Theoretical questions

Looking for a grammatical theory that is explanatory adequate
- It should capture any known grammatical constraint in a graded way (off-line grammaticality judgments)
- It should predict processing effects (on-line phenomena)

Focus on non-local dependencies (A' dependencies)
- How non-local dependencies are computed on-line?
- Which features shall we consider?
- how/when they enter the computation?

Kinds of non-local dependencies
Long distance Wh- dependencies

What do you think that Mary will buy?
Kinds of non-local dependencies
Object Clefts

- In Object Clefts (OCs), the copula selects a truncated CP (Belletti 2008):
  - It is \[ \text{[FocP on ice cream that [TP Mary will buy ...]} \]
  - \[ \text{BE [CP Force [FocP ... [FocP that [TP Subject ... Object]]]} \]

Kinds of non-local dependencies
Object Relatives

- In Object Relatives (ORs), the NP is restricted by a RC (see Bianchi 2001 for the peculiarities of raising vs matching analysis):
  - the ice cream \[ \text{[CP that [TP Mary will buy ...]} \]
    \[ \text{NP e, that ... [TP Subject ... Object]} \]
    \[ \text{D [CP NP, that ... [TP Subject ... Object]} \]

Measuring complexity
ORs processing evidence

- Gordon et al. (2001)
  - working memory request is evaluated by studying reading time (RT) and comprehension accuracy in self-paced reading experiments comparing critical regions of various kinds of Relative Clauses:

- **Experiment 1** (materials): SRs (a) and ORs (b)
  - a. **The banker** [that \_ praised the barber] climbed the mountain
  - b. **The banker** [that the barber praised \_] climbed the mountain
Measuring complexity
ORs processing evidence

Gordon et al. (2001) - Experiment 2

- Experiment 2 (materials): DP (a) vs. Pro (b)
  a. The banker [that the barber praised] climbed the mountain
  b. The banker [that you praised] climbed the mountain

Gordon et al. (2001) - Experiment 3 (materials):

- DP (a) vs. proper nouns (b)
  a. The banker [that the barber praised] climbed the mountain
  b. The banker [that Ben praised] climbed the mountain
Measuring complexity
OCs processing evidence

- Gordon et al. (2001) - Experiment 4 (materials):
  
  Subject vs. Object Clefts X DP vs. proper names

  a. It was the banker that the lawyer saw _ in the parking lot
  b. It was the banker that Bill saw _ in the parking lot
  c. It was John that the lawyer saw _ in the parking lot
  d. It was John that Bill saw _ in the parking lot

- Gordon et al. (2001) - Experiment 4 (results):

Measuring complexity
tentative accounts

- **Role-determinant** accounts (MacWhinney & Pleh 1988)
  - Double role for the RC head: subject in the matrix sentence, object in the RC.
  
    The banker [that the barber praised _] climbed the mountain (OR)

- **Memory-load** accounts (Ford 1983, MacWhinney 1987, Wanner & Maratos 1978 ...)
  - The RC head must be kept in memory longer in OR before being integrated:
    
    The banker [that praised the barber] climbed ...
    (SR)
    
    The banker [that the barber praised _] climbed ...
    (OR)

- **Linguistic Integration Cost** (Gibson 1998:12-13)
  - Processing difficulty is proportional to the distance expressed in terms of number of intervening discourse referents, following a "referentiality hierarchy":
    
    descriptions > (short) names > referential pronouns > indexical pronouns

- **Similarity based** accounts (Gordon et al. 2001)
  - Having two DPs of the same kind stored in memory makes the OR more complex than SR. This models memory interference during encoding, storage and retrieval (Crowder 1976)
Measuring complexity

tentative accounts

○ More on **Similarity based accounts** (Gordon et al. 2001)
  ● It might be able to explain why SR vs. OR asymmetry disappears with
    RC subject pro/proper names (those DPs are legal heads only for
    clefts)

