

The claims that linguists made

Testing the predictions of two theories on noun complementation

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THE RELABELING ANALYSIS

(1) **Labels.** When two objects α and β are merged, a subset of the features of either α or β become the label of the syntactic object $\{\alpha, \beta\}$. A label:

(i) can trigger further computation

(ii) is visible from outside the syntactic object $\{\alpha, \beta\}$.

(2) **Probing Algorithm:** The label of a syntactic object $\{\alpha, \beta\}$ is the feature(s) which act(s) as the Probe of the merging operation creating $\{\alpha, \beta\}$.

Words are special (they can always provide the label)

In our previous work (Cecchetto and Donati 2010) we proposed a mechanism of labeling (that we called Probing Algorithm) that captures the fact that words are special, because they can always provide the label when they are merged with another category.

This happens both in case of First Merge where we have a canonical Head-Complement configuration (cf. 3).

(3) John [_{VP} saw the teacher]

and in case of Internal Merge (movement). The latter configuration is illustrated by **free relatives**.

- (4) a. I wonder what you read
 b. I read what you read

In (4), a WH-lexical item, ‘what’, is internally merged to a Probing C. If the LI provides the label, the structure ends up being a DP, i.e. a free relative; if the probing C provides the label, the structure is a (interrogative) clause: as a result, the structure is systematically ambiguous.

Labeling conflicts: free relatives.

No ambiguity arises when a phrase is WH-moved: ‘what book’ in (5), not being a word, does not have a (re)labeling power. The target C is bound to project. (5) can only be an (indirect) interrogative clause.

- (5) What book you read
 - a. I wonder what book you read
 - b. *I read what book you read.

A relabeling analysis for full relative clauses

As we argued in Donati and Cecchetto (2011), full relatives can be fruitfully analyzed as involving movement of a lexical item, as in (6).

(6) I like the [_N book [_C which ~~book~~ [_T John read ~~which book~~]]]

In (6) the movement of a word, ‘book’, correlates with target relabeling: what moves is a N and the structure gets a N label. This label matches the selection requirements of the externally merged D.

A relabeling raising analysis for full relative clauses

This relabeling analysis in (6) inherits all the pros of the traditional raising analysis, as the external head noun and the gap are transformationally related. *Furthermore, it has the merit of explaining for free the fundamental properties of relative clauses, namely that they are clauses with a nominal distribution.*

(7) I like the [_N book [_C which ~~book~~ [_T John read ~~which book~~]]]

When the head is not a head

The relabeling analysis of relative clauses seems to face a problem when the external head of the relative clause is a phrase, as in (8).

(8) I like the book about Obama that John read

When the head is not a head

(8) I like the book about Obama that John read

We assume that the material that modifies the head noun (“about Obama” in 8) can (and must be) late-merged, after the head noun has moved and has “re-labeled” the structure. This assumption makes so-called complements of nouns and adjuncts to the nouns more similar than it is usually thought.

However, there is independent evidence that nouns do not take complements the same way verbs do.

Nouns do not Take Complements: Theta criterion exemption

Even so-called complements of nouns are never required for the structure to be acceptable, unlike the complements of transitive verbs. This is usually expressed by exempting the nouns from the theta criterion, but this is a tacit way to ‘adjunctivize’ the so-called complement of the noun.

Nouns do not Take Complements: Constituency Tests

Standard constituency tests indicate that while verb + internal argument is a minimal constituent, noun + alleged complement is not: a pronoun can replace determiner + noun without replacing the alleged complement of the noun (cf. 9);

(9) *a.* J'ai vu [le père de Jean]

I have seen the father of Jean

b. J'ai vu celui de Jean

I have seen that of Jean

- (9) *a.* J'ai vu [le père de Jean]
I have seen the father of Jean
- b.* J'ai vu celui de Jean
I have seen that of Jean

Note that the same is impossible with the complement of the verb.

Nouns do not Take Complements: Islandhood

In the verbal domain, there is an argument-adjunct asymmetry in that only adjunct clauses are islands for extraction, while extraction from argument clauses is much easier.

