Eliciting the production of doubly center-embedded object relative clauses in French:
The influence of lexical type and working memory capacity.

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According to the Syntactic Prediction Locality Theory (SPLT, Gibson, 1998), the processing difficulty of doubly center-embedded object relatives (DCEOR) like (1) reflects the maximal memory cost during parsing the sentence. This maximal cost is at the most embedded subject (the clinic) because at this point, the two syntactic predictions with a high cost concerning the second verb (VP2) (admitted) must be maintained. This high cost should result in the omission of predictions relative to the occurrence of the VP2. Consistent with this analysis, Gimenes et al. (2009) showed that eliminating VP2 reduced the complexity rating of (1). The SPLT also predicts that the memory cost of a prediction is reduced when it must be maintained across an indexical pronoun (e.g., "I") relative to full NP (e.g., "the clinic") (Warren and Gibson, 2002). An aspect of DCEOR processing that is not clear is whether DSEOR can be produced by adults (De Vries et al., 2008). Corpus studies showed very few sentences with such structure (Karlsson, 2007). SPLT suggests that adults could more often produce DCEOR if the most embedded subject is a pronoun than if it is a full NP. It also predicts that participants with a working memory (WM) capacity should be correlated with the number of verbs successfully processed in DCEOR structures.

(1) The patient who the nurse who the clinic had hired admitted met Jack
(2) The patient who the nurse who (the clinic) / (I) …
(3) Le malade que l'infirmière que (la clinique) / (je) …

Method:

We used continuation task to assess syntactic performance on DCEOR. The 48 French participants were presented a fragment to continue in a paper and pencil task. Each fragment contained 3 NPs starting a complex sentence, like in (3) which is the French translation of (2). We counted the number of verbs in the continuation. The occurrence of three verbs would indicate a complete syntactic parse, whereas only 2 verbs are consistent with a parsing failure. Two WM tests were used: the Reading Span (RS) test and a visuo-spatial WM test. Twenty-four sentences with three NPs, like (2) were used. They were mixed with 24 fillers. Each participant had to continue a group a 12 experimental fragments with a final "I" and 12 experimental fragments with a final NP.

Results:

There were 11.5% of 3 VPs continuations in the NP condition, and 20.5% in the pronoun condition (Khi2 = 17.5, p<.001), confirming the first prediction. A regression analysis using participants as a random variable showed that the Reading Span score was significantly correlated with the number of produced verbs (r(46)=0.528, p<.0001). A regression analysis showed that the RS test was a better predictor than the Visuo-Spatial test. The Table 1 reports other specific results, contrasting participants according to median RS.
Table 1: Mean number of continuations (/12) with 3 verbs and 2 verbs produced by participants with low WM span (N=24) and high WM span (N=24) according to the lexical type of the last NP in the fragment (Full NP vs. Pronoun)

<table>
<thead>
<tr>
<th></th>
<th>Indexical Pronoun</th>
<th>Full NP</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>3 verbs</td>
<td>2 verbs</td>
</tr>
<tr>
<td>Low WM</td>
<td>1.1</td>
<td>9.1</td>
</tr>
<tr>
<td>High WM</td>
<td>3.8</td>
<td>7.7</td>
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</tbody>
</table>

Discussion:
This experiment confirmed that adults can produce the 3 VPs sequence required by a DCEOR sentence. Consistent with SPLT, the results showed that two conditions facilitate such production: a high verbal WM capacity, and a pronoun in the most embedded OR clause. Christiansen and Chater (1999) showed that a simple recurrent network has difficulties to process DCEOR, although it has no specific WM device to support computation. We currently examine whether a specific training of such network could simulate our results.

References: