# Presuppositions of quantified sentences: Experimental Data*

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**Abstract**

Some theories (e.g., Beaver, 1994, 2001) assume that sentences with presupposition triggers in the scope of a quantifier carry an existential presupposition, as in (2), others (e.g., Heim, 1983) assume that they carry a universal presupposition, as in (3).

(1) No student knows that he is lucky.

(2) Existential presupposition: At least one student is lucky.

(3) Universal presupposition: Every student is lucky.

This work is an experimental investigation of this issue. The paradigm also proves to be useful to compare presuppositions with other phenomena: scalar implicatures and cases of adverbial modification. The projection properties of the inferences triggered by all these phenomena are indeed very similar to each other. In particular, I argue that negation cannot be used as a diagnosis for presupposition. The first result of the experiment is that presuppositions triggered from the scope of the quantifier *No* are universal and this provides a much more powerful diagnosis to distinguish presuppositions and scalar implicatures. Furthermore, the results of the experiment show that presuppositions triggered from the scope of a quantifier depend on the quantifier. This calls for important changes in the main theories of presupposition projection.

## 1 Introduction

The purpose of this work is to collect experimental data on presuppositions of quantified sentences. The main motivation comes from the empirical disagreement exemplified in (1): Some theories (e.g., Beaver, 1994, 2001) relied on the idea that such sentences carry an existential presupposition, as in (1a), others (e.g., Heim, 1983) argued that this sentence is better understood as having a universal presupposition, as in (1b).

(1) No student knows that he is lucky.

a. *Existential presupposition:* At least one student is lucky.

b. *Universal presupposition:* Every student is lucky.

I propose an experimental paradigm to establish the relevant data. The paradigm will also prove to be useful to compare presuppositions with other phenomena: scalar implicatures and cases of adverbial modification. The projection properties of the inferences triggered by all these phenomena are indeed very similar to each other. In particular, I will argue that negation cannot be used as a tool to detect presuppositions. The first result of the experiment is that presuppositions triggered from the scope of the quantifier *No* are universal and this provides a much more powerful diagnosis to distinguish presuppositions and scalar implicatures. Furthermore, the results of the experiment show that presuppositions triggered from the scope of a quantifier depend on the quantifier. This calls for important changes in the main theories of presupposition projection.

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In the first section of this paper, I minimally review the theoretical background which motivates experimental investigations of the projection properties of presuppositions, scalar implicatures and cases of adverbial modification. In particular, I argue that presuppositions and scalar implicatures look very much alike if one does not consider quantified contexts (section 2.2). In section 3, I present the details of the experimental paradigm proposed to address these issues. Section 4 reports the results of the experiment along two lines. A first set of analyses shows that presuppositions and scalar implicatures do differ while cases of adverbial modification seem to pattern intermediately. A second set of analyses investigate in more details the role of the quantifier for presupposition projection and some preliminary processing patterns. In section 5, I discuss the consequences of these results for current theories of presupposition projection.

# 2 Theoretical situation

I introduce here the theoretical background which motivates the experiment presented below. Section 2.1 introduces presuppositions from a very narrow perspective. It focuses on 1) the inferences they trigger and 2) the potential problems for the study of their projection properties out of the scope of a quantifier. Section 2.2 compares presuppositions to scalar implicatures and proposes a simple solution to account for the basic projection properties of presuppositions as a scalar phenomenon. Section 2.3 presents an example of inferences triggered by adverbial modification: they might share the projection properties of presuppositions.

## 2.1 Presuppositions in quantified sentences

### 2.1.1 Presuppositions: Existential or Universal

The sentences in (2) trigger the presupposition that Bill has an elephant. Intuitively, this amounts to saying that these sentences are more natural in conversations where participants agree, or are likely to agree, that Bill has an elephant (Karttunen, 1974; Stalnaker, 1974). For the purpose of this paper, the most important fact is that if a reliable speaker utters a sentence which triggers a presupposition $p$, it is natural to infer from this utterance that $p$ is true. In other words, if a speaker utters (2a) or (2b), s/he is committed to Bill having an elephant. The inferential process at play is called *(global) accommodation* and it is only under this aspect that presuppositions will be approached. This issue will arise in the interpretation and discussion of the data described here but for most of this paper, presuppositions will be considered as inferences.

(2) a. John knows that Bill has an elephant. $\rightsquigarrow$ *Bill has an elephant*
b. John doesn't know that Bill has an elephant. $\rightsquigarrow$ *Bill has an elephant*

Let us assume that the presuppositions of the sentences above are triggered by the verb *know* (assuming that presuppositions are triggered lexically is orthogonal to the problems investigated here). The sentences in (2) already show that whether this verb is embedded under negation does not change the presupposition and both sentences trigger the same inference that Bill has an elephant. In other words, presuppositions escape negation.

We can now ask what happens if the verb *know* is embedded under operators other than negation. More specifically, what happens when a presupposition trigger appears in the scope of a generalized quantifier (e.g., *every* or *no*)? This situation is exemplified in (1) repeated here as (3) and schematized in (4). The symbol $\mathcal{Q}$ stands for a generalized quantifier, $R$ stands for its restrictor and $S_p$ for its scope, where the subscript $p$ indicates that we are interested in cases where this scope triggers a presupposition $p$ (this presupposition should inherit from $S_p$ the dependence on $x$ in the interesting cases).

(3) No student knows that he is lucky.

(4) *Quantified sentence:* $[\mathcal{Q}x : R(x)]\, S_p(x)$

a. *Universal presupposition:* $[\forall x : R(x)]\, p(x)$

b. *Existential presupposition:* $[\exists x : R(x)]\, p(x)$

This piece of data is controversial. Heim (1983) (and more recently Schlenker, 2006, 2007) argued that sentences of the form given in (4) trigger a *universal presupposition* as schematized in (4a): every individual satisfying the restrictor should also satisfy the presupposition triggered by the scope of the quantifier. Applied to example (3), this amounts to saying that every individual who is a student, should also be a lucky individual: every student is lucky. Beaver (1994, 2001) argued that such sentences actually trigger much weaker *existential presuppositions* as schematized in (4b): some individual satisfying the restrictor also satisfies the presupposition of the scope (i.e. for example (3): *(at least) one student is lucky*).

Appendix A summarizes how these predictions are derived in each account. Importantly, for none of these theories do the predictions depend upon the quantifier $\mathcal{Q}$, contrary to the results presented below. Indeed, these theories intend to develop a dynamic semantics which could be uniform across quantifiers and therefore predict the same type of presupposition no matter what the quantifier is. It is technically possible to get around this constraint but it would raise new issues for the dynamic enterprise in general (e.g., how do children acquire these variations?, what explains the cross-linguistic stability or variability of these differences?).

Terminological note: in this paper, I use the adjectives *universal* and *existential* somewhat loosely to qualify presuppositions, inferences or predictions which fit the schemas in (4a) and (4b) respectively.

#### 2.1.2 Orthogonal issues

The empirical disagreement schematized in (4) might suffer from independent complications. I review them in this section and explain my attempt to stay away from these problems.

#### 2.1.3 Implicit domain restriction

A bare noun in the restrictor of a quantifier does not fix the domain of individuals involved in a quantified sentence, this domain is most often implicitly restricted via contextual assumptions. Given the context in (5), the noun *Italian* in (5a) is used to refer to a particular subset of Italians without any explicit linguistic mention of this.

(5) *Context: John is a teacher and, while he is talking about his new students, he says:*

a. Every Italian is tall.

b. *means:* Every Italian (among my new students) is tall.

This implicit operation of domain restriction is extremely common and powerful: in (6a), the phrase *every Italian* occurs twice within the very same sentence and yet, these two occurrences are subject to two different implicit domain restrictions.

(6) *Context: A committee must select some applicants. Some of the applicants are italian, and there are also Italians on the committee, though of course, they are not the same.*

a. Every Italian voted for every Italian.

b. *means:* Every Italian (who is in the committee) voted for every Italian (who is an applicant).

(from Schlenker, 2004, after D. Westerstahl)

To understand the importance of implicit domain restrictions for the purposes of this paper, consider example (3) and its schema in (4) again. Because of potential implicit domain restrictions, the set of students involved in sentence (3) is under-specified. Hence, it is very difficult to formulate the universal or the existential presupposition it might trigger and the predictions become virtually impossible to test with naive informants (note that domain restrictions may also appear in the formulation of the alleged presupposition). Furthermore, domain restrictions could also apply in such a way that we would be left with no prediction to test: sentence (7) is a possible outcome of domain restriction, where the phrase in parenthesis mimics the implicit domain restriction. In this case, the potential universal inference in (7a) is simply tautologous[1].

(7) No student (who is lucky) knows that he is lucky.

a. *Universal prediction:* Every student (who is lucky) is lucky.

b. *Existential prediction:* At least one student among the lucky students is lucky.

To avoid this confound, the sentences used in the experiment systematically specify overtly the domain of individuals which are quantified over as a set of 10 particular students. Thus, (8) is a version of sentence (3) which might qualify for the experiment. Indeed, explicit mentions of a domain of individuals, as 10 particular students, seem to block implicit domain restrictions (compare also (9) to (5) and (10) to (6)).

(8) None of these 10 students knows that he is lucky.

(9) Each of these 10 Italians is tall.

(10) *Context: A committee must select some applicants. Some of the applicants are italian, and there are also Italians on the committee, though of course, they are not the same.*

?? Each of these 10 Italians voted for each of these 10 Italians.

Admittedly, I did not prove that domain restrictions are impossible in sentences where a domain of individuals is specified overtly. Nonetheless, the data in (8) to (10) convincingly show that unmotivated implicit domain restrictions are now at least disfavored.

#### 2.1.4 Bound readings

A similar pitfall is the ambiguity of sentences with a plural bound pronoun in the scope of a plural quantifier as in sentence (11). The two potential interpretations are paraphrased in (11a) and (11b). Under the reading paraphrased in (11a), the complement of the verb *know* (which, as always, prefigures the presupposition) does not contain any “free variable”. In other words, what a student might or might not know does not depend on who this particular student is, it

[1] To keep the discussion simple, I do not discuss theories allowing *intermediate accommodation*: domain restrictions driven by the presence of presuppositional elements. The defenders are van der Sandt (1993) and Geurts (1999), the attackers are Beaver (2001) and Schlenker (2006).

is simply that *all of these 10 students are lucky.* As a result, the two predictions (existential or universal) schematized in (4) collapse into *all of these 10 students are lucky.* To understand why the predictions collapse in absence of "free variables", consider example (12). In this sentence, the proposition conveyed by the complement of the verb *know* does not contain any free variable: the weather does not depend on any property of the students at stake. As a result, the existential and universal versions of the presupposition of this sentence (spelled out in (12a) and (12b)) become equivalent[2] (and also somewhat ill-formed but this is a side issue).

(11) Less than 3 of these 10 students know that they are lucky.
  a. Less than 3 of these 10 students know that all of these 10 students are lucky.
  b. Among these 10 students, the number of students who knows that he (himself) is lucky is below 3.