○ **Intervention effects**
  ● Processing difficulty is proportional to the number and kind of
    relevant features shared between the moved item and any possible
    intervener:

\[
\begin{array}{c}
X \\
Z \\
Y
\end{array}
\]

Measuring complexity

intervention-based account

○ More on **Intervention effects** (Friedmann et al. 2009)
  ● **Identity** (bad for adults, bad for children)

\[
\begin{array}{c}
+A \\
+A
\end{array}
\]

● **Inclusion** (ok for adults, bad for children)

\[
\begin{array}{c}
+A +B \\
+A \hspace{1cm} (+A +B)
\end{array}
\]

● **Disjunction** (ok for adults, ok for children)

\[
\begin{array}{c}
+A \\
+B \hspace{1cm} (+A)
\end{array}
\]

Measuring complexity

Comparing features in OCs

○ Warren & Gibson (2005) - **Experiment** (materials):
  *definite descriptions vs. proper names vs. pronouns*
  a. It was the banker that the lawyer avoided at the party
  b. It was the banker that Dan avoided at the party
  c. It was the banker that we avoided at the party
  d. It was Patricia that the lawyer avoided at the party
  e. It was Patricia that Dan avoided at the party
  f. It was Patricia that we avoided at the party
  g. It was you that the lawyer avoided at the party
  h. It was you that Dan avoided at the party
  i. It was you that we avoided at the party

Measuring complexity

Comparing features in OCs

○ Warren & Gibson (2005) - **results** (Tessa Warren P.C.)
  \(D = \text{definite description} \quad (\text{e.g.} \, \text{the banker})\)
  \(N = \text{proper names} \quad (\text{e.g.} \, \text{Dan})\)
  \(P = \text{pronouns} \quad (\text{e.g.} \, \text{you})\)

<table>
<thead>
<tr>
<th>condition</th>
<th>D-D</th>
<th>D-N</th>
<th>D-P</th>
<th>N-D</th>
<th>N-N</th>
<th>N-P</th>
<th>P-D</th>
<th>P-N</th>
<th>P-P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Read. time (SE) ms</td>
<td>365 (19)</td>
<td>319 (12)</td>
<td>306 (14)</td>
<td>348 (18)</td>
<td>347 (21)</td>
<td>291 (14)</td>
<td>348 (18)</td>
<td>311 (15)</td>
<td>291 (13)</td>
</tr>
</tbody>
</table>
Assuming that Definite Description = (+NP, N), Proper Names = (+NP, N\textsubscript{proper}), pro = \emptyset (Belletti & Rizzi 2013), Intervention effects are predicted to be stronger in matching D-D and N-N condition (against memory-load accounts), while P-P is expected not to be critical (because of the +NP absence):

<table>
<thead>
<tr>
<th>condition</th>
<th>D-D</th>
<th>D-N</th>
<th>D-P</th>
<th>N-D</th>
<th>N-N</th>
<th>N-P</th>
<th>P-D</th>
<th>P-N</th>
<th>P-P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Read. time (54) ms</td>
<td>365 (19)</td>
<td>319 (12)</td>
<td>306 (14)</td>
<td>348 (18)</td>
<td>347 (21)</td>
<td>291 (14)</td>
<td>348 (18)</td>
<td>311 (15)</td>
<td>291 (13)</td>
</tr>
<tr>
<td>prediction</td>
<td>hard</td>
<td>?</td>
<td>easy</td>
<td>?</td>
<td>hard</td>
<td>easy</td>
<td>easy</td>
<td>easy</td>
<td>easy</td>
</tr>
</tbody>
</table>

Features triggering movement are those relevant for intervention (Friedmann et al. 2009:82), but:
- “+R” feature causing Object movement in ORs (or “+Foc” in OCs) is not present on Subject;
- Neither the “lexical restriction” nor phi-features trigger any movement in ORs or OCs;
- The “lexical restriction” should be not accessible at the edge of the DP, where features triggering movement should be located (but see Belletti & Rizzi 2013, next slide);
- Why slow-down is observed at verb segment?

