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# Presuppositions of quantified sentences: experimental data

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**Abstract** Some theories assume that sentences like (i) with a presupposition trigger in the scope of a quantifier carry an existential presupposition, as in (ii); others assume that they carry a universal presupposition, as in (iii).

(i) No student knows that he is lucky.
(ii) Existential presupposition: At least one student is lucky.
(iii) Universal presupposition: Every student is lucky.

This work is an experimental investigation of this issue in French. Native speakers were recruited to evaluate the robustness of the inference from (i) to (iii). The main result is that presuppositions triggered from the scope of the quantifier *aucun*'no' are in fact universal. But the present results also suggest that the presuppositions triggered from the scope of other quantifiers depend on the quantifier. This calls for important changes in the main theories of presupposition projection.

**Keywords** Presupposition · Scalar implicature · Quantifier · Experiment

## 1 Theoretical situation

### 1.1 Presuppositions as inferences

Each of the sentences below presupposes that John is lucky:

(1) a. John knows that he's lucky.
 b. John doesn't know that he's lucky.
 c. Does John know that he's lucky?

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Intuitively, this amounts to saying that these sentences are more natural in conversations where participants agree, or are likely to agree, that John is lucky (e.g., Stalnaker 1970, 1973, 1974; Karttunen 1974). As a result, presuppositions can be treated as inferences: a speaker who utters a sentence which triggers a presupposition *p* is committed to *p* being true. The inferential process at play is called "(global) accommodation"; it is through this prism that presuppositions will be approached here.

Let's go back to what's interesting about (1). The sentence in (1b) is the negation of (1a). These two sentences should thus convey roughly opposite meanings, but they do not: both of them imply that John is lucky. The third sentence, (1c), is a question—it questions the truth of (1a)—yet it still implies that John is lucky. In short, presuppositions are inferences or pieces of meaning which resist negation and interrogation. The paradigm in (1) illustrates the projection problem of presupposition: how do presuppositions interact with various embeddings and various linguistic operators?

## 1.2 The projection problem of presupposition: the case of quantified sentences

The projection problem of presupposition has received a lot of attention in the last decades. There is a large consensus about (1) and, more generally, about some (propositional) fragment of natural languages: to a very large extent, current theories make the same predictions as to how presuppositions interact with negation, conjunction, disjunction, and any combination of these operators.

However, when it comes to other examples the projection problem is still the subject of empirical debates. Thus, current theories predict drastically different behaviors for more complex embeddings.[1] One crucial situation is obtained for sentences with a presupposition trigger bound in the scope of a generalized quantifier (e.g., 'every,' 'most,' 'no'). This configuration is schematized in (2) and exemplified in (3):[2]

(2) Quantified sentence: $[\mathcal{Q}\text{x}: R(x)]\, S_p(x)$
  a. Universal presupposition: $[\forall\text{x}: R(x)]\, p(x)$
  b. Existential presupposition: $[\exists\text{x}: R(x)]\, p(x)$

(3) No student knows that he's lucky.
  a. Universal presupposition: Every student is lucky.
  b. Existential presupposition: (At least) one student is lucky.

[1] This debate has focused on English data, but it is widely assumed, as I will assume here, that the observed semantics carry over to other languages—in the present case, French—and that the resulting theoretical claims are crosslinguistically valid if they are valid at all.

[2] Notation: 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 this scope triggers a presupposition $p$. In the cases under discussion, this presupposition should inherit from $S_p$ the dependence on $x$ and the use of $S_p(x)$ instead of $S_{p(x)}(x)$ is merely a shortcut.