(12) No student knows that it's raining.
  a. *Universal prediction:* Every student is such that it is raining.
  b. *Existential prediction:* There is at least one student such that it is raining.

The examples used in the experiment are designed to disfavor the unfortunate bound reading described in (11a). This is exemplified in (13): *their father* is singular and, although the problematic bound reading is still possible, it would now imply that the 10 students involved are siblings and probably that their father will receive a unique letter. This situation does not seem to be the natural situation one might construct to interpret this example. The bound reading is then strongly disfavored.

(13) Less than 3 of these 10 students know that their father will receive a congratulation letter.

### 2.1.5 Summary

I presented the empirical controversy that generated divergent theories: do presuppositions project universally or existentially (cf. examples (3-4))? It seems that this dilemma should be settled by appropriate empirical investigations. I also described two superfluous difficulties which complicate the debate and explained how they should minimally intervene in the experimental material to be used.

## 2.2 Presupposition as a scalar phenomenon?

### 2.2.1 Scalar implicatures

Let us look at a different type of inference: *scalar implicatures.* Although its bare meaning described in (14a) does not convey this, it is natural to conclude from an utterance of (14) that not all students are happy. This can be accounted for as follows (Horn, 1972, 1989; Atlas and Levinson, 1981; Grice, 1989). Let us assume that the words *some* and *all* belong to a "scale" so that each time a sentence containing one of these words is uttered, it is compared with the minimally different sentence where this word is replaced by the other word in the scale. In the case of sentence (14), the alternative is then (14c): *all* replaces *some* and the rest is left unchanged. Now note that this alternative sentence is logically stronger than the original sentence. Nonetheless, it has been disregarded by the speaker: this calls for an explanation and the most natural explanation is to conclude that this

[2] At least in a situation where there exist students.

alternative sentence is actually false. The negation of the alternative (14c) is indeed equivalent to the attested inference (14b).

(14) Some of these 10 students are happy.
   a. *Bare meaning:* There are 2, 3, 4... or 10 happy students in this group.
   b. *Inference:* Not all of these 10 students are happy.
   c. *Alternative:* All of these 10 students are happy.

The pragmatic reasoning described above naturally generalizes to every sentence containing a scalar term (e.g., *some*, *all*). The resulting inferences are called scalar implicatures. Importantly, the behavior of these inferences when the scalar term is embedded under various operators straightforwardly follows from the pragmatic principles underlying the reasoning above and the notion of scale (or alternatives). In particular, it makes immediate predictions with regard to what should be the overall scalar implicatures of sentences containing a scalar term in the scope of a quantifier. Could we extend these principles to presuppositions?

### 2.2.2 Negation is not an issue

Abusch (2006), Simons (2001a, 2001b), provide independent arguments to reduce the theoretical differences between scalar implicatures and presuppositions, Abusch (2006) formally investigated the possibility that presupposition could be reduced to a scalar phenomenon.

At first sight, this seems incompatible with the following widespread idea: the fact that presuppositions escape negation (cf. example (2)) is a specific property of presuppositions. Indeed, if some projection behavior is specific to presuppositions, it seems useless to try to account for their projection properties as a special case of any other type of phenomenon.

This view is mistaken and in particular, scalar implicatures do escape negation. Indeed, whatever is a scalar implicature of a sentence $S$, is an entailment of the negation of $S$. The semi-formal proof is given in (15); the examples given in (16) and (17) should be compared to example (2).

(15) Let us assume that two sentences, $A$ and $B$, are alternatives to each other.
Let us further assume that $B$ is stronger than $A$: $B \rightarrow A$.
Hence, the negation of $B$ (written as $\neg B$) is an implicature of $A$.
But if $B \rightarrow A$, then $\neg A \rightarrow \neg B$.
In sum, $A$ implicates $\neg B$ *and* its negation $\neg A$ entails $\neg B$.
Again: $\neg B$ can be inferred from both $A$ and its negation.

(16) a. Some students are happy. *implicates* Not all students are happy.
   b. It's not the case that some students are happy.
   (*i.e.* No student is happy) *implicates* Not all students are happy.

(17) a. All students are happy. *implicates* Some students are happy.
   b. It's not the case that all students are happy.
   (*i.e.* Not all students are happy) *implicates* Some students are happy.

This fact was already noticed in Merin (1999). It reduces the alleged distance between presuppositions and scalar implicatures projection behavior. Noticeably, it also prevents the survival under negation to be used as a diagnosis of presupposition[3].

[3] Questions and antecedents of conditionals provide other common tests for presuppositions. Although I do believe

### 2.2.3 A scalar theory of presuppositions?

In this section I describe a simple minded theory to derive presuppositions as a scalar phenomenon.

A word of caution is in order. Spelling out the details of this theory is necessary to understand precisely its predictions and compare it to other theories. At this point, no attempt is made to motivate its details (e.g., the alternatives involved) since the theory did not prove to be viable yet. Nevertheless, this scalar theory is exactly intermediate between the theories presented above in section 2.1.1 in terms of logical ordering of the predictions it makes and as such, it should not be underestimated. (For more involved attempts to unify scalar implicatures and presuppositions projections, see Abusch, 2006 and Chemla, in progress).

Let us assume that a sentence of the form $x$ *knows that* $p$ receives a non-dynamic meaning: $p$ and $x$ *believes that* $p$. We can then postulate that the projection of the presupposition $p$ is governed by an (asymmetric) scale between this expression and $p$. The presupposition $p$ will then project just as (indirect) implicatures triggered for instance by the word *all* in downward entailing contexts (e.g., *John didn't read all the books* implicates *John read some of the books*).

Let us see for instance how this would predict the facts given in (2): (2a-2b) are analyzed in (18-19).

(18) John knows that Bill has an elephant.

a. *Alternative:* Bill has an elephant.

b. *Inference:* Bill has an elephant (The alternative is weaker than the assertion, *Bill has an elephant* is already part of the content of the sentence).

(19) John doesn't know that Bill has an elephant.

a. *Schematically:* NEGATION (John knows that Bill has an elephant).

b. *Alternative:* NEGATION (Bill has an elephant).

c. *Inference:* Bill has an elephant (This corresponds to the negation of the alternative which is stronger than the assertion in this case).

Importantly, the predictions of this theory differ from the predictions given by the theories presented before in the problematic quantified sentences. Interestingly, the predictions made by this scalar theory of presupposition are exactly intermediate between the two other theories in term of logical strength. The list of relevant predictions is given in Table 1, cases where the scalar mechanism described above is vacuous and where the prediction derives from the bare meaning of the sentence are indicated by a star. Further details on how to derive these predictions can be found in Appendix B.

## 2.3 Adverbial modification

Simons (2001a, 2001b) and Schlenker (2006) recently argued that cases of adverbial modification look very much like presuppositions. In particular, examples in (20) show that inferences driven by adverbial modifications (e.g., *for Nader*) pass the test of negation discussed above.

(20) a. John voted for Nader. $\rightsquigarrow$ *John voted*

that they might run into similar difficulties, I prefer to set this discussion aside because the experimental part of this work has no bearing on these issues. My point remains the same: negation is *not* a test.

| Environments | Prediction |
|---|---|
| *John knows that p* | $\star$ $p$ |
| *John doesn't know that p* | $p$ |
| Scope of a universal quantifier (*all*) | $\star$ Universal presupposition ($\forall x, R(x) \Rightarrow p(x)$) |
| Scope of *no* | Existential presupposition ($\exists x, R(x) \wedge p(x)$) |
| Scope of *less than 3* | At least 3 $x$ satisfying the restrictor satisfy $p(x)$ |
| Scope of *more than 3* | $\star$ idem |
| Scope of *exactly 3* | $\star$ idem |

Table 1: Predictions of a scalar theory of presuppositions

b. John didn't vote for Nader. $\rightsquigarrow$ *John voted*
*(Simons 2001a, 2001b)*

A secondary purpose of the following experiment is to establish to what extent the projection properties of these inferences indeed resemble scalar implicature or presupposition projection.

# 3 Methodology

In this section, I detail the experimental paradigm used to investigate the questions raised in the previous section.

## 3.1 General assumptions

As already discussed, if a sentence $S$ triggers a presupposition $p$, an occurrence of $S$ by a reliable speaker licenses the inference that $p$ is true. The present experimental paradigm heavily capitalizes on this fact: to detect whether a sentence $S$ has a presupposition $p$, naive speakers were asked whether they would infer from an utterance of $S$ (by a reliable speaker) that the alleged presupposition of $S$ holds (e.g., Figure 1). The same applies to scalar implicatures (e.g., Figure 2).

Figures 1 and 2 mimic two examples of what participants actually saw on the computer screen. The verb *to suggest* (*suggérer* in French) articulated the two sentences but the intended meaning for this word was clarified in the instructions (more on this below and in Appendix C).

"None of these 10 students knows that his father will receive a congratulation letter."

*suggests that:*

Each of these 10 students' father will receive a congratulation letter.

*No?* *Yes?*

Figure 1: Example of a trial involving the presupposition trigger *know*

"None of these 10 students passed all of his exams."

*suggests that:*

Each of these 10 students passed several of his exams.

*No?* *Yes?*

Figure 2: Example of a trial involving the scalar term *all*

## 3.2 Procedure

The participants to the experiment first read instructions given on a piece of paper (see Appendix C). These instructions were designed to achieve several goals:

- A natural context for the task was set up. Importantly, it aimed at establishing the reliability of the "speaker". In essence, the participants were told to consider that a well-informed and honest teacher utters a sentence (the sentence between quotation marks in the examples above in Figures 1 to 2). Their task was to tell whether such an utterance licenses (or *suggère*) the proposed inference.
- Two examples were provided to clarify the task that participants were to perform and the intended meaning for the verb *suggest*. The first example aimed at showing that this was an inferential task where they should not resist "logical" conclusions. Nevertheless, the second example showed that intuitions should be favored (it was a case of disfavored conversational implicature where it was made explicit that responses may vary).

After having read these instructions, the participants were left alone with a *dmdx* program which presented the material described below in random order. They were asked to position their index fingers on the *Yes* and *No* response buttons (which corresponded respectively to the keys *P* and *A* of the French keyboard as indicated by a piece of paper on these keys) so that they could provide their answers as soon as they made up their mind.

The first two trials were the examples already provided in the instructions to allow the participants to get used to the general setting of the experiment.

## 3.3 Participants

The experiment was carried out in French; 30 native speakers of French aged from 18 to 35 years old were recruited to take part in the experiment. They were paid a small fee. Participants were mainly university students in humanities (none of them had any relevant background in linguistics).

## 3.4 Material

As discussed above, the items had the general format of a classical inferential task. Each item contained two main sentences. The first sentence, henceforth *the utterance*, was presented between quotation marks: it was to be understood as a sentence uttered in the context previously set up. The second main sentence, henceforth *the conclusion*, conveyed the alleged inference which the participants had to evaluate. Figure 3 represents a schematic version of the items as they would appear on the screen (see Figures 1 and 2 above for concrete examples).

