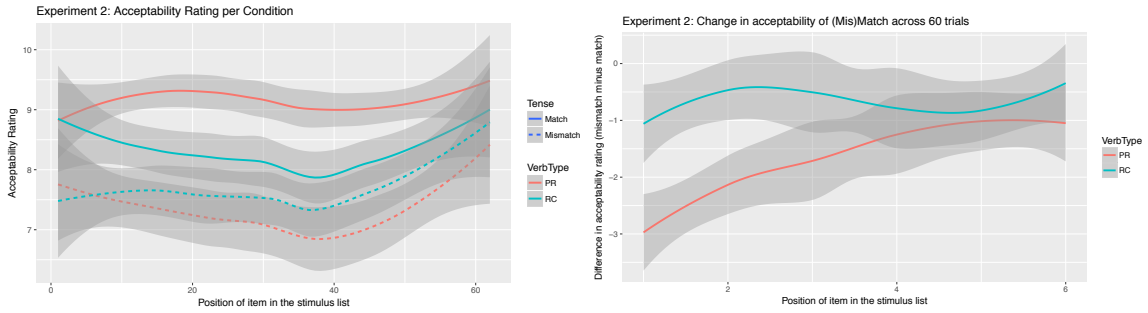

Figure 1 and 2: (Change in) acceptability of Tense across Verb Type in Experiment 2.

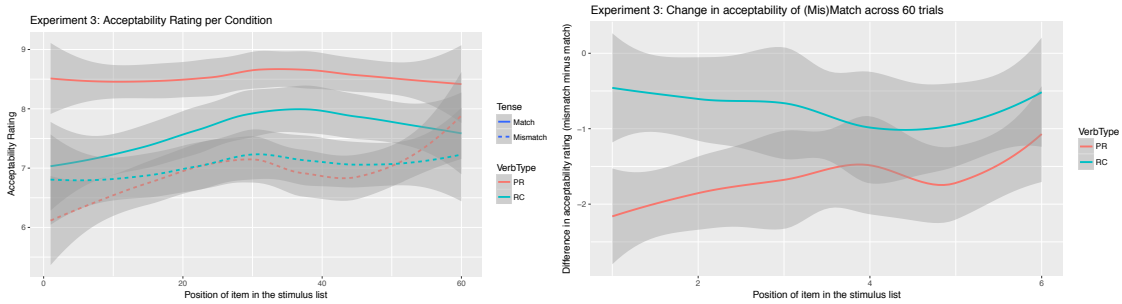

Figure 3 and 4: (Change in) acceptability of Tense across Verb Type in Experiment 3.

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