In the nominal domain there is no argument/adjunct asymmetry, since both relative clauses (RELATIVES) and complement clauses of the noun (CLAUSAL COMPLEMENTS OF NOUNS) are islands. This common pattern is captured by assuming the Complex NP Constraint.

Relative Clauses as complements

In Donati and Cecchetto's (2011) account, the fact that the head provides the label when it is internally merged with the relative clause makes relativization very similar to the configuration where a head provides a label when it is externally merged with its complement. In a nutshell, this account makes relativization look like complementation but for the fact that the head is internally and not externally merged.

Complements of nouns are adjuncts

Second, we have just argued that “complements” of the noun (including CLAUSAL COMPLEMENTS OF NOUNS:CC) have adjunct-like properties, despite their name.

The relabeling analysis reverses the picture with respect to standard analyses of Complex NP's: we see complementation in RCs, where canonical approaches see adjunction (RCs); while we see adjunction where more canonical approaches see complementation (CCs).

A TEMPORARY STRUCTURAL AMBIGUITY

A temporary structural ambiguity

Relative clauses (RCs) and clausal complements of nouns (CCs) can give rise to temporary structural ambiguity. How would you complete a sentence beginning with

(10) the claim that John made..... ?

Two possible types of completion:

(11) the claim that John made (is false)
RC (RC)

(12) the claim that John made (a mistake)
CLAUSAL COMPLEMENT (CC)

When there is a temporary structural ambiguity, the parser does not wait until the end of the sentence before analysing it, but bets on one analysis, as garden path effects teach us.

(13) The horse raced past the barn fell

When people reach the word 'fell' in (13), they become puzzled, as clearly shown by various behavioral measures (i.e. longer reading times). This happens because the verb 'raced' is initially interpreted as a main verb but it should have been interpreted as past participle ('The horse which was raced past the barn fell').

Whether a speaker goes for the RC interpretation or for the CC interpretation can tell us something about their status in the grammar. In other words, we can test the direction of this unnoticed garden path to test two competing analyses of Complex NPs just described (the relabelling one and the traditional one).

(11) the claim that John made (is false)
RC (RC)

(12) the claim that John made (a mistake)
CLAUSAL COMPLEMENT (CC)

Garden Path Model *(cf. Frazier 1979)*

The structure associated with the preferred (but ultimately wrong) interpretation of (13) is initially chosen because the parser is guided by formal principles like Minimal Attachment:

Minimal Attachment

“Choose a parse using the fewest nodes consistent with the rules of the language!”

Very different predictions

Assume that head-complement configurations are more transparent to the parser than adjunct-like configurations.

1. Standard view. CC should be preferred over RC
2. Relabeling analysis. RC should be preferred over CC.

TWO EXPERIMENTS

We tested the direction of the garden path effect (if any) in two eye-tracking experiments (29 participants each)

EXPERIMENT 1

EXPERIMENT 1

Object RCs as Opposed to CCs

A temporary ambiguity can arise between an object RC and a CC. We built minimal pairs like (14a) vs. (14b).

(14a)

1

2

3

4

5

Il progetto che il sindacato **sosteneva fra** gli operai irritò la Confindustria
the plan that the Unions supported among the workers annoyed the tycoons
“The plan that the Trade Unions supported among workers annoyed the tycoons”

(14b)

1

2

3

4

5

Il progetto che il sindacato **sostenesse** gli operai irritò la Confindustria
the plan that the Unions supported-SUB the workers annoyed the tycoons
“The plan that the Trade Unions would support the workers annoyed the tycoons”

The two structures differ only in critical area 3.

Some Details About Experiment 1

Subjects:

33 Italian participants read 24 object *that*-RCs (cf. 14a) and the corresponding structures in which the same noun took a CC (cf. 14b). We monitored eye movements of the 33 subjects involved. 4 subjects were excluded from the analysis due to lack of or poor eye-tracking data (e.g., poor calibration or lack of accurate eye-tracking).

Some Details About Experiment 1

Independent variable: We manipulated within items and within subjects whether the sentence was an object RC or a CC.