"$E_1[I_1]$"

*suggests that:*

$E_2[I_2]$

*No?* *Yes?*

Figure 3: Abstract format of the trials as they appeared on the screen: $E_1$ and $E_2$ represent linguistic environments (e.g., the scope of a quantifier like *Each* or *No*) while $I_1$ and $I_2$ represent some inference which could be embedded in these environments (e.g., $I_1$ could be a phrase involving a factive verb and $I_2$ its alleged presupposition, i.e. roughly, the complement of this factive verb). See Figures 1 and 2 above for concrete examples.

### 3.4.1 First factor: types of inference (represented by the pair $(I_1, I_2)$)

Schematically, $I_1$ and $I_2$ represent a target item and its associated inference. For instance, in the example given in Figure 1, $I_1$ corresponds to *x knows that x's father will receive a congratulation letter* and $I_2$ corresponds to the associated presupposition *x's father will receive a congratulation letter*. These inferences (i.e. pairs $(I_1, I_2)$) were classified into types and sub-types of inferences. The full details are given in Appendix D, the following list summarizes these types and sub-types of inferences (numbers between square brackets indicate how many items of each specified type were included in this experiment).

- Presupposition [10]: definite descriptions [2], factive verbs [4], change of state predicates [4]
- Scalar implicature [10]: scalar implicatures [5], scalar implicature with focus [5] (the focus was mimicked by presenting the scalar item in capital letters)
- Adverbial modification [3]: *no sub categories.*
- Entailment [4]: Upward [2], Downward [2] (These were control items, the sub-categories indicate the types of environments in which they yield valid inferences).

As far as possible, the target items were paired so that the content of the inferences varied maximally. For instance, an item involving *students' fathers being appointed* was paired with an item involving *students' fathers receiving congratulation letters*. This was done to minimize potential effects of world knowledge biases of the following form. Imagine that people assume by default that students' fathers are very likely to be appointed, this may artificially increase acceptance rates of universal conclusions such as *Each father of these 10 students was appointed*, independently of any particular utterance and situation. However, this very same bias should disfavored inferences towards conclusions such as *Each father of these 10 students received a congratulation letter*. Thus, varying the content of the inferences should rule out explanations of high acceptance rates based on *a priori* world knowledge.

### 3.4.2 Second factor: projection profiles (i.e. linguistic environments $E_1$ and $E_2$)

The purpose of this work is to investigate how inferences project when embedded in different linguistic environments (e.g., in the scope of different quantifiers), 10 different *projection profiles* were constructed to serve this purpose and test the different predictions described above.

A projection profile is a pair of linguistic environments ($E_1$, $E_2$) (see Figure 3.4), referred to as $\langle E_1 \rightsquigarrow E_2 \rangle$. The first member $E_1$ corresponds to the linguistic environment in which the inference trigger is embedded to form the *utterance* (the top sentence of a given item). The second member $E_2$ corresponds to the linguistic environment in which the alleged consequence is embedded to form the *conclusion* (the bottom sentence of a given item).

For instance, a projection profile in which the first member $E_1$ is the scope of a quantifier tests how an inference projects out of the scope of this quantifier; if the second member of the projection profile is the scope of a universal quantifier, it tests whether the inference projects universally. This is the case in the example given in Figure 1 and repeated below in (21) where the projection profile is $\langle \mathit{No} \rightsquigarrow \mathit{Each} \rangle$: it tests whether an inference (which corresponds here to the factive presupposition of the verb *know*) projects universally out of the scope of the quantifier *No*.

(21) *Utterance:* "None of these 10 students knows that his father will receive a congratulation letter."
*Conclusion:* Each of these 10 students' father will receive a congratulation letter.

Ten projection profiles were included to test the predictions described in the previous sections, the role of each of these profiles should become clear again in the following sections: $\langle \mathit{John} \rightsquigarrow \mathit{John} \rangle$, $\langle \mathit{NOT\ John} \rightsquigarrow \mathit{John} \rangle$, $\langle \mathit{No} \rightsquigarrow \mathit{At\ least\ one} \rangle$, $\langle \mathit{No} \rightsquigarrow \mathit{Each} \rangle$, $\langle \mathit{Less\ than\ 3} \rightsquigarrow \mathit{At\ least\ 3} \rangle$, $\langle \mathit{Less\ than\ 3} \rightsquigarrow \mathit{Each} \rangle$, $\langle \mathit{More\ than\ 3} \rightsquigarrow \mathit{More\ than\ 3} \rangle$, $\langle \mathit{More\ than\ 3} \rightsquigarrow \mathit{Each} \rangle$ and $\langle \mathit{Exactly\ 3} \rightsquigarrow \mathit{Each} \rangle$.

Notes: Whenever a quantifier is involved in these environments, the restrictor explicitly specifies *of these 10 students* to avoid problems discussed in section 2.1.3; *No* stands for the quantifier realized as *None of these 10 students*. The negation *NOT* was mimicked by the expression *I doubt that* to avoid scope ambiguities.

### 3.4.3 Summary

In sum, there were 270 items constructed from the combination of 1) 27 inferences grouped in 4 main types (presuppositions, scalar implicatures, adverbial modifications, entailments) and 2) 10 projection profiles which enclosed these inferences into different linguistic environments to test their projection behavior.

# 4 Results

This section is organized as follows. Section 4.1 presents the results for trials in which the response is theoretically uncontroversial, the high scores for these items prove the soundness of the methodology. Section 4.2 presents a comparison between the projection properties of presuppositions and scalar implicatures: the two phenomena differ in quantified sentences. Section 4.3 is a slight digression from our main purpose, the main results are that presupposition triggers pattern similarly and that the projection properties of cases of adverbial modifications are intermediate between those of presuppositions and scalar implicatures. Section 4.4 investigates further the results obtained for presuppositions, the data presented here reveal some preliminary processing results and show that presuppositions project differently when triggered from the scope of *No* on the one hand, and from the scope of numerical quantifiers on the other hand.

The main theoretical consequences of these results are drawn in section 5.

## 4.1 Control results

### 4.1.1 Analysis: Entailments

Among the 270 trials, 40 were constructed from simple monotonicity inferences which presumably should not involve implicatures or presuppositions (this corresponds to the 4 inferences referred to as "Entailments" in section 3.4, appearing in the 10 different projection profiles). The versions of these inferences as they combine with the projection profile $\langle$*John*⇝*John*$\rangle$ are given in (22-23).

(22) a. "John is French." *suggests:* John is European.
b. "John succeeded in every class." *suggests:* John succeeded in Math.

(23) a. "John is European." *suggests:* John is French.
b. "John succeeded in Math." *suggests:* John succeeded in every class.

These items naturally receive a "logical" answer (e.g., inferences in (22) are valid, inferences in (23) are not). Subjects responded accordingly 90.2% of the time.

### 4.1.2 Analysis: Harmless projection profiles

Because of the way the other inferences were constructed, three of the ten projection profiles should normally receive "Yes" responses independently from the implicatures or presuppositions computations they might involved: $\langle$*John*⇝*John*$\rangle$, $\langle$*Each*⇝*Each*$\rangle$, $\langle$*More than 3*⇝*More than 3*$\rangle$.

Indeed, these projection profiles involve upward monotonic quantifiers, similar in the target sentence and in the alleged inference. Whether there is a presupposition trigger or a (strong) scalar term embedded there, the validity of the alleged inference follows from logic (rather than following from any presupposition or implicature computation). Examples of this sort are given in (24) and (25).

(24) a. "John knows that his father is going to receive a congratulation letter."
b. ⇝ John's father is going to receive a congratulation letter.

(25) a. "More than 3 of these 10 students read the class notes and did an exercise."
b. ⇝ More than 3 of these 10 students read (at least) one or the other.

The participants of the experiment gave a positive answer to 93.1% of the trials involving adverbial modification or presuppositions in such "harmless" profiles but only 73.2% of the time for the trials involving a scalar term. Arguably, this can be attributed to the fact that the alleged conclusion in cases of scalar implicatures systematically contains a weak scalar term (e.g., *some* in example (25)). Therefore, the proposed conclusion may systematically trigger the implicature that the original sentence is false since the latter is a stronger alternative to the former.

For instance, (25a) and (25b) are alternatives to each other (because of the scale between *some* and *every*) and the former is stronger than the latter. Therefore, an utterance of (25b) might trigger the implicature that (25a) is false. Thus, participants might reject the inference because, although the second sentence is indeed entailed by the first sentence, it triggers the implicature that the first sentence is false.

This seems to be true in 26.8% of these cases, despite our attempt to block such implicatures by inserting "*(at least)*" next to problematic scalar terms.

### 4.1.3 Summary: Safe methodology

Subjects provided very accurate responses to control items (despite the large number of 270 trials). Nevertheless, scalar implicature scores seem to suffer from independent factors. This prevents us from drawing conclusions from comparison of absolute scores of scalar implicatures and presuppositions for instance. Nevertheless, we can abstract away from this factor by comparing *relative* influences of some specific factor (let us say a change of projection profile) on different phenomena.

Overall, these control results ensure that the experimental paradigm is sound.

## 4.2 Presuppositions vs. scalar implicatures

The purpose of this section is to compare the projection behavior of presuppositions and scalar implicatures (cases of adverbial modifications are put aside in this section although the figures discussed do contain the associated results). The diagnostic tools used to reveal different projection properties have the following format: considering two minimally different projection profiles (e.g., $\langle John{\leadsto}John\rangle$ and $\langle NOT\ John{\leadsto}John\rangle$), does moving from one projection profile to the other influence presuppositions and scalar implicatures in the same way?

### 4.2.1 The role of negation

In section 2.2.2, I showed that both presuppositions and scalar implicatures project out of negation. Relevant examples which were actually present in the experiment are given in (26) and (27). Nonetheless, we can still ask how negation affects the robustness of each type of inference.

(26) Presupposition:

a. "John takes care of his computer." $\leadsto$ John has a computer.

b. "I doubt that John takes care of his computer." $\leadsto$ John has a computer.

(27) Scalar implicature:

a. "John passed all his exams." $\leadsto$ John passed some of his exams.

b. "I doubt that John passed all his exams." $\leadsto$ John passed some of his exams.

The results given in Figure 4 show that negation does not affect presuppositional inferences while it affects scalar implicatures (Cases of adverbial modifications are represented in these figures but should be ignored for the moment, they will be discussed in section 4.3). Indeed, a 2 x 2 ANOVA was run with main factors: 1) types of inference (presupposition vs. scalar implicature; as in (26) vs. (27)) and 2) projection profiles ($\langle John{\leadsto}John\rangle$ vs. $\langle NEG\ John{\leadsto}John\rangle$ as in (26a-27a) vs. (26b-27b)). The interaction is statistically significant: $F(1, 29) = 4.6$, $p < .05$.