An “integration cost” (cf. Gibson 1998) is not enough
- È il bambino che il signore ha salutato …
- È Luigi che Gianni ha salutato …

Intervention-based accounts are not “gradable” (no quantitative, precise measurements)

Bottom-Up standard theories do not make any clear predictions on processing: they predict what creates complexity, but not when, why and how exactly in parsing and generation?

Belletti & Rizzi 2013:
- Evidence that lexically restricted wh-items occupy different positions in the left periphery (Munaro 1999):
  a. Con che tosat à-tu parlà?
     with which boy did you speak?
  b. Avé-o parlà de chi?
     Have you spoken of whom?

Evidence that lexically restricted wh-items occupy different positions in the left periphery (Munaro 1999):
A processing friendly proposal
Phase-based Minimalist Grammar (Chesi 2015)

- Common restriction on Merge:
  - Given two lexical items \([x, X]\) and \([y, Z]\) such that
    \(X\) selects \(Z\), then:
    - \([x, X]\) is processed before \(Y\)
    - When \([x, X]\) is processed, an expectation for \([y, ...]\) is created

- If we assume that selection can include both functional features \((+F)\) and lexical features \((Y)\) at the same time, a Phase becomes a subtree to be expanded:
  - Given a lexical item \([x, X]\), \([y, ...]\) is the selected phase:
    \[=+[F Y] X\]
    \[=+[F Y] [y, ...]\]
    \[+[F ...] [y, ...]\]
  - \([+F Y ...]\) is an extended projection of a lexical category \(Y\)
    (e.g., a DP is an extended projection of \(N\), i.e. \([+D N]\))
A processing friendly proposal
Phase-based Minimalist Grammar (Chesi 2015)

- Common trigger for Move:
  - An item \( [y, x] \), in a given structure, must be moved if it cannot not be fully interpreted in its insertion position:

  ![Diagram](image)

  - Discourse related position
  - Thematic position

- The derivation unfolds Top-Down and Left-Right
- Unexpected features trigger movement
- Phases restrict the domain in which a non-local dependency must be satisfied
- Last-In-First-Out memory buffer, as a first approximation, is used to store and retrieve items for non-local dependencies (memory buffer must be empty at the end of the derivation)

---

A processing friendly proposal
Phase-based Minimalist Grammar (Chesi 2015)

- \( [\text{wh}, +D N \text{what}], [\text{v}, +T \text{did}], [\text{s}, +S \text{John}], [\text{dp}, +DP \text{buy}] \)

  ![Diagram](image)

  - Memory buffer

---

A processing friendly proposal
Deriving OCs (Top-Down) using PMGs

- In Object Clefts (OCs), the copula selects a truncated CP (Belletti 2008):

  \[
  \ldots \text{BE}\{\text{CP Force} \ldots \text{finp} \{\text{TP Subject} \ldots \text{Object} \} \}\]

- Reduced CP \( \text{CP}_1 \) = \( [+\text{Foc} +\text{Fin} +S +T V] \)
A processing friendly proposal
Deriving OCs (Top-Down) using PMGs

- It \[ \ldots \text{CP} \ldots \text{was} \] \[ \text{CP} \text{John that Bill saw} \]

\[
P(I_i|Q_{1}, \ldots, Q_{n}) = \frac{\prod_{k=1}^{n} s(Q_{1},I_{i})^{w_{j}}}{\sum_{k=1}^{n} \prod_{j=1}^{w_{j}} s(Q_{1},I_{j})^{w_{j}}}
\]

A processing friendly proposal
On complexity: cue-based retrieval and intervention

- \textit{interference} is the major constraint on accessing information in memory (Anderson & Neely 1996; Crowder 1976; see Nairne 2002 for a review).
- The locus of the interference effect is at retrieval, with little or no effect on memory encoding or storage (Dillon & Bittner 1975; Gardiner et al. 1972; Tehan & Humphreys 1996)
- \textit{Content-addressable memory} (e.g. memory load paradigm, Van Dyke & McElree 2006), no exhaustive search, no delay
- \textit{Search of Associative Memory (SAM) model} (Gillund & Shiffrin 1984)