This piece of data is controversial; the main purpose of this paper is to settle this controversy. On the one hand, Heim (1983) and more recently Schlenker (2008, 2009) argue that sentences of the form given in (2) trigger a universal presupposition as schematized in (2a): every individual satisfying the property $R$ expressed in the restrictor should also satisfy the presupposition triggered from the scope of the quantifier. Applied to example (3), this simply amounts to (3a): every student is lucky. On the other hand, Beaver (1994, 2001) and (as a first approximation) DRT accounts of presuppositions à la van der Sandt (1992) argue that sentences like (2)/(3) trigger only much weaker existential presuppositions as schematized in (2b): some individual satisfying the restrictor also satisfies the presupposition of the scope (see (2b) and (3b)).[3]

Terminological note: I use the adjectives ‘universal’ and ‘existential’ to refer to presuppositions, inferences, or predictions which fit the schemas in (2a) and (2b) as well as classes of theories which make such predictions homogeneously across quantifiers.

There are at least two recent proposals that differ from the ones mentioned above in that they predict universal presuppositions for some quantifiers and not others, namely Chemla (2008, 2009c) and George (2008). I will restrict my attention to the predictions made by the Similarity Theory developed in my own work, but my goal is to make a more general argument in favor of a whole class of theories which predict that presuppositions vary with quantifiers.[4,5]

In a nutshell, the Similarity Theory requires that presuppositions and their negations be locally trivial. The relevant formal apparatus is sketched in Appendix B. Of main importance are the following predictions for quantified sentences (these predictions are also represented graphically in Fig. 1):

(4) Each student knows that he’s lucky.
$\rightsquigarrow$ Each student is lucky.

(5) More than 3 students know that they’re lucky.
$\rightsquigarrow$ More than 3 students are lucky and less than 3 aren’t.

[3] Both Heim’s and Beaver’s accounts are phrased in the general framework of dynamic semantics. They arrive at their prediction by making a different choice in the way they set up an admittance condition for presupposition (see Appendix A and the discussion in Chap. 10 of Kadmon 2001). In a sense, this reduces the strength of both of these accounts from the start: no matter what the actual data is, these accounts will lack explanatory power (see discussion in Soames 1989 and Schlenker 2008). Hence, it is important to mention that Schlenker’s theories are committed to the universal presupposition while DRT accounts cannot derive them.

[4] At the time when the first version of this work was written and distributed, neither Chemla (2008, 2009c) nor George (2008) were serious proposals.

[5] In fact, Heim’s and Beaver’s dynamic accounts could emulate differences between quantifiers, but any such move would cast doubt on their enterprise by weakening further the explanatory power of the framework (see also footnote 3). It would also raise new issues for them: what distinguishes the quantifiers so that they have different dynamic behavior? How do children acquire these differences? What explains the crosslinguistic stability (or variability) of these differences?

(6) Many students know that they're lucky.
⇝ Many students are lucky.

(7) Most students know that they're lucky.
⇝ Most students are lucky.

(8) No student knows that he's lucky.
⇝ Each student is lucky.

(9) Less than 3 students know that they're lucky.
⇝ At least 3 students are lucky and less than 3 aren't.

(10) Exactly 3 students know that they're lucky.
⇝ More than 3 students are lucky, and it's not the case that exactly 3 of them aren't.

(11) Few students know that they're lucky.
⇝ Few students aren't lucky (i.e. Most students are lucky).

Notice that the predictions vary from one quantifier to the next, contrary to homogeneously universal or existential theories. In short, the Similarity Theory predicts a universal presupposition for 'no'-sentences (see (8)) and weaker presuppositions for most other quantifiers (this particular aspect is shared with George's 2008 theory).

### 1.3 Scalar implicatures: a convenient control

Scalar implicatures are pragmatic inferences, which will provide a convenient point of comparison. More specifically, it is *indirect* scalar implicatures that will be of particular interest for our purposes: these involve a strong scalar item in a downward entailing context. This situation is illustrated in (12a), from which it is natural to conclude that John read some of the books.