In other words, negation preserves presuppositions while it *weakens* scalar implicatures. Importantly, inferences due to scalar items are derived both from positive and negative sentences (the respective acceptance rates are 74% and 51%). Scalar implicatures are less robust in negative sentences but nonetheless present (as expected). This result confirms that negation should not be considered as a powerful test to tease apart presuppositions from scalar implicatures since it would only rely on the relative optionality of these inferences. This might not be easily accessible to introspective judgments. This point is reinforced by results presented in section 4.3 below (subsection: *Focus and scalar implicatures*).

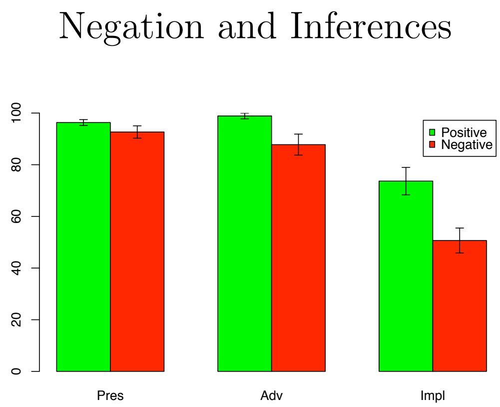


Figure 4: This figure represents the acceptance percentages for presuppositions ("Pres"), adverbial modifications ("Adv") and scalar implicatures ("Impl") in two projection profiles which differed by the fact that the utterance gets negated from one to the other (i.e. $\langle$*John*$\rightsquigarrow$*John*$\rangle$, referred to as "Positive" and $\langle$*NOT John*$\rightsquigarrow$*John*$\rangle$, referred to as "Negative").

#### 4.2.2 Universal inferences: the quantifier *No*

Which inferences project universally out of the scope of a quantifier, which inferences project as predicted by a scalar theory (as described in section 2.2.3)?

The relevant results for the quantifier *No* are presented in Figure 5. These results show that 1) for scalar implicatures, universal inferences are less endorsed than existential inferences; 2) for presuppositions there is no such difference[4]. Again, a 2 x 2 ANOVA (first factor: Presupposition vs. Implicature; second factor: $\langle$*No*$\rightsquigarrow$*At least one*$\rangle$ vs. $\langle$*No*$\rightsquigarrow$*Each*$\rangle$) reveals a statistically significant interaction: $F(1, 29) = 16.3$, $p < .05$.

These results show that the quantifier *No* provides a robust test to tease apart presuppositions and scalar implicatures: presuppositions project universally out of the scope of the quantifier *No* (acceptance rate: 84%) scalar implicatures do not project universally (acceptance rate: 28%).

#### 4.2.3 Universal inferences: the quantifier *Less than 3*

Figure 6 presents the corresponding results for the quantifier *Less than 3*. Again, the interaction (first factor: Presupposition vs. Implicature; second factor: $\langle$*Less than 3*$\rightsquigarrow$*At least 3*$\rangle$ vs. $\langle$*Less than 3*$\rightsquigarrow$*Each*$\rangle$) is significant ($F(1, 29) = 5.15$, $p < .05$) revealing that scalar implicatures project

[4] There seems to be a counterintuitive result: the acceptance rate of the universal inference (84%) is higher than the acceptance rate of the weaker existential inference (79%), this difference is not significant. Note however that would it be significant, it would reinforce the idea that presuppositions project universally and that recovering the existential conclusion from there should actually involve an additional step which might decrease the acceptance rate.

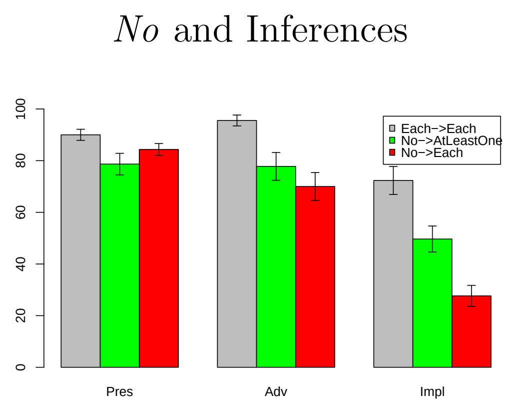


Figure 5: This figure represents the acceptance percentages for presuppositions ("Pres"), adverbial modifications ("Adv") and scalar implicatures ("Impl") in two projection profiles involving the quantifier *No*: ⟨*No*⇝*At least one*⟩ (which tests existential predictions, coming from scalar theories for instance) and ⟨*No*⇝*Each*⟩ (which tests universal predictions). The projection profile ⟨*Each*⇝*Each*⟩ is added to provide a visual baseline.

as a scalar theory would predict rather than universally and that presuppositions do not show such a preference.

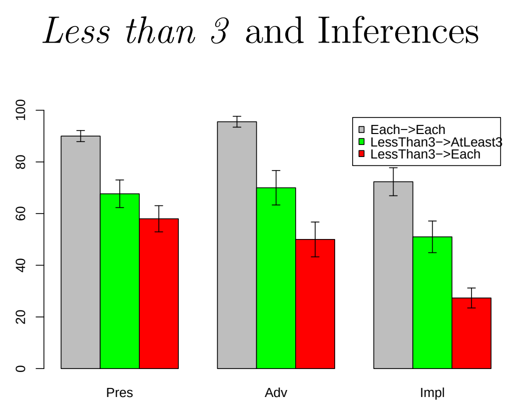


Figure 6: This figure represents the acceptance percentages for presuppositions ("Pres"), adverbial modifications ("Adv") and scalar implicatures ("Impl") in two projection profiles involving the quantifier *Less than 3*: ⟨*Less than 3*⇝*At least 3*⟩ (which tests predictions from scalar theories) and ⟨*Less than 3*⇝*Each*⟩ (which tests universal predictions). The projection profile ⟨*Each*⇝*Each*⟩ is added to provide a visual baseline.

#### 4.2.4 Summary

The results presented in this section show that the projection behaviors of presuppositions and scalar implicatures differ along three different tests. The analysis of the projection out of the scope of the quantifier *No* seems to provide the best diagnostic to tease the two types of inferences apart: presuppositions project universally, scalar implicatures don't.

### 4.3 Sub-types of inferences?

#### 4.3.1 Different presupposition triggers pattern alike

The results discussed in the previous section rely on the theoretical claim that the range of items that were analyzed as giving rise to presuppositional inferences behave uniformly with regard to their projection properties. Indeed, it could be that definite descriptions, factive verbs and change of state predicates show different properties. Three 3 x 2 ANOVAs were performed with these 3 sub-types of inferences as a first factor and each of the contrast of projection profiles used as diagnostic tools in the previous section, none of these interactions is significant: negation ($\langle \textit{John} \rightsquigarrow \textit{John} \rangle$ vs. $\langle \textit{NOT John} \rightsquigarrow \textit{John} \rangle$): $F(1,29) = .972$, $p = .38$; the quantifier *No* ($\langle \textit{No} \rightsquigarrow \textit{At least one} \rangle$ vs. $\langle \textit{No} \rightsquigarrow \textit{Each} \rangle$): $F(1,29) = .855$, $p = .43$; the quantifier *Less than 3* ($\langle \textit{Less than 3} \rightsquigarrow \textit{At least 3} \rangle$ vs. $\langle \textit{Less than 3} \rightsquigarrow \textit{Each} \rangle$): $F(1,29) = 1.17$, $p = .32$.

In sum, presuppositions triggered by different types of presupposition triggers project alike.

#### 4.3.2 Focus and scalar implicatures

Similarly, items involving a scalar term came in two varieties which might show different projection properties: in half of the items, the scalar terms were presented in capital letters to mimic focus. No interaction was found as to whether this focus influence the projection property out of the scope of the quantifiers *No* ($F(1,29) = 2.61$, $p = .12$) or *Less than 3* ($F(1,29) = .139$, $p = .71$). This shows that the projection properties of scalar implicatures remain those predicted by a scalar theory rather than universal, whether or not the scalar term is marked with (artificial) focus.

However, the interaction of this focus (capital letters vs. non capital letters) with negation ($\langle \textit{John} \rightsquigarrow \textit{John} \rangle$ vs. $\langle \textit{NOT John} \rightsquigarrow \textit{John} \rangle$) does reach significance: $F(1,29) = 8.56$, $p < .05$. In other words, the effect of negation on scalar implicatures is less important when the scalar term is focused.

A question naturally arises: the effects of negation on scalar implicatures are weakened when the scalar term is focused; are the effects of negation just as weak as they are for presuppositions? In other words, we saw before that negation affects presuppositions and scalar implicatures differently but this might only be due to cases of scalar implicatures where the scalar term is not focused. Indeed, the interaction of the type of inference (presupposition vs. scalar implicature) with negation ($\langle \textit{John} \rightsquigarrow \textit{John} \rangle$ vs. $\langle \textit{NOT John} \rightsquigarrow \textit{John} \rangle$) is not significant anymore when scalar implicatures are restricted to cases where the scalar term is in capital letters[5]: $F(1,29) = 0.906$; $p = 0.35$. This result definitely makes the point repeated in various occasions throughout this paper: negation does not distinguish presuppositions and scalar implicatures.

[5] This move does not affect the significance of the interactions with the projection profiles which involve quantifiers.

### 4.3.3 Another type of inference: Adverbial modification

Section 4.2 established that scalar implicatures and presuppositions project differently. Interestingly, the projection properties of cases of adverbial modifications do not differ from any of these two phenomena, despite their own difference. (The relevant statistical interactions are given in Table 2). In other words, cases of adverbial modifications are exactly intermediate between two different phenomena. The discussion of this result is left for the general discussion.

| | Negation<br>(⟨*John*⇝*John*⟩ vs.<br>⟨*I doubt that John*⇝*John*⟩) | Quantifier *No*<br>(⟨*No*⇝*At least one*⟩<br>vs. ⟨*No*⇝*Each*⟩) | Quantifier *Less than 3*<br>(⟨*Less than 3*⇝*At least 3*⟩<br>vs. ⟨*Less than 3*⇝*Each*⟩) |
|---|---|---|---|
| Adv. modif. vs. Presuppositions | $F(1,29) = 3.63$, $p = .067$ | $F(1,29) = 3.37$, $p = .077$ | $F(1,29) = 2.39$, $p = .13$ |
| Adv. modif. vs. Implicatures | $F(1,29) = 1.80$, $p = .19$ | $F(1,29) = 3.81$, $p = .061$ | $F(1,29) = .249$, $p = .62$ |

Table 2: Comparisons of different projection properties of presuppositions and scalar implicatures to cases of adverbial modification.

### 4.3.4 Summary (of the results)

The different presupposition triggers involved in the present experiment pattern similarly: definite descriptions, factive verbs and change of state predicates. Scalar implicatures project uniformly out of the scope of quantifiers independent of the fact that the scalar term be focused or not. Nonetheless, focusing the scalar term weakens the effects of negation which then mimicked cases of presuppositions.

