**Case interference and phrase length effects in processing Turkish center-embeddings**

Özge Bakay & Nazik Dinçtopal Deniz (Boğaziçi University)

**Background:** Doubly center-embeddings with relative clauses (2-CE-RCs) such as *The rat that the cat that the dog chased ate died* [1, p. 286] are reported to be extremely difficult to process despite their grammaticality. Several accounts have been proposed to explain their processing difficulty [e.g., 1,2,3]. The present study tests the predictions of (i) similarity-based interference [4] and (ii) prosodic phrase lengths [5]. (i) predicts that decreasing the similarity among the NPs, e.g., in their syntactic [e.g., 6] or phonological case markings [e.g., 7 but cf. 6], may ease the processing difficulty of CE structures. (ii) predicts that when the 2-CE-RCs have optimal and balanced phrase lengths, their processing is easier. An eye-tracking experiment was conducted to examine these predictions. **Materials:** The experiment employed Turkish 2-CE-RCs nested as a complement clause inside a matrix clause (see the examples in (1)). The experiment manipulated syntactic and phonological case interference (syntactic case indicates syntactic functions of NPs; phonological case indicates phonological similarity of cases irrespective of their syntactic functions), and prosodic phrase lengths. For case interference, in high syntactic-high phonological interference condition (HS-HP; 1a), all three subject NPs were marked with the genitive case, *-(n)In*. In low syntactic-high phonological interference condition (LS-HP; 1b), NP1 had the (null) nominative case to decrease the syntactic case similarity among the subject NPs, and the first object NP, NP4 was marked with genitive case to keep phonological case similarity high (at three). In low syntactic-low phonological interference condition (LS-LP; 1c), NP1 had the (null) nominative case, and the first object NP, NP4, was marked with the accusative case to decrease case similarity (at two). For phrase lengths, in conditions that encouraged a relatively balanced phrasing of Turkish 2-CE-RCs, viz., NP1||NP6||VP1, (ENC; 1a-c), NP1 and VP1 were each lengthened with two additional prosodic words (PWds), resulting in three PWds each [8]. In conditions that discouraged the optimal phrasing (DISC; 1a-c), NP6 was lengthened with four additional PWds, and NP1 and VP1 were one PWd each. Overall sentence length was the same across ENC and DISC conditions. **Procedure**: The participants' ($N$ = 44) eye-movements were recorded as they read the sentences. A question followed each sentence to ensure comprehension. **Results:** The eye-tracking data, summarized in Table 1, were analyzed with mixed-effects linear/logistic regression models for the critical region (region 14: VP1) and the spillover region (region 15: matrix verb). Case interference and phrase lengths were fixed effects. The analyses on the critical region showed that HS-HP were harder to read than LS-HP (gaze duration (GD), regression path duration (RPD), rereading duration (RRD), total duration (TD) ($t$'s ≥ 2.99)) and LS-LP (GD, RPD, TD ($t$'s ≥ 3.92), probability of regression out (PRO) ($z$ = 1.95)). There was an increased difficulty in reading DISC compared to ENC in the critical (first fixation duration (FFD), RPD, RRD, TD ($t$'s ≥ 3), PRO ($z$ = 2.51)) and spillover region (RPD ($t$ = 2.52)). In the critical region, the complex models with syntactic case interference and phrase lengths explained the data better than simpler models with a single predictor (GD, RPD, RRD, TD, PRO ($\chi^2$'s (1) ≥ 6.22, $p$ < .05)). The follow-up analyses showed that HS-HP/DISC was the most difficult to read (RPD, RRD, TD ($t$'s ≥ 2.45)) and LS-HP/ENC was the easiest to read (RPD ($t$'s ≥ 2.31). There were no effects of phonological case interference in either region. **Conclusion:** The results show that the processing difficulty of Turkish 2-CE-RCs can be alleviated with decreased syntactic case similarity (as in Japanese [6]) and with optimal and balanced phrase lengths (as in English [9]). This was the case in both early and late measures. Unlike syntactic case interference effects, phrase length effects persisted to a later region. This may suggest that the integration of prosodic phrase length information into the current structure may take longer [10] or may "alter a [parse] that was starting to take hold" [11, p. 119]. An end-of-sentence acceptability task to examine whether the two forces or only phrase lengths affect final decisions is underway. No effect of phonological case interference can be a true null effect [12] or due to the increased level of embeddings [7].