(12) a. John didn't read all the books.
b. Alternative: John didn't read any of the books.
c. Scalar implicature: John read some of the books.
(negation of the stronger alternative, the two negations cancel each other out)

The scalar implicature of (12a) can be derived as follows (e.g., Grice 1967; Ducrot 1969; Horn 1972; Atlas and Levinson 1981). Let us assume that 'any' 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 on the scale. As a result, (12b) is an alternative to (12a): 'any' replaces 'all' and the rest is left unchanged.[6] Now notice that this alternative

[6] Strictly speaking, it is 'any *of*' that replaces 'all' in this example. I leave this issue out of this rather informal discussion. Nor will I engage in a full discussion of the respective roles of 'any' and its positive counterpart 'some' to the theory.

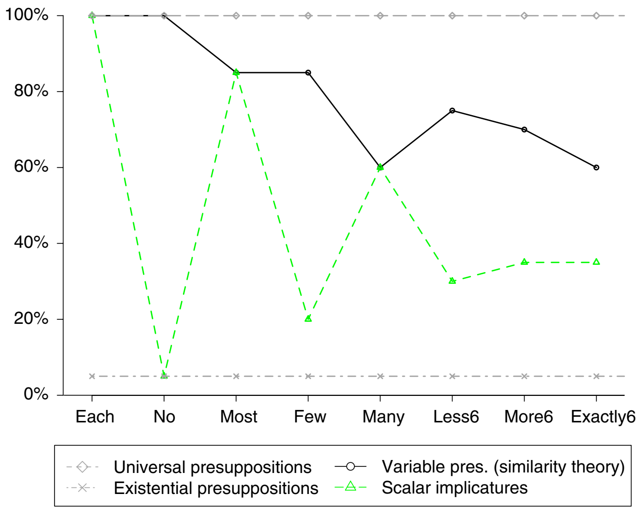


**Fig. 1** Predicted presuppositions for quantified sentences. Predictions are shown from various theories of presuppositions for scalar implicatures when a presupposition trigger (or a strong scalar item) is embedded in the scope of 'each', 'no', 'most', 'few', 'many', 'less than 6', 'more than 6', and 'exactly 6'. The *y*-axis represents the proportion of individuals which are predicted to satisfy the relevant property. This representation is based on some arbitrary choices: the domain is supposed to contain 20 individuals (when it matters), 'most' is represented as 80%, 'many' as 60%, and 'few' as less than 20%

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 alternative sentence is actually false. The negation of the alternative (12b) is indeed equivalent to the attested inference (12c).

This sketch of a theory makes immediate predictions for all sorts of sentences containing the lexical item 'all' (and 'any' for that matter). In a sense, it is a solution to what could be thought of as the projection problem for scalar implicatures. Most current accounts of scalar implicatures make the same predictions for the examples we will be interested in: alternative sentences get negated whenever they can be negated in a way that is consistent with the bare meaning of the sentence. The reader can check that this predicts the following inferences from 'all' to 'some' (these predictions are also represented graphically in Fig. 1, together with corresponding predictions from various theories of presupposition):

(13) John read all the books.
⇝ John read (at least) some of the books.

(14) Each student read all the books.
⇝ Each student read (at least) some of the books.

(15) More than 3 students read all the books.
⇝ More than 3 students read (at least) some of the books.

(16) Many students read all the books.
⇝ Many students read (at least) some of the books.

(17) Most students read all the books.
⇝ Most students read (at least) some of the books.

(18) No student read all the books.
⇝ (At least) one student read (at least) some of the books.

(19) Less than 3 students read all the books.
⇝ (At least) 3 students read (at least) some of the books.

(20) Exactly 3 students read all the books.
⇝ More than 3 students read (at least) some of the books.

(21) Few students read all the books.
⇝ Not few students read (at least) some of the books.

For the first examples, (13)–(17) above, the prediction simply follows from the bare meaning of the sentence.[7] The case of (18) involving the quantifier ‘no’ is of particular interest: the predicted inference is existential. If presuppositions project existentially from the scope of ‘no,’ they should be similar to scalar implicatures; if they project universally, we should find clear differences between the two types of inferences. This will provide an ideal point of comparison in the first experiment below. The rest of the predictions above, (19)–(21), will be revisited and discussed as we go.