It might be useful to spell out why these last results are consistent. Focus may weaken the optionality of scalar inferences and as such reduced the difference of presuppositions and scalar implicatures when the predictions coincide for both phenomena (i.e. for negation); nonetheless, focus has no effect on the possible inferences that might be triggered, in particular the inferences do not become universal: they might be more robust but not logically stronger.

Finally, adverbial modifications trigger inferences which projection properties are intermediate between scalar implicatures and presuppositions.

## 4.4 Quantifiers and existential/universal presuppositions

### 4.4.1 Acceptance rates

The acceptance rates of universal presuppositions associated with different quantifiers are reported in Figure 7. There is a difference between the rates of acceptance of universal presuppositions when they are triggered from the scope of *Each* and *No* on the one hand (87% of acceptance), and numerical quantifiers such as *Less than 3*, *More than 3* and *Exactly 3* on the other hand (53% of acceptance). A two-tailed t-test shows that difference is statistically significant: $F(1,29) = 53.8$, $p < .05$.

This result shows that while the universal presupposition is robustly triggered from the scope of *No*, the results are much less clear cut for other quantifiers where the acceptance rate oscillates close to 50%. Such a dissimilarity among quantifiers is not predicted by any major theory of presupposition projection. Furthermore, it seems that no formal theory of presupposition projection alone can explain why the acceptance rate is close to 50%.

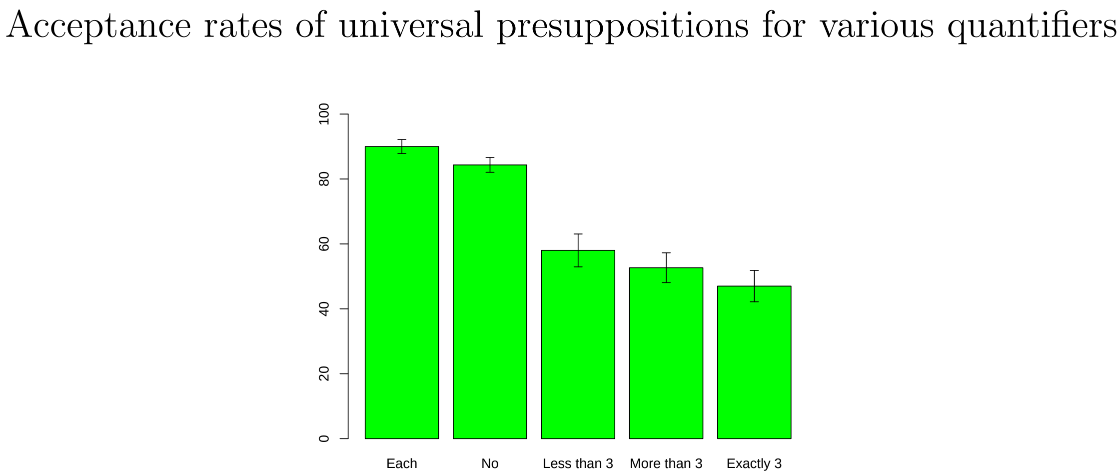


Figure 7: This figure presents the acceptance percentages of universal inferences when the presuppositional items are embedded in the scope of different quantifiers: *Each*, *No*, *Less than 3*, *More than 3* and *Exactly 3*.

Does it mean that presuppositions are weaker than universal and that they are sometimes reinforced? Does it mean that they are universal and that they are sometimes weakened or maybe sometimes difficult to retrieve? The next section provides preliminary processing results which should play an important role to settle this issue.

#### 4.4.2 Time responses

Let us assume that presuppositions are universal. The 50% type of acceptance rate in the case of numerical quantifiers might be explained by the existence of an independent and optional mechanism which could block or weaken these presuppositions. It then becomes reasonable to investigate the processing differences that can be found depending on whether the presupposition does come through (i.e. whether participants accept or reject the alleged universal presupposition).

The exact same question applies to scalar implicatures and already received important attention in psycholinguistics (Noveck and Posada, 2003; Bott and Noveck, 2004, Breheny, Katsos and Williams, 2006): deriving a scalar implicature requires an extra processing effort. In a nutshell, the form of the psycholinguistic argument is to show that given a stimulus, answers are provided faster when they do not involve any implicature computation, everything being equal. A parallel argument can be made for the present experiment: *yes* and *no* responses to a given item indicate exactly if an inference was drawn or not. Therefore, time differences between *yes* and *no* responses might indicate a difference in the processing time of the inference.

The relevant projection profiles to investigate this issue for presuppositions are those where a universal inference is proposed: ⟨*No*⇝*Each*⟩, ⟨*Less than 3*⇝*Each*⟩, ⟨*More than 3*⇝*Each*⟩, ⟨*Exactly 3*⇝*Each*⟩. Similarly, the relevant projection profiles to investigate the processing properties of scalar implicatures are those where the proposed inference matches the prediction of a usual theory of scalar implicatures (so that the acceptance of the inference indeed corresponds to the derivation of a scalar implicature): ⟨*No*⇝*At least one*⟩, ⟨*Less than 3*⇝*At least 3*⟩.

Next, it is standard to remove from the analysis reaction times which are particularly fast or slow. Indeed, particularly fast response times might correspond to automatic responses due to a lack of attention, imagine for concreteness a response below 200 ms when the task involves reading two long sentences. On the other hand, very slow response times might correspond to short breaks taken by the participants somewhere in the course of the 270 trials. Alternatively, one could say that slow response times might correspond to cognitive processes further away from normal conversation: imagine that a participant gets interested in one of the particular trial, because it reminds him of another trial or because it seems to raise some interesting issue, this participant might start to think about it and, if s/he thinks long and hard enough, might become a linguist. Linguists were banned from this experiment.

Eventually, every response times above 18,774ms (the mean response time 7,999ms plus 1.5 standard deviation 7,183ms) were disregarded from this analysis. Several other attempts were made and no qualitative difference was found.

Figure 8 represents the mean response times of the participants depending on their acceptance or rejection of the inference, both for presuppositions and scalar implicatures (for the respectively relevant projection profiles listed above).

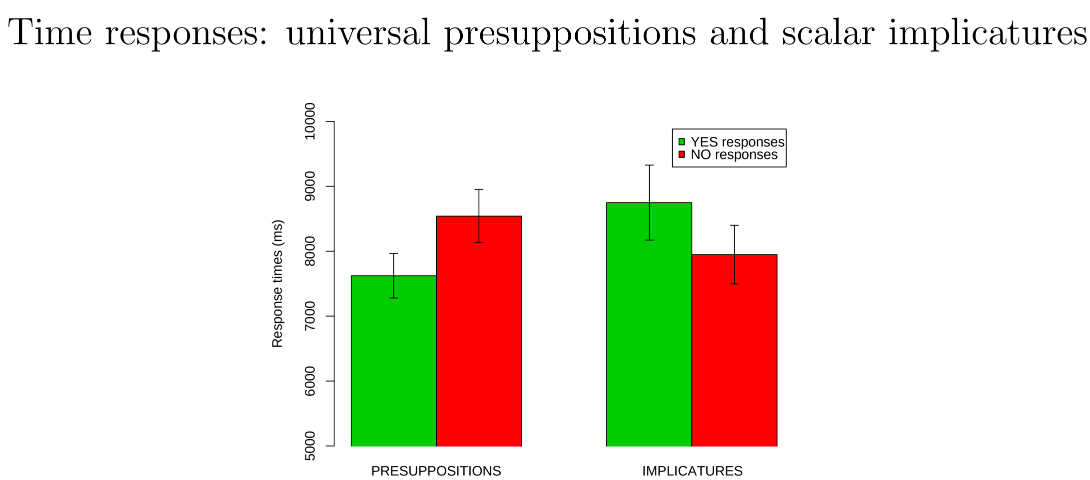


Figure 8: This figure represents the mean time responses for acceptance and rejection of universal inferences in the presuppositional cases (the profiles taken into account for presuppositions are: ⟨*No*⇝*Each*⟩, ⟨*Less than 3*⇝*Each*⟩, ⟨*More than 3*⇝*Each*⟩, ⟨*Exactly 3*⇝*Each*⟩) and for uncontroversial cases of scalar implicatures (profiles: ⟨*No*⇝*At least one*⟩, ⟨*Less than 3*⇝*At least 3*⟩).

The results for scalar implicatures confirm previous results showing that deriving a scalar implicature requires additional time but the difference between *yes* and *no* responses does not reach significance: $F(1,27) = 2.16$, $p = 0.15$. Interestingly, the pattern is reversed for presupposition: *rejecting* a presupposition requires an extra effort. This result is significant ($F(1,29) = 21.1$, $p < .05$) and so is the interaction between scalar implicatures and presuppositions ($F(1,27) = 9.16$, $p < .05$). Note that the asymmetry revealed by the statistically significant interaction also rules out potential yes- or no-biases (a tendency for one of the two answers to be faster for irrelevant factors, e.g., psychological bias towards saying yes, better reactivity of one hand, of one of the response buttons etc.).

#### 4.4.3 Summary

The data presented in this section are puzzling. First, it seems that inferences generated by a presupposition trigger embedded in the scope of a quantifier are sensitive to the quantifier: it is clearly universal for *No* but much less so for the numerical quantifiers *Less than 3*, *More than 3* and *Exactly 3*. No theory of presupposition projection presented in this paper predicts any such influence of the quantifier on a presupposition triggered from its scope.

Furthermore, the acceptance rates of the universal inferences proposed for the numerical quantifiers are very close to 50% which suggests that this inference could be optional. This seems to be very difficult to accommodate in a theory of presupposition projection. Should we claim that presupposition accommodation is optional? Could we characterize the cases where it is unnecessary? What would it mean then to say that these cases do trigger a presupposition? Does this suggest that the inferences which actually go through are not presuppositions?

Importantly, the results obtained in terms of processing show that when presupposition triggers do generate a universal inference, this inference comes for free. This seems to be compatible with a view where this inference is indeed a presupposition, and where presuppositions call for presupposition accommodation as early as possible in the process of understanding a sentence, although the effects of this accommodation might be undone at a latter stage (this retraction would account for the additional processing cost).

In the general discussion below, I discussed different theoretical amendments which one would need to develop to accommodate the whole range of facts obtained from this experiment.

## 5 General Discussion

In this section, I discuss the data established in the experiment described above. In section 5.1, I discuss the first set of results which establish a hierarchy between presuppositions, cases of adverbial modification and scalar implicatures. In section 5.2, I review a list of possibilities left open for current theories of presuppositions to accommodate the new facts presented here. My main purpose is not to provide an ultimate proposal but rather to discuss different tempting amendments to current theories of presupposition projection and the challenges they face: there is no happy ending yet.

### 5.1 Distinguishing different types of inferences

The results of this experiment firmly establish three main categorization facts: 1) the presuppositions triggered by different classes of presupposition triggers (definite descriptions, factive verbs and change of state predicates) project similarly; 2) scalar implicatures and presuppositions project differently in quantified contexts; 3) inferences due to adverbial modification are intermediate between presuppositions and scalar implicatures.

