

Coherence-driven predictability and referential form: evidence from English corpus data

Xixian Liao (Universitat Pompeu Fabra)

Introduction. Variation in referential form, such as a proper name (*Trump*) and a more reduced pronominal expression (*he*), is an important component of language use. There is a long-standing debate regarding the relationship between referential predictability (likelihood of a referent being the next-mention) and referential form. Some suggest that referents that have a higher probability of being mentioned next are more likely to be pronominalized (Arnold, 2001); other suggest a dissociation between likelihood of next-mention and likelihood of pronominalization (Kehler et al, 2013). According to the *strong* Bayesian model proposed by Kehler et al. (2013), pronoun production biases are conditioned dominantly by grammatical factors and information structure, while next-mention biases, which are conditioned primarily on semantic-pragmatic factors (e.g. verb types, rhetorical relations), hold independently of referential choice. This study contributes to this debate with new evidence in two aspects. 1) Rhetorical relation-driven predictability: while the cases that have been studied in previous psycholinguistic studies have been fairly restricted to particular verbs types (e.g. transfer of possession verbs), this study is, to the best of our knowledge, the first attempt of broadening the empirical base with expectation biases primarily driven by rhetorical relations; 2) Natural language in corpora: instead of using constructed language to elicit production, we use natural coreference chains that can be automatically retrieved from corpora developed in the natural language processing field.

Methods. All the contexts were automatically retrieved from the English OntoNotes corpus, which is richly annotated with structural information and shallow semantics. In the absence of discourse structure annotation, we left out relations that are typically signaled by ambiguous connectives and selected a set of connectives for the following relations: Occasion, Contrast, Result, Explanation, Purpose, as listed in Table 1. We compare Occasion against Contrast and Result: since the most typical connectives of these three relations are coordinating, they were retrieved inter-sententially, as (1). In contrast, Explanation and Purpose, relations oftentimes marked by subordinating connectives, were retrieved intra-sententially like (2) as a comparison to examine the effects of syntactic factors. The first grammatical subject after the connective is considered as the next mention. For each rhetorical relation, we retrieved all contexts which were then classified into three coreference types: the next mention is coreferential with the preceding subject, with a preceding non-subject, or with other referents that have not been mentioned in the preceding clause.

(1) <s>Judas ate the bread Jesus gave him.</s > <s>**Then** he immediately went out.</s >

(2) <s>Some people are telling the message about Christ **because** they are jealous ...</s >

Hypotheses. We put forward the following hypotheses: **(H1)** Occasion will show stronger next-mention biases towards the subject than Contrast and Result. The underlying rationale is the following: a) Occasion typically connects descriptions for temporally and spatially continuous events, thus will display continuity in the entities which narrative sequences of events center around; and b) the canonical place to mention both the topic and the agent role is the grammatical subject. By contrast, in other relations, this subject bias could be mitigated. For instance, in a Result such as "Hurricane Maria struck Puerto Rico yesterday. As a result ...", it is quite likely that the patient role bears the consequences. **(H2)** If next-mention biases affect pronoun production, a comparatively higher pronominalization rate will be observed in Occasion when re-mentioning the preceding subject (subject coreference contexts). This effect from next-mention biases should be examined in addition to the effects from structural/syntactic factors. With respect to the latter ones, we predict the following: **(H3)** We expect more pronouns are used in subject coreference contexts than in non-subject coreference ones, namely, we expect a subject preference in pronoun production. **(H4)** We also expect more pronouns produced following subordinating connectives than coordinating ones, as referents in the main clause should remain highly activated as subordinating clauses are produced.

Results. With respect to **H1**, Figure 1 reports the distribution of coreference types in each relation. Within coordinating relations, Occasion shows stronger next-mention biases towards the

subject ($X^2(2)= 20.3, p < .0001$; no difference between Contrast and Result $X^2(1)= 0.5, p = .5$). Within subordinating relations, Purpose shows stronger next-mention biases towards non-subject referents than Explanation ($X^2(1)= 21.1, p < .0001$). Therefore, our results confirm H1, and in addition, a stronger non-subject bias in Purpose emerged from the data. With respect to H2, Figure 2 shows the pronominalization rates. Within coordinating relations, no evidence was found that more pronouns were produced in Occasion when re-mentioning the subject referent ($X^2(2) > = 3.0, p = .2$), despite Occasion's stronger next-mention biases towards the subject. Within subordinating relations, more pronouns were found in reference to a non-subject antecedent in Purpose ($X^2(1) > = 5.9, p = .02$). One concern is that the referents in each category may not all have the same degree of topicality. In order to check, we used prior pronominalization as a proxy for topicality. Among coordinating relations, the percentages of contexts with a pronominal subject antecedent do not differ ($X^2(2) > = .1, p = .93$). On the other side, since a larger proportion of contexts with a pronominal non-subject antecedent were found in Purpose ($X^2(1) > = 5.3, p = .02$), the data coming from the two subordinating relations is not fully comparable. Therefore, we did not find evidence that next-mention biases affect pronoun production. The uniform pronominalization rate across coordinating relations suggests, on the contrary, a possible dissociation between next-mention biases and pronoun production biases. With respect to H3, Figure 2 shows that overall, there are more pronouns produced in subject coreference contexts than in non-subject conference ones across all relations. Thus, H3 is confirmed. In addition, subordinating relations in general obtain higher pronominalization rates than coordinating ones (subject: $X^2(1) > = 59.7, p < .0001$; non-subject: $X^2(1) > = 76.2, p < .0001$). This confirms H4.