### 1.4 Goals and organization of the paper

The main goal of this paper is to provide a controlled empirical basis for theories of presupposition projection. The main question to be answered is: do presuppositions project universally from the scope of quantifiers? The results of Experiment 1 will show that presupposition triggers give rise to universal inferences when they occur in the scope of the quantifier ‘no’ but not when they occur in the scope of other quantifiers. More quantifiers (and environments) are investigated in Experiment 2; the results confirm that the robustness of the universal inference varies with the quantifier.

Eventually, I will argue that participants endorsed universal inferences on the basis of (1) the presuppositions of quantified sentences which depend on the quantifier and are most often intermediate between existential and universal and (2) a general strengthening mechanism which also applies to scalar implicatures.

[7] This is a general result when ‘all’ is embedded in an upward monotonic environment.

## 2 Experiment 1: differences between quantifiers

The goal of this first experiment is to tell whether presuppositions project universally when triggered from the scope of the quantifiers ‘each’, ‘no’, ‘less than 3’, ‘more than 3’ and ‘exactly 3’. (The case of ‘each’ mainly serves as a baseline because the potential universal presupposition also comes up as an entailment in this case.)

### 2.1 Methodology

As discussed above, 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 capitalizes on this fact: naive French speakers were asked whether they would infer from an utterance of *S* (by a reliable speaker) that the alleged presupposition of *S* holds. Figure 2 approximates in English what participants actually saw in French on the computer screen. The intended meaning for the verb “to suggest” (*suggérer* in French), which linked the two test sentences on the screen, was clarified in the instructions (more on this below and in Appendix C, which gives the original French instructions in full).

#### *2.1.1 Instructions: context and clarification of the task*

The participants to the experiment first read instructions given to them on a piece of paper. These instructions are reproduced in Appendix C. They were designed for two main goals:

- To set up a natural context for the task. Importantly, this context 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 example in Fig. 2). Their task was to tell whether such an utterance licenses (“suggère”) the proposed inference.[8]
- To clarify the task and the intended interpretation of the verb “suggest”. This was done mainly with the help of two examples. The first example was a clearly valid entailment; subjects were told that they were expected to endorse such inferences. This example was provided so that participants would not resist logical conclusions. The second example showed that intuitions mattered: it was a case of disfavored conversational implicature where it was made explicit that responses might vary.

Having read these instructions, participants were left to themselves with a program which presented the items described below one by one in random order on the screen. They were asked to position their index fingers on the *Oui* (‘yes’) and *Non*

[8] Notice that the contents of the test sentences were (intuitively) natural in the given context. For instance, with the example in Fig. 2, it is easy to imagine that teachers mention letters they agreed to send to parents to congratulate them on their children’s success in school (a standard practice in France).

| |
|---|
| "None of these 10 students knows that his father will receive a congratulation letter." |
| *suggests that:* |
| The father of each of these 10 students will receive a congratulation letter. |
| *No?* *Yes?* |

**Fig. 2** Example of a trial involving the presupposition trigger 'know', glossed in English here

('no') buttons so that they could provide their answers as soon as they made up their mind. (These buttons corresponded respectively to the P and A keys of a French keyboard. Their function was indicated on the keys themselves: *Oui* and *Non*.) The first two trials were the exact examples provided in the instructions, to allow participants to get used to the general set-up of the experiment.

### *2.1.2 Participants*

The experiment was carried out in French; 30 native speakers of French ranging in age from 18 to 35 years 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).

## 2.2 Material

The items had the general format of classic inferential tasks. Each item contained two main sentences (cf. Fig. 2). The first sentence, henceforth the *premise*, 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. Schematically, the items were of the following form:

(22) "$E_1(I_1)$" $\rightsquigarrow E_2(I_2)$

In (22), $E_1(I_1)$ represents the premise and $E_2(I_2)$ the conclusion. $E_1$ and $E_2$ represent linguistic environments (e.g., the scope of a quantifier like 'each' or 'no') and $I_1$ and $I_2$ in sequence 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 presupposition, i.e., roughly, the complement of this factive verb).