Dependent variables: reading times (Total Reading Time, First Pass, Selective Regression Path Duration, Second Pass), regressions (Regression in, Regression out, Regression out full, Regression out full count) and Skip.

Some Details About Experiment 1

To make sure that participants read and understood sentences we included 6 comprehension questions involving a *yes-no* response. Each question appeared immediately after the experimental sentence. All participants responded correctly to at least 75% of responses.

Materials also included a total of 48 filler sentences that involved a *wh*-question. We added 12 comprehension questions related to the fillers.

In all the models, the length (in characters) of the areas was included as a covariate.

Some Details About Experiment 1

We used the 7 nouns listed in (15) which can be naturally modified by a RC or by a CC. For each noun (but for 'order', which was used 6 times), the experimental set included 3 RC and 3 CC structures.

(15)	<i>Ordine</i>	'order'
	<i>Paura</i>	'fear'
	<i>Progetto</i>	'plan'
	<i>Comando</i>	'command'
	<i>Dubbio</i>	'doubt'
	<i>Insinuazione</i>	'implication'
	<i>Desiderio</i>	'desire'

Some Details About Experiment 1

We submitted reading times measures and regression measures of critical area 3 (and in areas 2 and 4), to a series of mixed effects models using the lme4 package (Bates, 2007) in R (www.r-project.org).

Regression measures are categorical, and were therefore submitted to a logistic regression model with mixed effects. Continuous measures such as reading times raw data were first log-transformed, then submitted to a linear regression model with mixed effects.

RESULTS OF EXPERIMENT 1

Results of Experiment 1, Critical Area 3

At area 3, when we considered as dependent variables **reading time**, RCs and CCs did not differ.

However, CC caused significantly more **regressions out** of Area 3 than RCs. This was confirmed by the analysis of both Regressions Out and Regressions Out Full variables.

Comment on Results of Experiment 1 in Critical Area 3

We interpret this result as a first indication that, when the reader finds a temporarily ambiguous structure, (s)he goes for the RC interpretation. If the subject is reading (14b), at area 3 (s)he finds evidence that this was the bad analysis and the higher number of regressions indicates that reanalysis occurs.

(14b)

1	2	3	4	5
Il progetto che	il sindacato	sostenesse	gli operai	irritò la Confindustria
the plan that	the Unions	supported-SUB	the workers	annoyed the tycoons
“The plan that the Trade Unions would support the workers annoyed the tycoons”				

EXPERIMENT 2

EXPERIMENT 2

Subject RCs as Opposed to CCs

A temporary ambiguity arises also between a subject RC and a CC, and in Italian, which is a pro-drop language, it is possible to build minimal pairs like (16a) and (16b).

(16a)

1	2	3	4	5
Alla fine	l'ordine che	convinse	l'ufficiale	a dare l'allarme fu cruciale
At the end	the order that	led	the officer	to give the alarm was critical

“All in all, the order that led the officer to give the alarm was critical”

(16b)

1	2	3	4	5
Alla fine	l'ordine che	convincessero	l'ufficiale	a dare l'allarme fu cruciale
At the end	the order that	(they)-lead-SUBJ	the officer	to give the alarm was critical

“All in all, the order that they should convince the officer to give the alarm was critical”

The two structures differ only in critical area 3.

Some Details About Experiment 2

Subjects:

Same as in Experiment 1.

Independent variable: We manipulated within items and within subjects whether the sentence was a Subject RC or a CC.

Dependent variables:

Same as in Experiment 1.