A processing friendly proposal
On DP features (and structure)

- Both \textit{proper} and \textit{common nouns} have a category \( N \)
- \textit{N in situ} (common nouns) \( \sim \text{N-to-D raising} \)
  
  \begin{align*}
  \text{Il mio Gianni} & (\text{Il mio amico}) \quad \text{*mio Gianni} \\
  \text{the my G.} & \quad \text{my G.} \\
  \text{La sola Maria} & (\text{la sola amica}) \quad \text{Maria sola (*l’amica sola)} \\
  \text{the only M.} & \quad \text{M. only} 
  \end{align*}

- But two different kinds of \( N \): \( N_{\text{proper}}, N_{\text{common}} \)

A processing friendly proposal
On DP features (and structure)

- Longobardi (1994-2005), a (rough) summary:
  - \textit{Definite Descriptions} \( \left[ \text{the } [\text{a man}] \right] \)
  - \textit{Proper Nouns} \( \left[ \text{John, } [\text{a t.}] \right] \)
  - \textit{Pronouns} \( \left[ \text{you } [\text{a } \ominus ] \right] \)

- Elbourne (2005)
  \( [[\text{THE } \text{NP}]] \)
A processing friendly proposal
On DP features (and structure)

- Both determiners and personal pronouns introduce a “referential pointer” to an individual constant or variable in the domain of discourse.

- Pro are NP-ellipsis licensors (they can be used as determiners «we Italians»): [D noi [N italiani]] (D introduces an index, that bounds a variable predicated in N).

- (More) features on pro:
  - 1st and 2nd person (highly accessible referents) vs. 3rd person (default person, context-determined referent)
  - case

Feature Retrieval Cost (FRC) metrics at work

- Cost function (at X given m, items to be retrieved from memory)

\[ C_{FRC}(x) = \prod_{i=1}^{m} \frac{(1+nF_i)^{m_i}}{(1+dF_i)} \]

- \( m \) = number of items stored in memory at retrieval
- \( nF \) = number of features characterizing the argument to be retrieved that are non-distinct in memory (i.e. also present in other objects in memory)
- \( dF \) = number of distinct cued features (e.g. agreement and case features probed by the verb)

- \( D-D \) matching

It was the lawyer\_{\text{i=0, num=inf, n}} who the businessman\_{\text{i=0, num=inf, n}} avoided...

\[ C_{FRC}(\text{avoided}) = 16 \]

That is 16 - 1:
- 16 for retrieving the businessman,
- \( nF=3, m=2 \) (because two Ds are in memory at that retrieval time), and \( dF=0 \) (because no feature is cued by the verb distinguishing one D from the other);
- 1 for retrieving the lawyer, since \( nF=0, m=1 \) and \( dF=0 \)
Feature Retrieval Cost (FRC) metrics at work

\[ C_{FRC}(x) = \prod_{i=1}^{m_x} \frac{(1+nF_i)^{m_i}}{(1+dF_i)} \]

\begin{itemize}
    \item \textbf{N-N matching}
    \begin{itemize}
        \item it was Dan{[+D, +num_sing, +N_prop]} who Patricia{[+D, +num_sing, +N_prop]} avoided...
        \end{itemize}
    \end{itemize}

\[ C_{FRC}(\text{avoided}) = 16 \]

that is \(16 \cdot 1\):
16 for retrieving Dan,
\(nF=3\), \(m=2\) (because two Ds are in memory at that retrieval time), a
nd \(dF=0\) (because no feature is cued by the verb distinguishing one D
from the other);
1 for retrieving Patricia,
since \(nF=0\), \(m=1\) and \(dF=0\)