The experimental items were obtained by systematically combining 10 pairs of environments $\langle E_1(\_\_), E_2(\_\_)\rangle$ with 27 inferences ($I_1$, $I_2$), 10 of which were presuppositional. I first describe the environments and then the inferences. The most important items are exemplified in (25)–(29). Appendix D details how two potential problems were taken care of: implicit domain restrictions and potential ambiguities due to the pronoun.

### 2.2.1 Environments ($E_1$, $E_2$)

The pairs of environments were designed to test the projection properties of presupposition, and as a control, of scalar implicatures. The whole set of pairs of environments that were used is described below (see also (66) in Appendix E):[9]

*Non-quantified environments*
⟨John___, John___⟩, ⟨I doubt that John___, John___⟩: these pairs of environments allow us to test for the projection behavior in simple positive sentences and under negation.[10] For instance, these environments lead to the following examples:

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

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

*Universal inferences*
⟨Each, Each⟩, ⟨No, Each⟩, ⟨Less than 3, Each⟩, ⟨More than 3, Each⟩, ⟨Exactly 3, Each⟩: these pairs of environments were used to test universal inferences (the second quantifier is always universal here) from the scope of various quantifiers. They led to the following items:

(25) Each of these 10 students knows that his father is going to receive a congratulation letter.
⇝ The father of each of these 10 students is going to receive a congratulation letter.

(26) None of these 10 students knows that his father is going to receive a congratulation letter.
⇝ The father of each of these 10 students is going to receive a congratulation letter.

(27) Less than 3 of these 10 students know that their father is going to receive a congratulation letter.
⇝ The father of each of these 10 students is going to receive a congratulation letter.

[9] The sign ___ marks the position where the presupposition trigger (or, more generally, inference triggers, which include scalar items) was inserted. The environment represented by a quantifier alone is the scope of this quantifier.

[10] For this first experiment, negation was mimicked with the phrase *Je doute que* ('I doubt that') to avoid scope ambiguities.

(28) More than 3 of these 10 students know that their father is going to receive a congratulation letter.
⇝ The father of each of these 10 students is going to receive a congratulation letter.

(29) Exactly 3 of these 10 students know that their father is going to receive a congratulation letter.
⇝ The father of each of these 10 students is going to receive a congratulation letter.

*Scalar inferences*
⟨No, (At least) one⟩, ⟨Less than 3, (At least) 3⟩, ⟨More than 3, More than 3⟩: these pairs of environments were used to test scalar inferences (see the predictions in (14)–(21)). Corresponding items were:

(30) None of these 10 students knows that his father is going to receive a congratulation letter.
⇝ The father of (at least) one of these 10 students is going to receive a congratulation letter.

(31) Less than 3 of these 10 students know that their father is going to receive a congratulation letter.
⇝ (At least) 3 of the fathers of these 10 students is going to receive a congratulation letter.

(32) More than 3 of these 10 students know that their father is going to receive a congratulation letter.
⇝ More than 3 of the fathers of these 10 students is going to receive a congratulation letter.

### 2.2.2 Inferences ($I_1$, $I_2$)

The pairs ($I_1$, $I_2$) corresponded mainly to presuppositions. For instance, a factive verb and its complement could form such a pair, as is the case in (23)–(32): (knows that his father is going to receive a c.l., (his) father is going to receive a c.l.). The items were of four main types: presuppositional, scalar, cases of adverbial modification, and entailments.