This typology is not surprising although the last point deserves particular attention. The difference between scalar implicatures and presuppositions is theoretically clear: scalar inferences are enrichments of the bare meaning of a sentence, inferences driven by means of presuppositions involve a repair strategy which consists in accepting that certain conditions must be met to make sense of what a speaker said. What does it mean then to say that adverbial modification behaves intermediately between those two very different phenomena?

At this point, it is important to make explicit that the hierarchy between the phenomena only holds with regard to some of their specific properties. In particular, presuppositions have only been investigated through a very specific manifestation: accommodation. What constraints or preconditions do presuppositions impose on the so-called common ground? What types of inferences do they trigger: that the alleged conclusion is true? that it is true and uncontroversial? This is impossible to tell on the basis of this study.

Thus, the intriguing typology established for the projection properties of presupposition, adverbial modification and scalar implicatures might suggest that a subpart of the system which handles projection of these inferences is common for all of these phenomena but it does not have to say anything about the fundamental status of these phenomena and the way they come into existence in the first place (e.g., alternatives, seek for relevance etc.).

Two promising directions of analysis must be acknowledged. First, the adverbial modifications involved in this experiment were systematically sentence final. As such, the modifier might be interpreted in a focus position and this might provide an explanation for the inferences observed, see in particular Schwarzschild (1999). Second, Schlenker (2006) suggests that cases of adverbial modification are *Quasi-Presuppositions*: they do trigger presuppositions, these presuppositions are somewhat less robust because of particular syntactic properties of these constructions.

To conclude with these intriguing cases, let me just restate the open question they raise: how should we explain the inferences triggered by adverbial modification in order to account for its similarities with both scalar implicatures and presuppositions?

## 5.2 Theoretical amendments

Presuppositions yield universal inferences when triggered from the scope of *No*; from the scope of a numerical quantifier (i.e. *Less than 3*, *More than 3* and *Exactly 3*), presuppositions yield a universal inference about half of the time. None of the theories above predicts this pattern; I review in this section the theoretical possibilities left.

### 5.2.1 Enriching existential presuppositions

Let us first assume a theory which predicts existential presuppositions for every quantifier: this is the weakest possible prediction and might thus be the safest. Note that theories of enrichment of presuppositions seem to be necessary for independent problems: some presuppositions triggered in the consequent of conditional sentences are regularly reinforced when they are accommodated (this is known as the *proviso problem*, see Geurts, 1999 and most recently Pérez Carballo, 2006).

To account for the facts described here, one would then have to describe and motivate an enrichment mechanism which first explains how a weak existential presupposition can license a (stronger) universal inference. Importantly, the effects of this mechanism should be optional in presence of numerical quantifiers and mandatory in presence of the quantifier *No*.

Let me entertain the most obvious possibility. A contextual "uniformity assumption" among the 10 students involved in the utterance would enrich any existential statement into a universal statement: since all students behave similarly, as soon as one did X they might as well all have done X[6]. It seems natural to expect this reasoning to be optional in cases of numerical quantifiers: stating that three students did something is already casting doubt on the alleged uniformity assumption. Unfortunately, what could be the status of this contextual assumption? Importantly, one would have to explain why it enriches inferences triggered by presuppositions but not scalar implicatures. Indeed, scalar term in the scope of *No* trigger existential implicatures but they do not turn into universal inferences.

In other words, starting from existential presuppositions, one would have to explain how they systematically get enriched in some cases and not in others and why similar existential inferences escape such enrichments. It seems unlikely to me that such an explanation can be easily found. Note also that this type of enrichment in general seems to predict a reversed processing pattern than the one attested here: deriving universal inferences would require an additional cognitive step.

### 5.2.2 Problematic accommodation of universal presuppositions

Would a theory predicting universal presuppositions be in a better position? The challenge is now to explain why presuppositions are not systematically accommodated. Note that this challenge does not interfere with scalar implicatures as above (i.e. the question of whether scalar implicatures are similarly weakened does not arise since scalar implicatures are never claimed to be universal). Furthermore, the data for the quantifier *No* go exactly as predicted.

There remains to explain why these presuppositions are weakened or not accommodated in cases of numerical quantifiers. Schlenker (2007) describes the technical details of a theory of presupposition projection which might provide an explanation. Indeed, this theory predicts universal presuppositions for every quantifier but the presuppositions come out in different shapes for the different quantifiers. Appendix E shows that retrieving a universal statement in the case of numerical quantifiers might involve steps which can be avoided in the case of the quantifier *No*. Thus, the 50% of rejection of the universal inferences might correspond to cases where the accommodation process does not terminate.

A proper formulation of such a theory is rather involved because it relies on potential difficulties of the accommodation process and still, should account for the processing facts: when accommodation leads to a universal inference, it is costless. I leave it to the (very) interested reader to evaluate the viability of this proposal spelled out in Appendix E.

Before leaving the universal presuppositions camp, I would like to suggest that other types of explanation are conceivable. It seems plausible that the proper explanation should involve a cancellation of a routine process of accommodation. For instance, it might be that participants sometimes realize (consciously or not) the ambiguity of the sentences with plural quantifiers and might thus hesitate to validate the conclusion.

A more elaborated version of such a theory was suggested to me by Bart Geurts. Numerical quantifiers might introduce a discourse referent which is a subset of the 10 students specified in the

[6] Schwarzschild (1994), Loebner (1995), Beck (2001) and Gajewski (2005) argued that such an assumption could come out as a regular presupposition.

sentence. The (still universal) presupposition might then either apply to this subset of students or to the whole group of students, explaining the distribution of responses for these cases. Taking this proposal to further tests requires more detailed explanations on how these discourse referents are introduced and what particular properties they inherit (e.g., how does the size of the subset depends on the quantifier?).

### 5.2.3 Presuppositions depend on the quantifier

Eventually, it is also tempting to conclude that presuppositions project differently from the scope of *No* and from the scope of numerical quantifiers. A theory predicting such variations, say theory T, would face difficult challenges.

Theory T should first explain why the projection properties driven by different quantifiers differ. In particular, it would ideally have to predict how these differences may or may not vary cross-linguistically and how these variations can be acquired by children. For these particular issues, the framework of dynamic semantics used in the theories described in section 2.1.1 is not of any help.

It seems also natural to expect theory T to predict that *No* robustly allows universal presuppositions. But what is the presupposition of the sentences involving a numerical quantifier then? If it is not universal, theory T would have to exhibit a mechanism which optionally supplies its prediction to derive a universal inference in half of the trials. Theory T would then face most of the difficulties described above for a theory predicting existential presuppositions across the board.

# 6 Conclusion

This work was motivated by an empirical controversy coming from formal investigations of linguistic presuppositions. I argued that this dilemma should be tackled with empirical means. I proposed an experimental paradigm relying on accommodation. The results show that the projection properties of presuppositions and scalar implicatures differ significantly and, in particular, the quantifier *No* provides the appropriate test to tease the two phenomena apart (as opposed to simple negation). The results also show that the way presuppositions project out of the scope of a quantifier depends on the quantifier involved and without an appropriate theory of accommodation, this contradicts the leading theories of presupposition projection. Further theoretical work is needed to produce a theory capable of finer-grained predictions or to mesh present theories with a better understanding of potential interferences due to presupposition accommodation.

Importantly, the experimental paradigm proposed here proved to be powerful and ascertained subtle facts on presupposition projection. This is very encouraging and suggests that other puzzles should be investigated similarly. For instance, could we entertain a theory which would predict numerical presuppositions (e.g., *at least $x$ out of these 10 students...*)? How would this $x$ depend on the quantifier or on the overall number of individuals involved? At the very least, the methodology proposed here should help establish further controversial facts: how do presuppositions project out of the scope of an indefinite quantifier? how do they project out of the restrictors of quantifiers? how do they behave when they contain scalar terms (is the scalar term enriched in the presupposition)?

**APPENDICES**

# A Deriving universal/existential presuppositions

How can we derive the presupposition of a quantified sentence such as (28) from the presupposition $ps[S(x)]$ of $S(x)$? In this appendix, I repeat Heim (1983) and Beaver (2001)'s solutions, see Kadmon (2001, chapter 10) for discussion.

(28) $[\mathcal{Q}x : R(x)]\, S(x)$

## A.1 Universal presuppositions: Heim (1983)

Heim (1983) predicts a universal presuppositions: **every** individual which satisfies the restrictor should satisfy the presuppositions of the scope: $[\forall x : R(x)]\, ps[S(x)]$. This follows from the general *admittance* condition for any sentence $S$ with presupposition $ps[S]$ in a context $c$ in (29), where $\langle g, w\rangle$ is a pair of assignment function $g$ and world $w$:

(29) $\forall \langle g, w\rangle \in c$, $\exists g' \supseteq g$ s.t. $\langle g', w\rangle \in c + ps[S]$

This admittance condition then applies "incrementally" to sentences of the form (28). For the presupposition triggered in the scope of the quantifier to be harmless, it must be admissible in the initial context updated with the restrictor: $c + R(x)$:

(30) $\forall \langle g, w\rangle \in c + R(x)$, $\exists g' \supseteq g$ s.t. $\langle g', w\rangle \in (c + R(x)) + ps[S(x)]$

The expression "$\exists g' \supseteq g$" is responsible for the universal force of the presupposition: roughly, it eventually forces the existence of a *superset* of the individuals satisfying the restrictor to satisfy the presupposition of the scope.

## A.2 Existential presuppositions: Beaver (1994, 2001)

This phrase "$\exists g' \supseteq g$" is absent from Beaver (2001)'s admittance condition (see (31)). This ends up in the admissibility condition in (32) for sentence (28) in a context $c$. A set of individuals where one satisfies both the restrictor and the presupposition of the scope can produce an assignment function $g'$ as the one needed to satisfy (32).

(31) $\forall \langle g, w\rangle \in c$, $\exists g'$ s.t. $\langle g', w\rangle \in c + ps[X]$

(32) $\forall \langle g, w\rangle \in c + R(x)$, $\exists g'$ s.t. $\langle g', w\rangle \in (c + R(x)) + ps[S(x)]$

# B Scalar presuppositions?

I present here some more details of the toy scalar theory of presuppositions introduced in section 2.2.3. The main postulates are as follows. A presuppositional expression $S_p$ (e.g., *x knows p*) receives a bivalent meaning equivalent to *p and a* where *a* is the usual assertive content of the expression (e.g., *p and x believes p*). The presupposition *p* is always an alternative to this expression (e.g., *p* is an alternative to *x knows p*). Note that this alternative is weaker than the meaning of the expression.