C. ChesiReal - time processing of complex sentences

\begin{itemize}
    \item \textbf{D-N matching}
    \begin{itemize}
        \item it was the lawyer{[+D, +num_sing, +N]} who Patricia{[+D, +num_sing, +N_prop]} avoided...
        \end{itemize}
    \end{itemize}

\[ C_{FRC}(\text{avoided}) = 12.25 \]

that is \(12.25 \cdot 1\):
12.25 for Patricia,
\(nF=2.5\), \(m=2\), \(dF=0\) \((N_{\text{max}} \text{ vs. } N \text{ counts as half because of movement})\)

C. ChesiReal - time processing of complex sentences

\begin{itemize}
    \item \textbf{P-P matching}
    \begin{itemize}
        \item it was you{[+D, +num_sing, +N_prop]} who we{[+D, +pers_I, +num_plur, +case_nom]} avoided...
        \end{itemize}
    \end{itemize}

\[ C_{FRC}(\text{avoided}) = 9 \]

that is \(9 \cdot 1\):
9 for the the businessman,
\(nF=2\), \(m=2\), \(dF=0\)

C. ChesiReal - time processing of complex sentences
Feature Retrieval Cost (FRC) metrics at work

\[ C_{\text{FRC}}(x) = \prod_{i=1}^{m_x} \left( \frac{(1 + nF_i)^{m_i}}{(1 + dF_i)} \right) \]

1. **D-P condition**

   it was the lawyer who we avoided...

   \[ C_{\text{FRC}}(\text{avoided}) = 4.5 \]

   that is 4.5 * 1:

   4.5 for the we,

   \( nF=2, m=2, df=1 \) (case is cued)

Some potential corrections:

- **The pro subject effect** (fastest verb reading in D-P, N-P, P-P conditions)

  pronominal subjects expressing 1st and 2nd person features create expectations that could facilitate verb processing (see antilocality effects, Jaeger et al. 2005):

- **The referentiality hierarchy** makes the correct prediction most of the time (N is more accessible than D, hence at the verb segment: N<D):

  \( rHi = 1 \) for D, 0.5 for N

\[ C_{\text{FRC}}(x) = \prod_{i=1}^{m_x} \left( \frac{(1 + nF_i + rHi)^{m_i}}{(1 + dF_i + rHi)} \right) \]

---

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<thead>
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<th>D-P</th>
<th>N-D</th>
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<td>311 (15)</td>
<td>291 (13)</td>
</tr>
<tr>
<td>prediction</td>
<td>16</td>
<td>12.25</td>
<td>4.5</td>
<td>12.25</td>
<td>16</td>
<td>4.5</td>
<td>9</td>
<td>9</td>
<td>1</td>
</tr>
</tbody>
</table>

---

Real-time processing of complex sentences

C. Chesi

New prediction:

\[ 30,38 \quad 20,54 \quad 7.50 \quad 19,20 \quad 21,17 \quad 3.60 \quad 12.25 \quad 10.24 \quad 1.00 \]

Old prediction:

\[ 16 \quad 12.25 \quad 4.5 \quad 12.25 \quad 16 \quad 4.5 \quad 9 \quad 9 \quad 2 \]

Real-time processing of complex sentences

C. Chesi
A processing friendly proposal
Testing the FRC with restricted pronouns

- **Idea** (Chesi, Canal, Belletti & Rizzi – in progress)
  pronouns can be used as determiners, but they have more features than articles: keeping number features constant and the lexical restriction present, we can test the impact of person (2nd vs 3rd) features on encoding and retrieval.

- **Materials**: 32 items (8 per condition) + 112 fillers
  - Sono/siete gli/voi architetti che gli/voi ingegneri hanno/avete consultato _ prima di iniziare i lavori.
  - have_p've/consulted before beginning the work

**Subjects**
33 subjects (age range = 19-35; 15 male; center-north Italian native speakers)

**Methods**
- eye-tracking experiment (Eyelink 1000, desktop, dominant eye tracking)
- yes/no comprehension question (50% YES, 50% NO; 50% targeting the subject, 50% targeting the object; 50% with PP in question, 50% without)

