**Hierarchical relations in memory retrieval: Evidence from a local anaphor in Turkish**

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Several studies on the processing of local anaphors such as *himself* showed that comprehenders are sensitive to structural constraints in antecedent retrieval [e.g.1-3,cf.4]. Our review of 45 experiments from 27 crosslinguistic studies revealed (i) they all employed stimuli that confounded a combination of structural cues such as c-command, clause-mateness, case and subjecthood as in *'The surgeon [who treated Jonathan] had pricked himself'* and (ii) 37 of them examined postverbal anaphors, which may not be ideal for investigating structural cues due to target subject's advantage at retrieval point through recent formation of its subject-verb dependency [2]. None of them directly tested use of the relational notion of *c-command*, a core syntactic constraint of local anaphors, in their online resolution. Here we investigate role of c-command in processing the preverbal, local reciprocal *birbirleri* in Turkish. Hierarchical relations such as c-command are *not* consistent features of individual items, but rather depend on the relationship among them. Prominent cue-based accounts [5] model encoding of items in memory with their consistent features such as *+/-plural,* but they face a challenge in representing item-to-item relations [2,6-9]. Structurally oriented accounts [10] model encoding and retrieval with reference to syntactic position information, allowing to capture hierarchical relations. We present new evidence from local anaphors for rapid use of hierarchical relations in retrieval, supporting structural accounts.

In three visual world studies, we teased apart c-command from other structural information (clause, case, subjecthood) and a domain general memory factor (recency). E1 disentangled c-command from clause-mateness, case and recency and E2 from subjecthood; E3 was a pre-registered, high-power replication of E1-2. Eye-movements on c-commanding subjects/indirect objects (IOs) and distractors on a visual display were recorded. Analyses were conducted on probabilities of *new* fixations [11] towards critical referents that were launched within reciprocal window, with *glmer* [12]. If c-command is a retrieval cue, we predicted more new fixations towards subjects/IOs than distractors. Results confirmed this: c-commanding local arguments, i.e. subjects and IOs, were differentiated from clause-mate, case matching distractors immediately upon processing the reciprocal. There was only limited evidence for interference in E1, which was not replicated in E2-3. Our data show that hierarchical relations among NPs determine availability of antecedents in early stages of retrieval above and beyond clause, case and subject features.

E1 ($N_{subj}$=68, $N_{item}$=24) compared availability of c-commanding subjects and clause-mate (possessor) distractors with the same case marking, i.e. GEN. The stimuli had a 2x2 design (1), manipulating RECENCY of subject, i.e. whether it followed or preceded distractor, and number (MIS)MATCH of distractor, i.e. SG or PL. In E1-3, offline antecedent selection tasks confirmed c-command constraint of *birbirleri* [13]. Participants listened to stimuli and clicked on the referent of *birbirleri* while looking at a display as in **FIG1**. Results of E1 (see **FIG2**) showed that probability of a fixation towards subject was overall above 50% chance level. There was an interaction between RECENCY and MATCH; with less fixations towards subject with a PL distractor when subject was distant (z's≥3.47), but no difference with SG and PL distractors when subject was recent (z=1.37).

E2 ($N_{subj}$=54, $N_{item}$=30) compared availability of c-commanding IOs and (PP-modifier) distractors that were clause-mates to anaphor and marked with the same case, i.e. DAT. The stimuli had 5 conditions: 2x2 design (2a), manipulating C-COMMAND of dative noun, i.e IO or distractor, and its number (MIS)MATCH, i.e. SG or PL, plus a control condition with a SG subject and PL IO (2b). For the 2x2 design (see **FIG3**), there was an interaction between C-COMMAND and MATCH on fixations towards dative within reciprocal; with more fixations towards PL than SG IO (z's≥2.41), but no difference between SG and PL distractors ($z$=.13). There were more fixations towards PL IO than SG subject in the control condition ($p$<.01).