The presupposition triggers included factive verbs (‘know’ and ‘be unaware’), change of state predicates (‘stop’ and ‘continue’) and definite descriptions (‘his’). The (pairs of) scalar items were: (‘all’,‘several’), (‘and’,‘or’), (‘excellent’, ‘good’). Entailments served as control cases (see Sect. 2.3.1), while cases of adverbial modifications were mere fillers for present purposes.[11]

[11] The corresponding data were analyzed in a different venue (Chemla 2009b) with a different objective: a direct comparison of various types of inferences rather than a study of presupposition.

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 receiving congratulation letters was paired with an item involving students' fathers being summoned (this is normally interpreted as the negative counterpart of a congratulation letter). 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 summoned. It is well known from the reasoning literature that this assumption may artificially increase acceptance rates of universal conclusions such as "Each father of these 10 students was summoned," independently of any particular utterance (e.g., Evans et al. 1983). However, this very same bias should disfavor 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.

### *2.2.3 Summary: the material in numbers*

The building blocks of the experimental items are 27 "inferential pairs" ($I_1$, $I_2$) (including five different presupposition triggers associated with two different contents each) and 10 pairs of environments $\langle E_1, E_2 \rangle$. The experiment thus contains $27 \times 10 = 270$ trials, $(5 \times 2)$ contents $\times 5$ universal tests $= 50$ of which are the universal presupposition targets corresponding to the main results reported in Fig. 4a.

## 2.3 Results

### 2.3.1 Control results

Among the 270 trials, 40 were constructed from simple monotonicity inferences which presumably should not involve implicatures or presuppositions (i.e. the four examples in Appendix E under (73) as they appear in the 10 different environments exemplified for presupposition in (25)–(32)). These items naturally receive a "logical" answer (e.g., (73a) is valid, (73b) is not). Subjects responded accordingly 90% of the time.

Similarly, the experiment involved uncontroversial cases with presuppositions: items where a presupposition trigger is embedded in a non quantified environments (see (23) and (24)) or where the premise and the conclusion involve the same upward monotonic quantifier (examples (25) and (32) above). Again, subjects answered as expected in 92% of these cases.

We also wanted to check that subjects did not develop problematic strategies over time in the course of this long experiment. To see this, we tracked differences between the first and the second halves of the items by computing the $4 \times 10 \times 2$ ANOVA taking into account the following factors: types of inference versus environments versus blocks (i.e. first/second halves of the experiment). We obtained no evidence that there was any relevant effect of block: $F(27, 680) = 1.07, p = .36$. In other words, participants responded in the same way at the beginning and at the end of the experiment.

These first results validate the experimental paradigm: despite the large number of trials, subjects answered accurately to control items and there is no evidence that they developed strategies over time.

### *2.3.2 Universal inferences: the quantifier 'no'*

Do presuppositions project universally when triggered from the scope of the quantifier 'no'? Do they project existentially? As discussed in Sect. 1.3, scalar implicatures provide a convenient point of comparison: in this environment scalar implicatures trigger existential inferences.

Figure 3a presents the acceptance rates of existential and universal inferences for presupposition and scalar implicatures when the target sentence involves the quantifier 'no'. These results show that (1) for scalar implicatures, universal inferences are less endorsed than existential inferences; and (2) for presuppositions there is no such difference.[12] A $2 \times 2$ ANOVA (first factor: Presupposition versus Implicature; second factor: ⟨No, At least one⟩ versus ⟨No, Each⟩) reveals a statistically significant interaction [$F(1, 29) = 16.3, p < .05$].

These results strongly support the hypothesis that contrary to scalar implicatures, presuppositions project universally rather than existentially when triggered from the scope of the quantifier 'no'.

### *2.3.3 The quantifier 'less than 3': intermediate inferences?*

From the scope of 'less than 3', scalar implicatures are supposed to be neither existential nor universal but rather intermediate between these two extremes: at least 3 individuals should satisfy the relevant property (see prediction in (19)). To continue using scalar implicatures as a baseline, I will not compare universal and existential inferences but rather universal inferences and this type of scalar inference pattern (e.g., (27) vs. (31)).