**Materials**
- 32 items (8 per condition) + 112 fillers

**Regions**
<table>
<thead>
<tr>
<th>Sono</th>
<th>gli architetti</th>
<th>che</th>
<th>voi ingegneri</th>
<th>avete consultato</th>
<th>prima di iniziare</th>
</tr>
</thead>
<tbody>
<tr>
<td>BE</td>
<td>DP1</td>
<td>C</td>
<td>DP2</td>
<td>verb</td>
<td>spill</td>
</tr>
</tbody>
</table>

**Statistics**
- We use mixed-effects regression models (Baayen, Davidson & Bates, 2008; lme4 R package, Bates, 2011).
- Reading times data were analyzed by fitting general linear mixed models (lmer function, e.g., Baayen et al., 2008), whereas (categorical) regression data were analyzed by fitting mixed-effects logistic regressions (glmer, e.g., Jaeger, 2008).
- In all analyses we tried to identify the optimal random structure justified by the data, starting from the maximal model and pruning the factors which showed very little variance or high correlations in the random effects covariance matrix.
- Reading times were log-transformed to respect the normality assumption of mixed-effects regression models. The presence of significant interaction was attested comparing models likelihood with and without interaction terms.
A processing friendly proposal
Testing the FRC with restricted pronouns

- **Results:** accuracy in comprehension questions

<table>
<thead>
<tr>
<th>DP1</th>
<th>DP2</th>
<th>Accuracy %</th>
</tr>
</thead>
<tbody>
<tr>
<td>art</td>
<td>art</td>
<td>75%</td>
</tr>
<tr>
<td>art</td>
<td>pro</td>
<td>81%</td>
</tr>
<tr>
<td>pro</td>
<td>pro</td>
<td>70%</td>
</tr>
<tr>
<td>pro</td>
<td>art</td>
<td>74%</td>
</tr>
</tbody>
</table>

- art pro > art art ≥ pro art > pro pro

- **Comparing accuracy results with an Off-line grammaticality judgment test:**
  - **Subjects:** 48; age range: 20-64; 25 Females, 23 Males; center/north Italian native speakers
  - **Methods:** 7-point Likert scale grammaticality judgment (on-line data collection, using Osucre)
  - **Materials:** same items/filler of the eye-tracking experiment

**In sum**
- Accuracy in comprehension questions (eyetracking) art pro > art art ≥ pro art > pro pro
- Off-line grammaticality judgment test art pro > art art > pro art > pro pro
RESULTS

First Fixation (verb region):
- Main effect of DP2 (-0.095, t=-4.37) (art is read faster than pro)
- Main effect of WM (-0.39, t=-2.82) (high WM faster reading than low WM)
- Interaction between WM and DP2 (0.33, t=2.48) suggesting that the slowdown associated to DP2 pro is mainly driven by low WM participants.
- Even tough the interaction between DP1 and DP2 is not very robust (comparison between the relevant models has chisq=2.16, p=0.14): pro pro > art pro > art art > pro art

Gaze Duration (DP2 region):
- Gaze duration is marginally affected by type of DP2 (-0.066, t=-2.07).
- The effect of WM is also significant (faster gaze for high WM: -1.10 t=4.35).
- No further interactions resulted significant.

Second Pass (verb region):
- Main effect of DP1 (art speeds up re-reading verb compared to pro);
- DP2 X WM interaction and a three ways interaction suggesting a strong effect of WM only when DP1 is pro and DP2 is art: in pro art, low WM participants spend more time re-reading verb.
A processing friendly proposal
Testing the FRC with restricted pronouns

- RESULTS

- Total Time Duration:
  - main effects are not significant.
  - some hints of an interaction (chisq=2.32, p=0.12) emerged when the DP2 is art, no differences emerge as function of DP1, whereas when DP2 is pro a slow down is associated when also DP1 is pro.

