Comprehension of double-center embedded relatives in Italian: a case for hierarchical intervention

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Introduction: Object relatives are more difficult to process than subject relatives (King & Just, 1991; Gibson, 1998; Traxler, Morris, & Seely, 2002). Several sentence processing models have been proposed to explain this difference. These models can be divided into linear (e.g., Dependency Locality Theory; Gibson, 2000) or hierarchical intervention models (e.g., featural Relativized Minimality; Belletti & Rizzi, 2013). The debate about linear and hierarchical intervention models was mostly based on externally headed prenominal relatives in languages like Chinese. (1) and (2) schematically illustrate the structure of Chinese relatives (for concreteness, the relativizer *de* is taken to sit in C, and the head noun is taken to sit in a right-branching Spec, CP, but the debate on hierarchical or liner intervention does not hinge on these details). Linear intervention models predict an object advantage since the head noun 'dog' is closer to its gap than to the subject position in terms of intervening words in (2). Conversely, hierarchical intervention models predict a subject advantage since the noun 'dog' is closer to its gap than to the object position in terms of intervening branching nodes in (1).

(1) $[_{NP} [_{CP} [_{IP} e_1 \text{ chase cat}] \text{ } de] \text{ dog}_1]$
        'the dog that is chasing the cat '
(2) $[_{NP} [_{CP} [_{IP} \text{cat chase } e_1] \text{ } de] \text{ dog}_1]$
        'the dog that the cat is chasing'

As the literature is not consensual (cf. Gibson and Wu 2013 and Vasishth et al. 2013 for two opposing views), in the present work, we investigate another configuration that allows teasing apart the two processing models: double-center embedding in Italian.

Methods: 57 healthy, right-handed native Italian speakers (24 males, mean age = 23.5, SD = 2.2) participated in the study. Participants performed an auditory comprehension task. The experimental material consisted of two types of target sentences (N=96): subject double-center embedded relatives (the Italian counterpart of 3) and object double-center embedded relatives (the Italian counterpart of 4). Participants also listened to control sentences containing coordinate clauses (cf. 5).

(3)   The boy$_1$ [that e_1 calls the dogs$_2$ [that e_2 chase the cat]] eats an ice cream.
(4)   The boy$_1$ [that the women$_2$ [that the dog watches e_2] scold e_1] eats an ice cream.
(5)   The mechanic is riding while the policewomen whisper and the newsagent plays.

For each sentence comprehension questions were created concerning the first, second or third verb. For example, the three questions associated with (4) were (i) "who is watched?", (ii) "who is scolded?" and (iii) "who eats an ice cream?". After listening to each sentence, participants had to answer one comprehension question. The presentation order of the comprehension questions was counterbalanced across participants.

Results: Accuracy and response times were analyzed using generalized and linear mixed models. We observed that questions concerning the matrix predicate of both subject and object double-center embedding structures (for example, "who eats an ice cream?") were significantly easier and were associated with faster response times than questions concerning the embedded verbs. This is clear evidence for hierarchical intervention models against linear intervention models: although linearly the main subject 'the boy' and predicate 'eats an ice cream' are very distant, hierarchically, there is zero distance between them (they are sister nodes in the

underlying tree). Furthermore, in object double-center embedding relatives like (4), the questions concerning the verb of the most embedded clause (cf. "who is watched?" "the women") were easier than the ones concerning the verb of the intermediate embedded clause (cf. "who is scolded?" "the boy"). This is expected under featural Relativized Minimality, which postulates that the main source of difficulty in long-distance dependencies is the number of intervening elements with morphosyntactic features shared with the head of the chain. Indeed, in (4), the chain between 'boy$_1$' and its trace e_1 requires the processing of a dependency in which there are more intervening elements compared to the chain between 'women$_2$' and its trace e_2.

However, in control sentences, we observed that questions concerning the last verb (for sentence 5, this would be the question "who plays"?) had higher accuracy and faster response times than questions concerning the first and the second verb of the sentence. This can likely be explained as a recency effect.

Conclusions: Our data suggest that the sentence's underlying structure, typically represented by a syntactic tree, is consulted in sentence processing. We provide clear evidence that structural factors (particularly hierarchical intervention) play a crucial role, at least when the sentences have a sufficient degree of complexity (for example, when they contain long-distance dependencies). In this case, the main source of difficulty in sentence processing seems to be the intervention of elements with morphosyntactic features such as lexical restriction. However, linear factors could play a role in other cases, for example, coordination of full clauses with the most recent clause being better recovered than the least recent clauses.

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