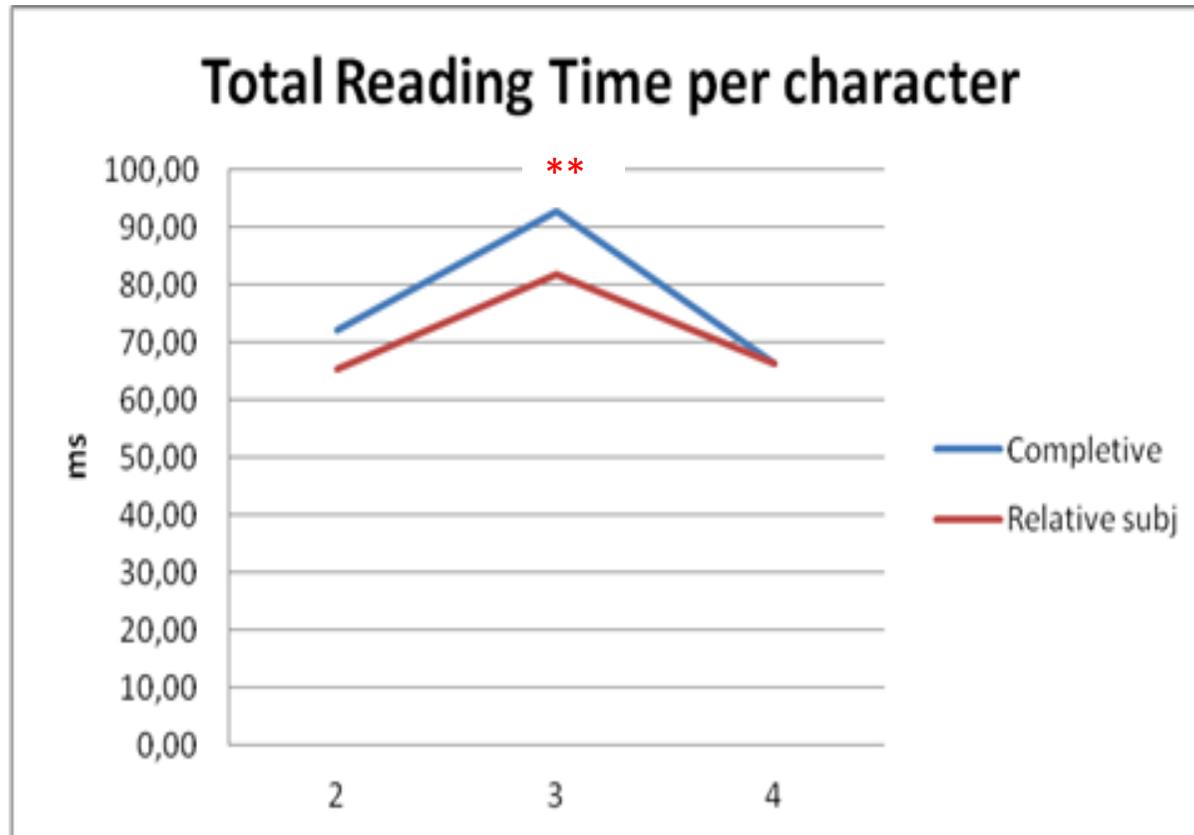
Some Details About Experiment 2

The procedure and other details described for Experiment 1 hold for Experiment 2 as well.

RESULTS OF EXPERIMENT 2

Results of Experiment 2, Critical Area 3

At critical area 3, Total Reading Time was significantly longer in CCs than in subject RCs.



Results of Experiment 2, Critical Area 3

Also another measure (First Pass) indicates longer reading time with CCs in Area 3.

First Pass is the summation of the duration across all fixations *of the first run* within the relevant area.

Results of Experiment 2, Critical Area 3

We interpret longer reading times in Area 3 as a result of the manipulation in this area. Namely, subjects have to do re-analysis when they realize that they are reading a CC.

(16a)

1	2	3	4	5
Alla fine	l'ordine che	convinse	l'ufficiale	a dare l'allarme fu cruciale
At the end	the order that	led	the officer	to give the alarm was critical

“All in all, the order that led the officer to give the alarm was critical”

(16b)

1	2	3	4	5
Alla fine	l'ordine che	convincessero	l'ufficiale	a dare l'allarme fu cruciale
At the end	the order that	(they)-lead-SUBJ	the officer	to give the alarm was critical

“All in all, the order that they should convince the officer to give the alarm was critical”

Results of Experiment 2, Area 4

The First Pass measure indicates longer reading time with CCs in Area 4. We interpret this as a spill-over effect deriving from the manipulation in Area 3.