Conclusions. Our study provides corpus evidence supporting the dissociation between next-mention biases and pronoun production biases posited by the *strong* Bayesian Model, particularly in that next-mention biases move around depending on rhetorical relations, whereas pronoun production biases do not. This is argued for in a two-step fashion: a) We firstly provided evidence for the hypothesized next-mention biased pattern: stronger subject biases in Occasion over other coordinating relations. b) After establishing the stronger subject biases in Occasion, we proceeded to examine its effects on pronoun production. The results show that pronoun production is subject to syntactic/structural factors (referring to the preceding subject vs. to a preceding non-subject; relations presented in coordinating structures vs. relations in subordinating structures). On the other hand, we observed uniform pronominalization rates across relations despite the different next-mention biases. Therefore, no evidence has been found that predictability, disentangled from syntactic/structural factors and primarily driven by rhetorical relations, influences pronoun production.

Selected references. Arnold, J. E. (2001). The effect of thematic roles on pronoun use and frequency of reference continuation. *Discourse processes*, 31(2):137-162. • Kehler, A. & Rohde, H. (2013). A probabilistic reconciliation of coherence-driven and centering-driven theories of pronoun interpretation. *Theoretical Linguistics*, 39(1-2), 1-37.

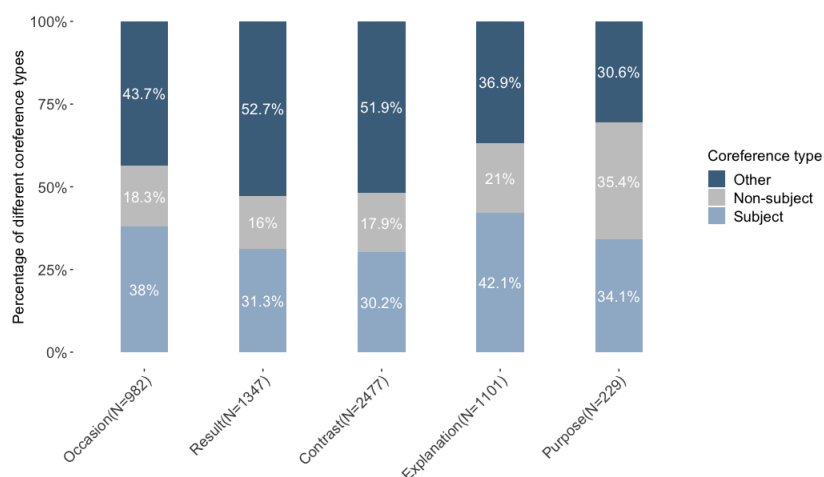


Figure 1: Coreference type by rhetorical relation.

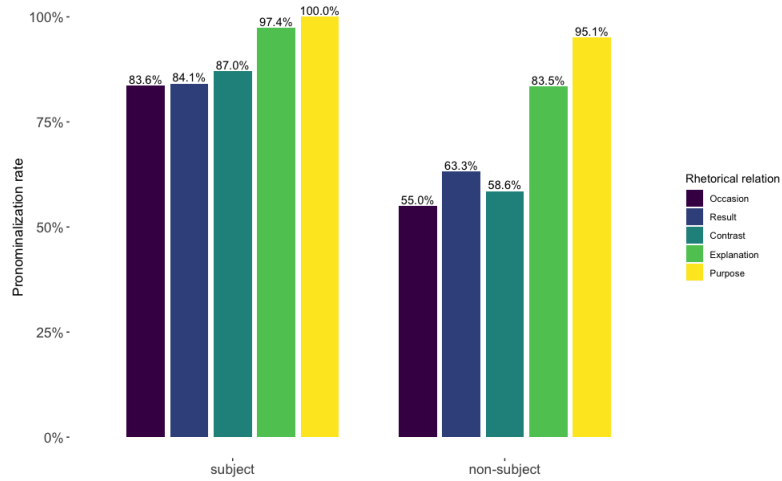


Figure 2: Pronominalization rate of next mention by rhetorical relation.

| | Relation | Connectives |
|---------------|-------------|--|
| coordinating | Occasion | (and) then, later, next, (a period of time) later/after, afterward(s), after it/that |
| | Result | (and) so, thus, accordingly, consequently, hence, therefore, as a result, as a consequence |
| | Contrast | but, on the contrary, by contrast, however |
| subordinating | Explanation | because |
| | Purpose | so that, so (annotated as the beginning of a modifier argument denoting purpose) |

Table 1: Connectives used for rhetorical relation retrieval.