Figure 3b presents the relevant results. As in the case of 'no', the interaction (first factor: Presupposition versus Implicature; second factor: scalar versus universal inference) is significant [$F(1, 29) = 5.15$, $p < .05$]. This shows that (1) scalar implicatures project as a scalar theory would predict rather than universally and (2) that presuppositions are different. However, it is not clear in this case that this means that presuppositions project universally. In fact, these results could be taken as evidence that presuppositions give rise to inferences intermediate between scalar and

[12] There seems to be a counterintuitive result in that the acceptance rate of the universal inference (84%) is higher than the acceptance rate of the weaker existential inference (79%), but this difference is not significant [$t$-test: $F(1, 29) = 2.51$, $p = .12$]. Note, however, that if it were significant, it might well reinforce the idea that presuppositions project universally. First, recovering the existential conclusion from the universal inference involves an additional step, which might be costly and decrease the acceptance rate. Second, the weaker conclusion may come with an implicature that the stronger conclusion is false, this could justify rejections of this weak conclusion.

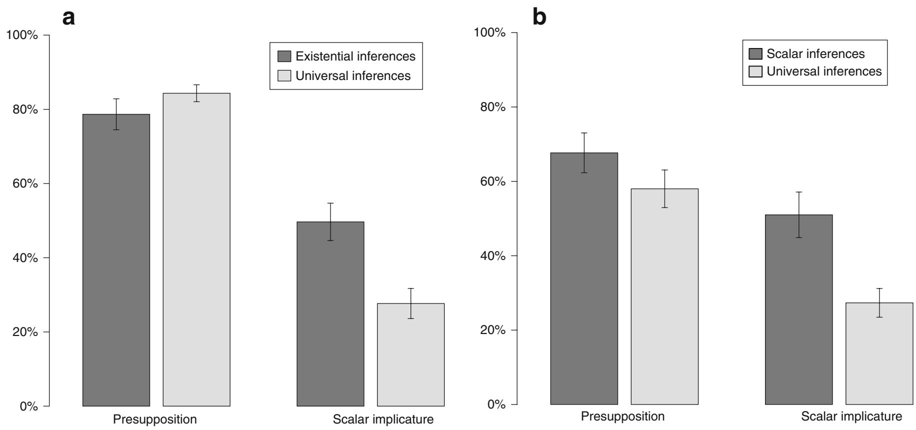


**Fig. 3** **a** Acceptance rates (%) of existential and universal inferences for presupposition and scalar implicature triggered from the scope of the quantifier 'no'. **b** Acceptance rates (%) of scalar and universal inferences for presupposition and scalar implicature triggered from the scope of 'less than 3'

universal inferences,[13] but I will postpone discussion of that possibility until I present Experiment 2. For now, I will discuss results that reflect on the status of universal presuppositions with other quantifiers.

### 2.3.4 *Universal inferences: comparing quantifiers*

From Figs. 3a and b, it is already apparent that the robustness of the universal presupposition depends on the quantifier (compare the second bars of each of these graphs). Figure 4a focuses on such distinctions and takes into account more quantifiers. This figure reveals a clear difference in the acceptance rates of universal presuppositions when they are triggered from the scope of 'each' and 'no', on the one hand (87%), and numerical quantifiers such as 'less than 3', 'more than 3', and 'exactly 3', on the other hand (53%). A two-tailed *t*-test confirms that this difference is statistically significant [$F(1, 29) = 53.8$, $p < .05$].

These results show that while universal presuppositions are robust when triggered from the scope of 'no', the results are much less clear cut for other quantifiers, for which the acceptance rate of the universal presupposition oscillates around 50%.