- RESULTS

- In sum
  - On-line
    - First fixation on verb segment
      - art < pro (DP2 main effect)
      - pro art < art art < art pro < pro pro (non significant DP1:DP2 interaction)
    - Second Pass on verb segment
      - DP1 x DP2 x WM DP1 is pro and DP2 is art: in pro art, low WM
      - art pro = art art < pro art = pro pro
  - Off-line
    - Accuracy in comprehension questions
      - art pro > art art > pro art > pro pro
    - Grammaticality judgment test
      - art pro > art art > pro art > pro pro

C. Chesi
Real-time processing of complex sentences
A processing friendly proposal
Testing the FRC with restricted pronouns

RESULTS
- Regressions from DP2: no main effects, no interactions.
- Regressions from VERB: Main effect of WM: higher WM -> larger number of Regressions. no interactions.
- Regressions in DP1: Main effect of WM: higher WM -> larger number of Regressions. no interactions.
- Regressions in DP2: Main effect of WM: higher WM -> larger number of Regressions. no interactions.

Feature Retrieval Cost (FRC) metrics at work

$$C_{\text{FRC}}(x) = \prod_{i=1}^{m_x} \frac{(1+nF_i)^{m_i}}{(1+dF_i)}$$

- art-art matching
gli architetti_{(0, +num_pl, N)} e gli ingegneri_{(0, +num_pl, N)} hanno evitato

$$C_{\text{FRC}}(\text{avoided}) = 16$$
that is $16 \cdot 1$:
16 for retrieving gli ingegneri,
nF=3, m=2, and dF=0;
1 for retrieving gli architetti,
since nF=3, m=1 and dF=0

- pro-pro matching
voi architetti_{(0, +2P, +num_pl, N)} e voi ingegneri_{(0, +2P, +num_pl, N)} avete evitato

$$C_{\text{FRC}}(\text{avoided}) = 25$$
that is $25 \cdot 1$:
36 for retrieving gli ingegneri,
nF=3, m=2, and dF=0;
1 for retrieving gli architetti,
since nF=0, m=1 and dF=0

- art-pro matching
gli architetti_{(0, +num_pl, N)} e gli ingegneri_{(0, +2P, +num_pl, N)} hanno evitato

$$C_{\text{FRC}}(\text{avoided}) = 8$$
that is $8 \cdot 1$:
8 for retrieving gli ingegneri,
nF=3, m=2, and dF=1 (because +2P is cued by the verb);
4 for retrieving gli architetti,
since nF=0, m=1 and dF=0
Feature Retrieval Cost (FRC) metrics at work

\[ C_{\text{FRC}}(x) = \prod_{i=1}^{m_x} \left(1 + nF_i \right)^{m_i} \left(1 + dF_i \right) \]

- **pro - art** mismatch
  - voic (e.g. +D, +3P, +num_pl, N)
  - gli ingegneri (e.g. +D, +num_pl, N)

\[ C_{\text{FRC}}(\text{avoided}) = 16 \]

that is 16 \cdot 1:
- 16 for retrieving gli ingegneri, since \( nF=3, m=2, \) and \( dF=0 \) (because +3P is cued by the verb);
- 1 for retrieving gli architetti, since \( nF=0, m=1, \) and \( dF=0 \)

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Conclusion

- We rephrased the intervention-based idea (Friedmann et al. 2009) in Top-Down terms, trying to reconcile the formal account of intervention (what) with processing evidence (when and how)
- What permits to express the exact complexity cost is a Top-down (that in the end produce a left-right) derivation (this way the model fitting can be directly compared with other complexity metrics, e.g. SPLT, Gibson 1998)
- The special role of intervention has been expressed in terms of interference at retrieval (e.g. Van Dyke & McElree 2006)

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Further development

- Feature structures (and actual cues) need to be further refined (other features, e.g. animacy, Kidd et al. 2007, and semantic selection, Gordon et al. 2004, should be considered)
- The counterintuitive idea that Subject “is harder” to retrieve than Object in ORs should receive experimental support
- Is it a purely privative system (+/- F) enough?
- Doing away with UFO structure which is computationally OK, but psycholinguistically odd (cf. content-addressable memory).
Thank you!

Selected References