This now predicts that presuppositions should project as "indirect" scalar implicatures (implicatures due to a *strong* term in a scale, as in sentences with the word *all*). The derivations of the predictions for different quantifiers are given below. Actual sentences are given for concreteness but problems explained in section 2.1.2 are disregarded for simplicity. Note also that when the alternative is weaker than the original sentence, no additional inference is predicted, in this case I report the inference driven by the meaning of the sentence alone (recall that presuppositions are now part of the meaning of presuppositional expressions).

(33) John knows that he is lucky.

a. Schematically: $S_p(John)$
b. Alternative (weaker): $p(John)$
c. Presupposition: $p(John)$ (already entailed by the bare meaning of the sentence)
(i.e. *John is lucky*)

(34) I doubt that John knows that he is lucky.

a. Schematically: $\neg S_p(John)$
b. Alternative (stronger): $\neg p(John)$
c. Presupposition: $\neg\neg p(John)$, i.e. $p(John)$
(i.e. *John is lucky*)

(35) No student knows that he is lucky.

a. Schematically: $[No\ x : R(x)]\, S_p(x)$
b. Alternative (stronger): $[No\ x : R(x)]\, p(x)$
c. Presupposition: $\neg([No\ x : R(x)]\, p(x))$, i.e. $[\exists x : R(x)]\, p(x)$
(i.e. *At least one student is lucky*)

(36) More than 3 students know that they are lucky.

a. Schematically: $[More\ than\ 3\ x : R(x)]\, S_p(x)$
b. Alternative (weaker): $[More\ than\ 3\ x : R(x)]\, p(x)$
c. Presupposition: $[More\ than\ 3\ x : R(x)]\, p(x)$ (already entailed by the sentence)
(i.e. *More than 3 students are lucky*)

(37) Less than 3 students know that they are lucky.

a. Schematically: $[Less\ than\ 3\ x : R(x)]\, S_p(x)$
b. Alternative (stronger): $[Less\ than\ 3\ x : R(x)]\, p(x)$
c. Presupposition: $\neg([Less\ than\ 3\ x : R(x)]\, p(x))$, i.e. $[At\ least\ 3\ x : R(x)]\, p(x))$
(i.e. *At least three students are lucky*)

(38) Exactly 3 students know that they are lucky.

a. Schematically: $[Exactly\ 3\ x : R(x)]\, S_p(x)$
b. Alternative (unordered): $[Exactly\ 3\ x : R(x)]\, p(x)$
c. Presupposition $[At\ least\ 3\ x : R(x)]\, p(x)$ (already entailed by the bare meaning of the sentence)
(i.e. *At least three students are lucky*)

## C Instructions

I reproduce the instructions provided to the participants before the experiment. The context provided and the way the word *suggérer* is clarified are the methodological points of main interest.

## C.1 Actual (French) version

Bonjour et merci pour votre participation.

Imaginez la situation suivante:

*Après une session d'examens dans toutes les matières, 5 ou 6 professeurs viennent de rencontrer individuellement une dizaine des étudiants de leur classe (dont un certain Jean par exemple) et ces professeurs se retrouvent pour en discuter, informellement. Ces professeurs sont très bien informés sur leurs étudiants, honnêtes, justes...*

Vous allez alors voir des paires de phrases s'afficher à l'écran:

| |
|---|
| "Jean et Marie ont eu la moyenne partout" |
| *suggère que:* |
| Jean a eu la moyenne partout. |
| *NON?* *OUI?* |

Nous vous demandons de considérer qu'un des professeurs dit la première phrase ("Jean et Marie ont eu la moyenne partout.") et d'indiquer alors s'il est naturel, à partir de cette phrase, de penser que Jean a eu la moyenne partout (comme il est écrit plus bas dans l'exemple encadré). Comme les professeurs auxquels nous avons affaire sont bien informés, vous répondrez sans doute OUI dans ce cas.

Les exemples ne seront pas toujours si clairs cependant et nous vous demandons votre jugement intuitif. Prenons un autre exemple, si le professeur dit: "Lundi, en cours, Jean a posé une très bonne question et a insulté un camarade.", il suggère notamment que Jean a posé sa question avant d'insulter son camarade (et si c'est bien votre sentiment vous appuierez alors sur OUI). Ce n'est pas nécessairement votre intuition ici, cet exemple vous montre que nous ne vous demandons pas de calculs savants mais, encore une fois, vos jugements intuitifs.

Dernières remarques:

- Vous devez considérer que les exemples sont absolument indépendants. Vous devez les oublier au fur et à mesure et baser votre intuition uniquement sur la phrase 'prononcée' (et le contexte général décrit plus haut). Ne vous laissez donc influencer ni par ce que vous avez lu auparavant, ni par vos propres réponses précédentes.

- Vous aurez peut-être aussi l'impression d'avoir déjà vu certains exemples (beaucoup se ressemblent). Ceci n'a aucune importance, répondez toujours en suivant votre jugement intuitif pour l'exemple particulier.

- Certains mots apparaîtront en majuscules, vous devez SIMPLEMENT imaginer que ces mots ont été accentués oralement.

- Positionnez vos mains pour être prêt(e) à appuyer sur la touche appropriée aussitôt que vous vous serez fait un avis. Vous allez avoir à répondre à de nombreux exemples. C'est une raison supplémentaire pour répondre rapidement en suivant votre première intuition (en évitant bien sûr la précipitation excessive).

### C.2 English translation

Hello and thank you for your participation.

Imagine the following situation:

*After an exam session in every topic, 5 or 6 teachers just met individually with 10 students of their class (including one called John, for instance) and these teachers get together to talk about it, informally. These teachers are very well informed about their students, honest, fair...*

You are going to see pairs of sentences on the screen:

> "John and Mary succeeded in every topic"
>
> *suggests that:*
>
> John succeeded in every topic.
>
> *NO?* *YES?*

We ask you to consider that one of the teachers say the first sentence ("John and Mary succeeded in every topic") and to indicate if it is natural, from this sentence, to think that John succeeded in every topic (as written at the bottom of the frame). Since teachers involved here are well-informed, you might very well answer YES in this case.

Nevertheless, the examples will not all be so clear and we are asking you for your own intuitive judgment. Let us take an example, if the teacher says: "Monday, in class, John asked a very good question and insulted a fellow student.", this may suggest in particular that John asked a very good question before insulting his fellow student (and if it is indeed your feeling you will press YES). It is not necessary your intuition here, this example shows that we are not asking for sophisticated computations but, again, for your intuitive judgments.

Last remarks:

- You must consider that the examples are absolutely independent. You must forget them as the experiment goes and provide your intuition on the only basis of the sentence uttered (and the general context described above). Do not let previous trials or your own previous responses influence your responses.
- You might think that some examples already occurred (many examples look like each others). This has no importance, answer following your intuitive judgment for the particular example you see.
- Some words are written in capital letters, you should SIMPLY imagine that these words are orally stressed.
- Position your hands to be ready to push the appropriate key as soon as you made up your mind. You are going to face many examples. This is an additional reason to answer quickly following your first intuition (avoiding excessive precipitation, of course).

## D Material

The material was constructed by combining *projection profiles* (i.e. pairs of linguistics environments) with inferences. I provide the list of inferences used in the experiment embedded under the profile

$\langle \textit{John} \rightsquigarrow \textit{John} \rangle$. The rest of the items can be constructed from this by extracting the inference and embedding it under the other profiles. Formally, when the embedding environment involves a quantifier, one might want to replace *John* by a free variable and get this free variable bound in the scope of this quantifier, while its restrictor designates a set of 10 students.

(39) Definite description

a. "Jean prend soin de son ordinateur." $\rightsquigarrow$ Jean a un ordinateur.
"John takes good care of his computer." $\rightsquigarrow$ John has a computer.

b. "Jean maltraite son ordinateur." $\rightsquigarrow$ Jean a un ordinateur.
"John takes bad care of his computer." $\rightsquigarrow$ John has a computer.

(40) Factive verb

a. "Jean sait que son père va être convoqué." $\rightsquigarrow$ Le père de Jean va être convoqué.
"John knows that his father is about to be appointed." $\rightsquigarrow$ John's father is about to be appointed.

b. "Jean sait que son père va recevoir une lettre de félicitations."
$\rightsquigarrow$ Le père de Jean va recevoir une lettre de félicitations.
"John knows that his father is about to receive a congratulation letter."
$\rightsquigarrow$ John's father is about to receive a congratulation letter.

c. "Jean ignore que son père va être convoqué." $\rightsquigarrow$ Le père de Jean va être convoqué.
"John is unaware that his father is about to be appointed." $\rightsquigarrow$ John's father is about to be appointed.

d. "Jean ignore que son père va recevoir une lettre de félicitations."
$\rightsquigarrow$ Le père de Jean va recevoir une lettre de félicitations.
"John is unaware that his father is about to receive a congratulation letter."
$\rightsquigarrow$ John's father is about to receive a congratulation letter.

(41) Change of state predicate

a. "Au 2ème trimestre, Jean a commencé à s'appliquer."
$\rightsquigarrow$ Au 1er trimestre, Jean ne s'appliquait pas.
"In the second term, John started being serious." $\rightsquigarrow$ In the first term, John was not serious.

b. "Au 2ème trimestre, Jean a commencé à s'inquiéter."
$\rightsquigarrow$ Au 1er trimestre, Jean ne s'inquiétait pas.
"In the second term, John started worrying." $\rightsquigarrow$ In the first term, John was not worried.

c. "Au 2ème trimestre, Jean a arrêté de s'appliquer."
$\rightsquigarrow$ Au 1er trimestre, Jean s'appliquait.
"In the second term, John stopped being serious." $\rightsquigarrow$ In the first term, John was serious.

d. "Au 2ème trimestre, Jean a arrêté de s'inquiéter."
$\rightsquigarrow$ Au 1er trimestre, Jean s'inquiétait.
"In the second term, John stopped worrying." $\rightsquigarrow$ In the first term, John worried.

(42) Scalar implicature

a. "Jean a réussi tous ses examens." $\rightsquigarrow$ Jean a réussi plusieurs de ses examens.
"John passed all his exams." $\rightsquigarrow$ John passed several of his exams.

b. "Jean a raté tous ses examens." $\rightsquigarrow$ Jean a raté plusieurs de ses examens.
"John failed all his exams." $\rightsquigarrow$ John failed several of his exams.

c. "Jean a lu le cours et fait un exercice." $\rightsquigarrow$ Jean a fait (au moins) l'un des deux.
"John read the class notes and did an exercise." $\rightsquigarrow$ John did (at least) one or the other.

d. "Jean a manqué un cours et un examen." $\rightsquigarrow$ Jean a manqué (au moins) l'un des deux.
"John missed one class and one exam." $\rightsquigarrow$ John missed (at least) one or the other.

e. "Jean est excellent." $\rightsquigarrow$ Jean est bon.
"John is excellent." $\rightsquigarrow$ John is good.