**References:** **[1]** Chomsky & Miller (1963). In Luce et al. (Eds.), *Handbook of Math. Psy.* **[2]** Bever (1970). In Hayes (Ed.), *Cog. and the Dev. of Lang.* **[3]** Gibson (2000). In Marantz et al. (Eds.), *Image, Lang., Brain.* **[4]** Lewis & Vasishth (2005). *Cog. Sci., 29*(3). **[5]** Fodor (2013). In Montserrat et al. (Eds.), *Lang. Down the Garden Path: The Cog. & Bio. Basis for Ling. Str.* **[6]** Uehara & Bradley (1996). In Park & Kim (Eds.). *Lang., Info. & Comp*. **[7]** Nakayama et al. (2005). *Lang. Sci.*, *4.* **[8]** Deniz & Fodor (2017). *Lang. & Speech (60)*4. **[9]** Fodor et al. (2017). In Almeida & Gleitman (Eds.), *On Con., Modules & Lang.: Cog. Sci. at its Core.* **[10]** Marcus & Hindle (1990). In Altmann (Ed.), *Cog. models of speech process: comput. and psy. persp.* **[11]** Fodor (2002). In *Proceed. of NELS 32.* **[12]** Obata et al. (2010). In *Proceed. of NELS 41.*

**Materials:** Brackets indicate clause boundaries. Case marking is in bold face. Colored words manipulate phrase lengths: green in ENC and red in DISC. || marks implicit prosodic boundaries predicted to be induced by phrase lengths.

1. a. **ENC/DISC, HS-HP:**

ø [İşinin ehli marangoz-lar-**ın** || [nakliyeci-ler-**in** [kiracı-**nın** oldukça geniş gri…
*Pro* expert carpenter-PL-GEN mover-PL-GEN renter-GEN extremely large gray
NP1-GEN NP2-GEN NP3-GEN

b. **ENC/DISC, LS-HP:**

ø [İşinin ehli marangoz-lar-**ø** || [nakliyeci-ler-**in** [kiracı-**nın** koltuğ-**un** oldukça geniş…
*Pro* expert carpenter-PL-NOM mover-PL-GEN renter-GEN sofa-GEN extremely large
NP1-NOM NP2-GEN NP3-GEN NP4-GEN

c. **ENC/DISC, LS-LP:**

ø [İşinin ehli marangoz-lar-**ø** || [nakliyeci-ler-**in** [kiracı-**nın** oldukça geniş gri…
*Pro* expert carpenter-PL-NOM mover-PL-GEN renter-GEN extremely large gray
NP1-NOM NP2-GEN NP3-GEN

koltuğ-u /minder-leri-ni büyük özen-le yerleştir-diğ-i] odaya taşı-dık-ları]
sofa-ACC/cushion-3POSS.PL-ACC great care-with place-FN-3SG room-DAT move-FN-3PL
VP3 VP2

dolabı || dikkatli şekilde kur-duk-ları-nı/kur-du-lar] san-dı-m.
clozet-ACC careful manner build-PAST-3PL-ACC/build-PAST-3PL think-PAST-1SG
VP1

*'I know that the expert carpenters carefully built the closet that the movers moved to the room where the renter placed the extremely large gray sofa/sofa's cushions with great care.'*

**Table 1.** Mean and standard error (SE) values for first fixation duration (FFD), gaze duration (GD), regression path duration (RPD), re-reading duration (RRD), total duration (TD) (in milliseconds) and probability of regression out (PRO) for the critical region (region 14) and the spillover region (region 15). ENC and DISC conditions are given in green and red, respectively.

| | | FFD | GD | RPD | RRD | TD | PRO |
|---|---|---|---|---|---|---|---|
| **Critical Region** | **HS-HP, ENC** | 231 (6) | 380 (14) | 428 (19) | 315 (31) | 661 (31) | .10 (.02) |
| | **LS-HP, ENC** | 233 (5) | 318 (12) | 363 (17) | 253 (26) | 565 (28) | .11 (.02) |
| | **LS-LP, ENC** | 238 (7) | 333 (12) | 418 (24) | 275 (30) | 602 (30) | .15 (.03) |
| | **HS-HP, DISC** | 239 (6) | 409 (16) | 554 (27) | 434 (36) | 793 (35) | .20 (.03) |
| | **LS-HP, DISC** | 247 (8) | 347 (14) | 462 (23) | 327 (32) | 633 (31) | .21 (.03) |
| | **LS-LP, DISC** | 239 (6) | 324 (13) | 417 (21) | 352 (32) | 648 (31) | .19 (.03) |
| **Spillover Region** | **HS-HP, ENC** | 244 (7) | 283 (10) | 373 (27) | 146 (18) | 408 (19) | .15 (.03) |
| | **LS-HP, ENC** | 238 (6) | 267 (9) | 332 (18) | 180 (23) | 439 (24) | .19 (.03) |
| | **LS-LP, ENC** | 239 (7) | 290 (11) | 378 (24) | 178 (26) | 447 (25) | .19 (.04) |
| | **HS-HP, DISC** | 247 (7) | 280 (19) | 434 (26) | 210 (27) | 463 (24) | .26 (.04) |
| | **LS-HP, DISC** | 249 (7) | 297 (11) | 416 (27) | 170 (22) | 466 (26) | .26 (.04) |
| | **LS-LP, DISC** | 251 (8) | 278 (11) | 416 (27) | 192 (22) | 465 (22) | .24 (.04) |