E3 ($N_{subj}$=102, $N_{item}$=24) was a pre-registered, high-power replication of E1-2. The stimuli had 3 conditions (3) manipulating C-COMMAND and CASE on distractor: IO, Distractor Dative and Distractor Genitive. Results (see **FIG4**) showed more fixations towards IO than distractors within reciprocal ($z$=2.60), but no difference between the two distractors ($z$=.16). Analyses on gaze probabilities (see **FIG5-7**) for subject vs. distractor/IO in E1-3 yielded comparable results.

Subj(ect)$_i$ = blue, Dist(ractor)$_k$ = orange, IO$_l$ = purple, Reciprocal = **bold**, Embedded verb = *italic*

(1) a. Recent: A. [ yönetmen(-ler)-in$_k$ yeni kameraman-ları-nın$_i$ …
A. director(-PL)-GEN new cameraman-PL.POSS-GEN
b. Distant: A. [ kameraman-lar-ın$_i$ yönetmen(-ler)-in$_k$ etkisiyle …
A. cameraman-PL-GEN director(-PL)-GEN with.influence

(2) a. A. [ kameraman-lar-ın$_i$ { yönetmen(-ler)-e$_l$ / yönetmen(-ler)-e$_k$ göre } …
A. cameraman-PL-GEN director(-PL)-DAT / director(-PL)-DAT according.to
b. Control: A. [ kameraman-ın$_i$ yönetmen-ler-e$_l$ …
A. cameraman-GEN director-PL-DAT

(3) A. [ kameraman-lar-ın$_i$ { yönetmen-ler-e$_l$ / yönetmen-ler-e$_k$ karşın / yönetmen-ler-in$_k$ etkisiyle } …
A. cameraman-PL-GEN director-PL-DAT / director-PL-DAT despite / director-PL-GEN with.influence
… açıkça **birbirleri-ni$_{i/*k/l}$** *kötülediğini* ] duydu.
openly each.other-ACC discredited heard

(1) 'Ayşe heard that { *with the director(s)$_k$'s influence / the director(s)'s$_k$ new* } cameramen$_i$ openly discredited each other$_{i/*k}$'
(2) 'Ayşe heard that the cameraman(s)$_i$ openly discredited { *to the director(s)$_l$ / according to the director(s)$_k$* } each other$_{i/*k/l}$.'
(3) 'Ayşe heard that the cameramen$_i$ openly discredited { *to the directors$_l$ / despite the directors$_k$ / with the directors'$_k$ influence* } each other$_{i/*k/l}$.'

**FIG1**. Visual display in E1-3 for (1-3), with subject *cameramen* (top left), IO/distractor *director* (top right), two unmentioned referents (bottom).