(43) Scalar implicature with "focus"

a. "Jean a réussi TOUS ses examens." $\rightsquigarrow$ Jean a réussi plusieurs de ses examens.
"John passed ALL his exams." $\rightsquigarrow$ John passed several of his exams.

b. "Jean a raté TOUS ses examens." $\rightsquigarrow$ Jean a raté plusieurs de ses examens.
"John failed ALL his exams." $\rightsquigarrow$ John failed several of his exams.

c. "Jean a lu le cours ET fait un exercice." $\rightsquigarrow$ Jean a fait (au moins) l'un des deux.
"John read the class notes AND did an exercise." $\rightsquigarrow$ John did (at least) one or the other.

d. "Jean a manqué un cours ET un examen." $\rightsquigarrow$ Jean a manqué (au moins) l'un des deux.
"John missed a class and an exam." $\rightsquigarrow$ John missed (at least) one or the other.

e. "Jean est EXCELLENT." $\rightsquigarrow$ Jean est bon.
"John is excellent." $\rightsquigarrow$ John is good.

(44) Adverbial modification

a. "Jean a voté pour Paul." $\rightsquigarrow$ Jean a voté.
"John voted for Paul." $\rightsquigarrow$ John voted.

b. "Jean a voté pour PAUL." $\rightsquigarrow$ Jean a voté.
"John voted for PAUL." $\rightsquigarrow$ John voted.

c. "Lundi, Jean est arrivé en retard." $\rightsquigarrow$ Jean est venu (lundi).
"On Monday, John arrived late." $\rightsquigarrow$ John came (on Monday).

(45) Entailment

a. "Jean est français." $\rightsquigarrow$ Jean est européen.
"John is French." $\rightsquigarrow$ John is European

b. "Jean est européen." $\rightsquigarrow$ Jean est français.
"John is European." $\rightsquigarrow$ John is French.

c. "Jean aime toutes les matières." $\rightsquigarrow$ Jean aime les maths.
"John likes every topic." $\rightsquigarrow$ John likes Math.

d. "Jean aime les maths." $\rightsquigarrow$ Jean aime toutes les matières.
"John likes Math." $\rightsquigarrow$ John likes every topic.

## E The transparency theory, difficult accommodation

Schlenker (2006)'s projection theory of presupposition predicts that a sentence of the form in (46) presupposes (47) (the equivalence is supposed to be a contextual equivalence but it will not matter for our purposes). In a nutshell, this formula guarantees that replacing the presuppositional expression by its presupposition $p$ conjoined with any expression $\beta$ (i.e. abstracting away from the assertive content of the expression) is equivalent to replacing this expression by $\beta$ alone (i.e. the contribution of the presupposition is null).

(46) $[\mathcal{Q}x : R(x)]\, S_p(x)$

(47) $\forall\beta,\ [\mathcal{Q}x : R(x)]\, \beta(x) \leftrightarrow [\mathcal{Q}x : R(x)]\, (p \wedge \beta)(x)$

The prediction in (47) is equivalent to a universal presupposition. The claim in this appendix is that it is qualitatively different to recognize that this prediction is indeed equivalent to a universal presupposition when the quantifier is *No* on the one hand and when it is a numerical quantifier. Note that I will only focus on showing that this prediction entails the universal presupposition (see Schlenker, 2007 for general results).

### E.1 The quantifier *No*

To recognize that (47) entails the universal presupposition, one only has to replace $\beta$ by the predicate $\neg p$. This is proved in (48).

(48) a. Prediction: $\forall\beta,\ [No\ x : R(x)]\, \beta(x) \leftrightarrow [No\ x : R(x)]\, (p \wedge \beta)(x)$
i.e. $\forall\beta$, $\text{Card}([\![R]\!] \cap [\![\beta]\!]) = 0 \leftrightarrow \text{Card}([\![R]\!] \cap [\![p]\!] \cap [\![\beta]\!]) = 0$

b. For we can take $\beta$ being $\neg p$, this entails:
$\text{Card}([\![R]\!] \cap [\![\neg p]\!]) = 0 \leftrightarrow \text{Card}([\![R]\!] \cap [\![p]\!] \cap [\![\neg p]\!]) = 0$
The right-hand side of this equivalence is trivially true since $[\![p]\!] \cap [\![\neg p]\!] = \emptyset$, thus the left-hand side must also hold:
$\text{Card}([\![R]\!] \cap [\![\neg p]\!]) = 0$
i.e. No individual satisfies both $R$ and $\neg p$
i.e. Every individual which satisfies $R$ satisfies $p$.

In other words, the universal presupposition is retrieved in one instantiation of the predicate $\beta$.

### E.2 Numerical quantifiers

The same type of reasoning does not seem to be sufficient to derive the universal presupposition for the other numerical quantifiers. Let us look at the quantifier *Less than 3*, the other quantifiers (*More than 3* and *Exactly 3*) behave similarly. The prediction is given in (49).

(49) Prediction for the quantifier *Less than 3*:
$\forall\beta$, $\text{Card}([\![R]\!] \cap [\![\beta]\!]) < 3 \leftrightarrow \text{Card}([\![R]\!] \cap [\![p]\!] \cap [\![\beta]\!]) < 3$

No combination (disjunction or conjunction) of $R$, $p$ and their negations lead to the universal presupposition in one step. For instance, if we replace $\beta$ with $\neg p$ as above, we only obtain that $\text{Card}([\![R]\!] \cap [\![\neg p]\!]) < 3$ which leaves open the possibility that one or two individuals may satisfy $R$ and not the presupposition $p$.

So, retrieving the universal presupposition from (49), requires a different strategy: 1) No $\beta$ is sufficient *per se* to obtain the universal presupposition; 2) We need to accept that $\beta$ can be any triplet of individuals (or at least enough triplets to cover all the individuals). A full derivation of this universal presupposition is given in (50). An incomplete proof that no instantiation of $\beta$ can provide the universal presupposition follows in (51). This last proof is not fully general: I claim that the problem does not change if the set of potential $\beta$ is restricted to certain propositions.

(50) Full derivation of the universal presupposition from (49):
Let $\beta_1$ designates a set of 3 individuals satisfying $R$. If we take $\beta$ to be this $\beta_1$ in (49), the left-hand side of the equivalence is a contradiction. From the right-hand side, we then conclude that the three individuals in $\beta_1$ all satisfy $p$ since we need to keep them all in the set of individuals on the right-hand side. Doing this with sufficiently enough such triplets $\beta_1$, we obtain that all the individuals in $R$ satisfy the presupposition $p$.

(51) Partial proof that a single $\beta$ is not enough to retrieve the universal presupposition for presupposition triggers in the scope of the quantifier *Less than 3*.

a. For any $\beta$, $\Phi(\beta)$ stands for: $\text{Card}(\llbracket R\rrbracket \cap \llbracket \beta\rrbracket) < 3 \leftrightarrow \text{Card}(\llbracket R\rrbracket \cap \llbracket p\rrbracket \cap \llbracket \beta\rrbracket) < 3$.

b. **I claim (without any proof being available)** that the set of $\beta$ which could work is constituted by the boolean combinations of $R$, $p$ and any given set of individuals. The rest of the proof consists in showing that no such $\beta$ is convenient (i.e. no $\beta$ is such that $\Phi(\beta)$ is equivalent to the universal presupposition).

c. Having $R$ in the formula is useless:
   i. If $\beta \equiv R$: $\Phi(\beta)$ is equivalent to $\text{Card}(\llbracket R\rrbracket \cap \llbracket p\rrbracket) \geq 3$ which is inconclusive;
   ii. If $\beta \equiv R \wedge \alpha$: $\Phi(\alpha)$ is stronger than $\Phi(\beta)$, and such $\beta$ are ruled out for the same reasons which may rule out the case of $\beta \equiv \alpha$;
   iii. If $\beta \equiv R \vee \alpha$: $\Phi(\beta)$ is equivalent to $\Phi(R)$.

d. Having $\neg R$ in the formula is useless:
   i. If $\beta \equiv \neg R$ or $\beta \equiv \neg R \wedge \alpha$: $\Phi(\beta)$ is tautologous;
   ii. If $\beta \equiv \neg R \vee \alpha$: $\Phi(\beta)$ is equivalent to $\Phi(\alpha)$.

e. Having $p$ in the formula is useless:
   i. If $\beta \equiv p$ or $\beta \equiv p \wedge \alpha$: $\Phi(\beta)$ is tautologous;
   ii. If $\beta \equiv p \vee \alpha$: $\Phi(\beta)$ is $\text{Card}(\llbracket R\rrbracket \cap \llbracket p \vee \alpha\rrbracket) < 3 \leftrightarrow \text{Card}(\llbracket R\rrbracket \cap \llbracket p\rrbracket) < 3$.
   This equivalence is entailed by $\text{Card}(\llbracket R\rrbracket \cap \llbracket p\rrbracket) \geq 3$ which is inconclusive.

f. $\beta$s which simply refer to a set of individuals are inconclusive:
   i. If $\llbracket \beta\rrbracket \not\subseteq \llbracket R\rrbracket$: $\Phi(\beta)$ is equivalent to $\Phi(\beta \wedge R)$;
   ii. If $\llbracket \beta\rrbracket \subseteq \llbracket R\rrbracket$ and $\text{Card}(\llbracket \beta\rrbracket) < 3$: $\Phi(\beta)$ is tautologous;
   iii. If $\llbracket \beta\rrbracket \subseteq \llbracket R\rrbracket$ and $\text{Card}(\llbracket \beta\rrbracket) \geq 3$: $\Phi(\beta)$ is equivalent to $\text{Card}(\llbracket \beta \wedge p\rrbracket) \geq 3$: this is inconclusive;

g. Eventually, $\neg p$ does not help either:
   i. If $\beta \equiv \neg p$: $\Phi(\beta)$ is equivalent to $\text{Card}(\llbracket R \wedge \neg p\rrbracket) < 3$ inconclusive;
   ii. If $\beta \equiv \neg p \wedge \alpha$: $\Phi(\beta)$ is weaker than $\Phi(\neg p)$;
   iii. The last possibility is $\beta \equiv \neg p \vee \gamma$ where $\gamma$ is a given set of individuals. We can assume that $\llbracket \gamma\rrbracket \subseteq \llbracket R\rrbracket$ (or replace it with $\gamma \vee R$).
   • If $\text{Card}(\llbracket \gamma\rrbracket) \geq 3$: $\Phi(\beta)$ is equivalent to the inconclusive $\text{Card}(\llbracket p \vee \gamma\rrbracket) \geq 3$;
   • If $\text{Card}(\llbracket \gamma\rrbracket) < 3$: $\Phi(\beta)$ is equivalent to $\text{Card}(\llbracket R\rrbracket \cap \llbracket \neg p \vee \gamma\rrbracket) < 3 \leftrightarrow \text{Card}(\llbracket R\rrbracket \cap \llbracket p\rrbracket \cap \llbracket \gamma\rrbracket) < 3$. The right-hand side is necessarily true and we are left with the left-hand side being true, this is equivalent to $\llbracket \neg p\rrbracket \subseteq \gamma$ which is inconclusive. Ouf.

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