Results of Experiment 2, Area 2

Another significant difference was detected in Area 2 by looking at the “Regression In” variable (“Regression In” indicates the probability for the relevant area to receive at least one regression from later parts of the sentence).

In Area 2, CCs were more likely to receive regressions than RCs.

This is consistent with our interpretation. If CCs force a reanalysis, subjects reading Critical Area 3 and following areas are more likely to go back to Area 2.

(16a)

1	2	3	4	5
Alla fine	l'ordine che	convinse	l'ufficiale	a dare l'allarme fu cruciale
At the end	the order that	led	the officer	to give the alarm was critical

“All in all, the order that led the officer to give the alarm was critical”

(16b)

1	2	3	4	5
Alla fine	l'ordine che	convincessero	l'ufficiale	a dare l'allarme fu cruciale
At the end	the order that	(they)-lead-SUBJ	the officer	to give the alarm was critical

“All in all, the order that they should convince the officer to give the alarm was critical”

Results of Experiment 2, Area 2

Still another significant difference was detected in Area 2 by looking at the “Regression out full count” variable (“Regression out full count” indicates regression(s) from the relevant area to an earlier one, regardless whether later areas have been visited or not): CCs were more likely to elicit regressions than RCs in Area 2. Since the only area preceding Area 2 is Area 1, this means that subjects reading CCs were more likely to re-start reading the sentence from the very beginning.

This is consistent with the hypothesis that CCs force a reanalysis.

Summary of the Results of Experiment 2

Results of Experiment 2 indicate that subjects are led down the garden path in CCs, since they initially go for the RC clause interpretation.

The same conclusion emerged from Experiment 1.

So, a RC clause interpretation is initially chosen whenever a temporary ambiguity arises, both with subject and object RCs.

A different result?

In an unpublished manuscript, Pearlmutter & Mendelsohn (1999) ask whether the parser has a preference for CCs or object RCs

They interpret their results as showing a preference for CCs.

However, their experiment is a self-pace reading task, so they could not look at regressions.

Furthermore, their evidence is somewhat oblique, as they did not compare directly reading times in CCs and RCs.

We are currently replicating the experiments in English in Australia, Macquarie University.

Comments on the Results

These results go in the direction of the predictions of the Relabeling Analysis.

Comments on the Results

Assume that head-complement configurations are more transparent to the parser than adjunct-like configurations. If so, we predict that RCs are preferred to CCs: RCs are similar to the very basic head-complement configuration, but CCs are more similar to the less central adjunction configuration.

AN ALTERNATIVE EXPLANATION?

An alternative explanation Constrained-based (frequency bias) models

(Trueswell & Tanenhaus 1994, MacDonald, Pearlmutter, & Seidenberg, 1994 and Trueswell 1996 a.o.)

In frequency bias models the listener (or the reader) constructs multiple interpretations at the same time and rank them from the very beginning according to factors like plausibility with respect to the preceding context and lexical frequency. This way, the role of purely syntactic principles like Minimal Attachment, is much depotentiated.

(13) The horse raced past the barn fell

Under frequency bias models, the main reason why the sentence in (13) is so difficult to parse is that the form 'raced' occurs much more frequently as a main verb than as a past participle. So, although both the past tense and past participle forms are activated in parallel, the parser in which 'raced' is a main verb is ranked much higher.

An alternative explanation

Frequency bias models might provide an alternative explanation for these results. The story goes: RCs are more frequent, so they are preferred even if they are more difficult.

So the conclusion seems to be: frequency wins over syntactic complexity (under the standard view).....

But wait a minute!

Frequency of what?

Frequency bias for the 7 nouns we used

Frequency bias models are based on the assumption that frequency of lexical items counts. So, we looked at the frequency bias of the seven nouns used in our experiments. We calculated the frequency bias of the seven nouns in the following way.

Frequency bias for the 7 nouns we used

We made a Google search and we looked at the first 100 occurrences of the frame

“Det N that”

for each of the seven Ns used in experiments 1 and 2.