**FIG2**. Proportions of new fixations towards subject and dist(ractor) within reciprocal in E1.

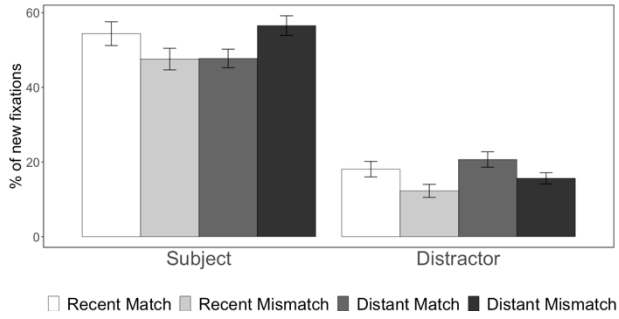



**FIG5**. Gaze probabilities to subj(ect) and dist(ractor) starting from the onset of the reciprocal in E1.

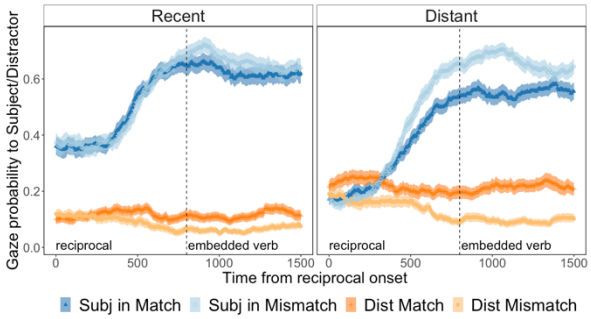



**FIG3**. Proportions of new fixations towards subject, IO and dist(ractor) within reciprocal in E2.

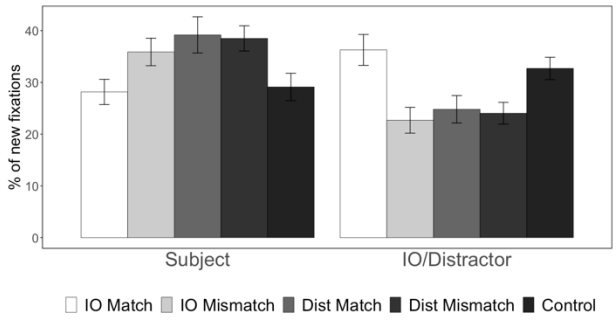



**FIG6**. Gaze probabilities to subj(ect), IO and dist(ractor) starting from the onset of the reciprocal in E2.

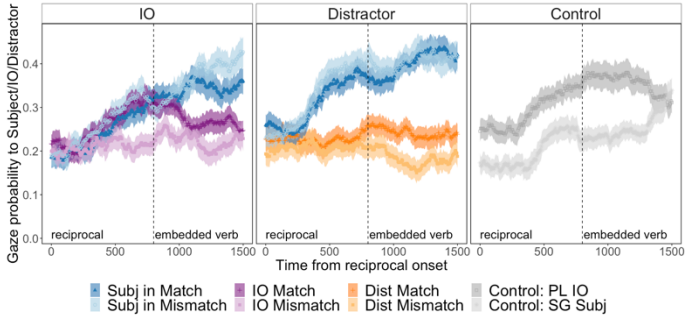



**FIG4**. Proportions of new fixations towards subject, IO and dist(ractor) within reciprocal in E3.

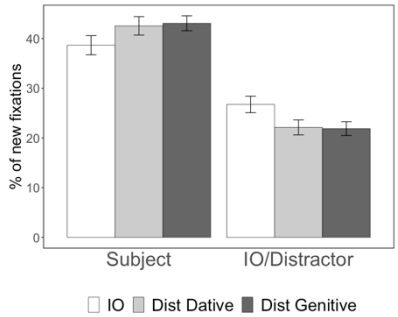
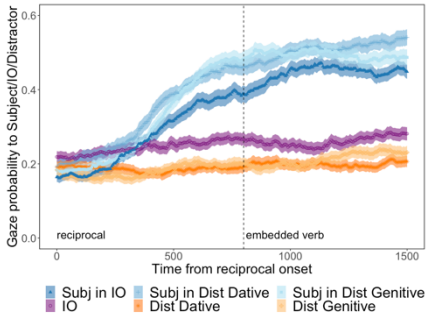



**FIG7**. Gaze probabilities to subj(ect), IO and dist(ractor) starting from the onset of the reciprocal in E3.




*Error bars in **FIG2-4** and error bands in **FIG5-7** show standard error of the mean corrected for between participant variance.*
*Gaze probabilities in **FIG5-7** are plotted at every 5 ms from the onset of the reciprocal spanning a period of 1500 ms.*
*New fixations and gaze probabilities to the two unmentioned referents are omitted in **FIG2-7** for ease of interpretation.*


REFERENCES [1] Sturt, 2003 [2] Dillon et al., 2013 [3] Kush & Phillips, 2014 [4] Patil et al., 2016 [5] Lewis & Vasishth, 2005 [6] Kush, 2013 [7] Wagers, 2008 [8] Kush et al., 2015 [9] Franck & Wagers, 2020 [10] Keshev et al., 2024 [11] Kingston et al., 2016 [12] Bates et al., 2015 [13] Akkuş, 2021