It was important to distinguish between type and token, since in many cases exactly the same phrase appeared more than one time among the first 100 results of the Google search.

Frequency bias for the 7 nouns we used

When types were considered, for each noun we looked at the frequency bias towards subject RC, object RC and CC.

Out of the total occurrences, 54% (SD = 22%) involved a Subject RC, 20 % (SD = 13%) an Object RC and 26% (SD = 31%) a CC.

Frequency bias for the 7 nouns we used

Frequency Biases

		SUBJECT RC	OBJECT RC	CC
<i>Ordine</i>	'order'	.55	.40	.05
<i>Paura</i>	'fear'	.61	.14	.25
<i>Progetto</i>	'plan'	.75	.24	.01
<i>Comando</i>	'command'	.65	.34	.01
<i>Dubbio</i>	'doubt'	.36	.04	.60
<i>Insinuazione</i>	'insinuation'	.11	.09	.80
<i>Desiderio</i>	'desire'	.73	.15	.12

Frequency bias for the 7 nouns we used

Two nouns (*dubbio* ‘doubt’, *insinuazione* ‘insinuation’) had a stronger frequency bias towards CC. The other nouns had a stronger frequency bias towards RC.

Does the frequency bias of the nouns predict our results?

We included as covariates in our analysis for each noun:

1. whether the noun showed a higher frequency bias towards a RC (subject or object) or a CC (e.g., categorical)
2. the estimated frequency bias (e.g., continuous) towards:
 - i) a subject RC;
 - ii) an object RC;
 - iii) a CC.

Results of the Experiments 1 and 2 when including frequency biases as covariates

Nothing changes.

Log-transformed Frequency Biases covariates (treated as continuous) did not contribute to the models' fit.

Continuation bias towards Object, Subject RCs and CCs

We further tested to what extent the 7 nouns elicited the production of a Subject RC, an Object RC or a CC.

In a continuation task, we asked 65 Italian native speakers to read a list of sentence onsets (involving the 7 nouns in the frame 'Det NP that') and write up a continuation.

There were significantly more continuations involving an object RC (Mean = 60%; SD = 18%) as compared to continuations involving a Subject RC (Mean = 17%; SD = 9%) and a CC (Mean = 23%; SD = 18%).

	<i>CC</i>	<i>Obj RC</i>	<i>Subj RC</i>
Order	.08	.69	.23
Desire	.30	.55	.16
Doubt	.30	.33	.37
Insinuation	.52	.43	.05
Order	.05	.78	.17
Fear	.50	.40	.10
Plan	.06	.83	.11

Results of the Experiments 1 and 2 when including Continuation Biases as covariates

In Experiment 1, continuation bias did not contribute to the models' fit.

In Experiment 2, area 3, the continuation bias towards CC significantly predicted First Pass data. The higher the continuation bias towards a CC, the shorter was the First Pass reading time.

Conclusion on the effect of the frequency bias of the single nouns

The preference for the RC parser over the CC parser cannot be explained as an effect of the frequency bias of the nouns!

Is subjunctive the culprit?

In our experimental setting, in CCs the verb was mostly in the subjunctive mood, while in RCs the verb was in the indicative mood. This could not be avoided because CCs in Italian require subjunctive in most cases, as confirmed by the production in the continuation tasks. This casts some doubt on the hypothesis that CCs are simple complements.

Still, a possibility is that CCs were dispreferred because the subjunctive is more complex to parse. We checked this explanation by looking at the frequency bias of the verb form.

Is subjunctive the culprit?

(14a)

1	2	3	4	5
Il progetto che	il sindacato	sosteneva fra	gli operai	irritò la Confindustria
the plan that	the Unions	supported among	the workers	annoyed the tycoons
“The plan that	the Trade Unions	supported among	workers	annoyed the tycoons”

(14b)

1	2	3	4	5
Il progetto che	il sindacato	sostenesse	gli operai	irritò la Confindustria
the plan that	the Unions	supported-SUB	the workers	annoyed the tycoons
“The plan that	the Trade Unions	would support	the workers	annoyed the tycoons”

Is subjunctive the culprit?

(16a)

1	2	3	4	5
Alla fine	l'ordine che	convinse	l'ufficiale	a dare l'allarme fu cruciale
At the end	the order that	led	the officer	to give the alarm was critical

“All in all, the order that led the officer to give the alarm was critical’

(16b)

1	2	3	4	5
Alla fine	l'ordine che	convincessero	l'ufficiale	a dare l'allarme fu cruciale
At the end	the order that	(they)-lead-SUBJ	the officer	to give the alarm was critical

“All in all, the order that they should convince the officer to give the alarm was critical’

Verb Form Frequency Bias

We normed whether the verbs used in our experimental sentences occurred more frequently in the indicative or in the subjunctive form.

We ran a Google search of all the verbs used in the experimental sets in both the indicative and the subjunctive verb forms and counted the Google hits.

Additionally, as our verbs occurred in a subordinate clause, we ran a further Google search involving the verb (in its indicative and subjunctive form) in the frame 'that-verb'.

Verb Form Frequency Bias

The log-transformed proportions of Google hits of the indicative and in the subjunctive verb form (with and without the “that”) for each verb was included in the final analysis in order to evaluate whether it contributed significant information to the models.

Results of Experiment 1 when including Verb form frequency bias as covariate

In Experiment 1, area 3, Verb Form Frequency bias involving ‘that’ (e.g., ‘che sosteneva’ vs. ‘che sostenesse’) contributed to the fit of all the models and had to be included. However it did never reach significance (i.e., it did not predict the results).

Frequency bias of the verb without ‘that’ (‘sosteneva’ vs. ‘sostenesse’) did not add significant information to the models.

Results of Experiment 2 when including Verb Form Frequency bias as covariate

Verb Form Frequency bias involving 'that' (e.g., 'che convinse' vs. 'che convincessero') contributed to the models' fit of a number of variables (i.e., had to be included in the models' regression), however it resulted significant only in regression out full count variable. Participants were less likely to make a regression when the verb form (in the 'that-verb' frame) was more frequent.

Frequency bias of the verb without 'that' ('convinse' vs. 'convincessero') did not add significant information to any of the models.

Frequency of a grammatical construction?

Frequency biases of the single nouns do not explain the results of Experiment 1 and 2. Frequency biases of the verb forms used in our experiments do not either.

So, if one wants to stick to a frequency explanation, the conclusion is that what counts is the frequency bias of the grammatical construction, no matter how this construction is filled by actual words.

Namely, what counts would be the frequency bias of the grammatical construction RC as opposed to the grammatical construction CC (of a noun).

Frequency of a grammatical construction? Not so sure...

It is of course possible that the human parser takes into consideration how frequent a grammatical construction is. This is not what constraint-based models predict though. More relevantly, this story is far from being satisfactory for general reasons.

Frequency of a grammatical construction? Not so sure...

For one thing, if frequency of the abstract construction RC counts, it is somewhat strange that it does not count when that frame is filled by the very words that the experimental subject is reading.

Frequency of a grammatical construction? Not so sure...

Traxler and Tooley (2007) found that the usual garden path associated with past participle (13) was greatly reduced when the critical sentence was preceded by another past participle clause *using the same verb*.

(13) The horse **raced** past the barn fell

However, the garden path remained if the sentence was preceded by a past participle clause using a different verb.

If the abstract construction involving the past participle were stored as such, one would expect it to be able to prime, irrespective of how it is filled by actual words.

CONCLUSIONS

Conclusions

The relative clause analysis is preferred to the clausal complement analysis when a temporary ambiguity arises.

Frequency does not play a significant role.

Conclusions

So, we think that our results are evidence for a radical revision of traditional approaches to noun complementation and relativization: in particular, relativization is similar to the most basic structure building operation at a sufficiently abstract level of analysis.

The preference for the RCs can then be explained as a sub-case of an example of the general preference of the parser for head-complement configurations.

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