Finally, there seem to be differences between the different type of presupposition trigger involved in the experiment. There is a significant interaction between the type of presupposition trigger and the environment (restricted to the universal environments as in Figs. 4a and b): $F(8, 232) = 2.07$, $p < .05$. This interaction is probably due to the fact that the universal presupposition for 'no'-sentences is less robust for change of state predicates than for other presupposition triggers. Note, however, that the type of trigger does not interact with the environment if we restrict the analysis to the environments ⟨No, (At least) one⟩ versus ⟨No, Each⟩

[13] At first sight, this hypothesis would leave unexplained the rather low acceptance rate of the scalar inference which is entailed by the presupposition. It is not necessarily so, see discussion in footnote 12.

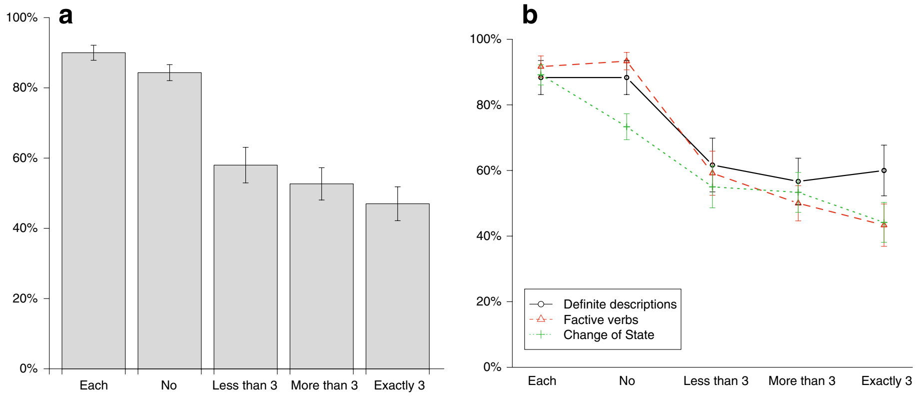


**Fig. 4** **a** Acceptance rates (%) of universal inferences when a presuppositional item is embedded in the scope of different quantifiers: 'each', 'no', 'less than 3', 'more than 3', and 'exactly 3'. **b** Results by type of presupposition trigger definite descriptions factive verbs, and change of state predicates

$[F(2,58) = .855, p = .431]$ or to ⟨Less than 3, (At least) 3⟩ versus ⟨Less than 3, Each⟩ $[F(2,58) = 1.17, p = .317]$. This shows that the conclusions from Sect. 2.3.2 and 2.3.3 do apply uniformly to every trigger. I will come back to these results in the general discussion (Sect. 4.2.3) although they are not replicated in Experiment 2.

### *2.3.5 Comparing quantifiers: processing results*

Finally, we can analyze the response times needed to accept or reject the universal inferences. The difference between acceptance and rejection times should reflect the time needed to derive the inference.[14] As is standard, response times more than 1.5 standard deviations away from the mean response time were excluded from the analysis (9.7% of the relevant trials).[15]

The key data are reported in Fig. 5. These results show that participants are faster to accept than to reject universal inferences for 'no'-sentences [*t*-test: $F(1,21) = 10.3, p < .05$]. This result could simply be due to a general tendency to be faster to say Yes than to say No.[16] However, this difference vanishes for numerical quantifiers: a *t*-test yields a non-significant result $[F(1,29) = .95, p = .34]$, and this pattern for numerical quantifiers is significantly different from the pattern for 'no', as an interaction computed with a $2 \times 2$ ANOVA shows $[F(1,21) = 3.75, p < .05]$.

[14] A relevent finding was made recently in the realm of scalar implicatures (e.g., Noveck and Posada 2003; Bott and Noveck 2004; Breheny et al. 2005): deriving a scalar implicature requires an extra processing effort. This conclusion comes from results showing that for a given stimulus (sentence), answers which involve the computation of a scalar implicature are slower. A parallel argument could be made for the present experiment: Yes and No responses to a given item indicate whether or not an inference was drawn. Therefore, time differences between Yes and No responses might reflect the time needed to derive this inference.

[15] Several other attempts were made and no qualitative difference was found.

[16] Notice for instance that all participants answered Yes with their right hand.

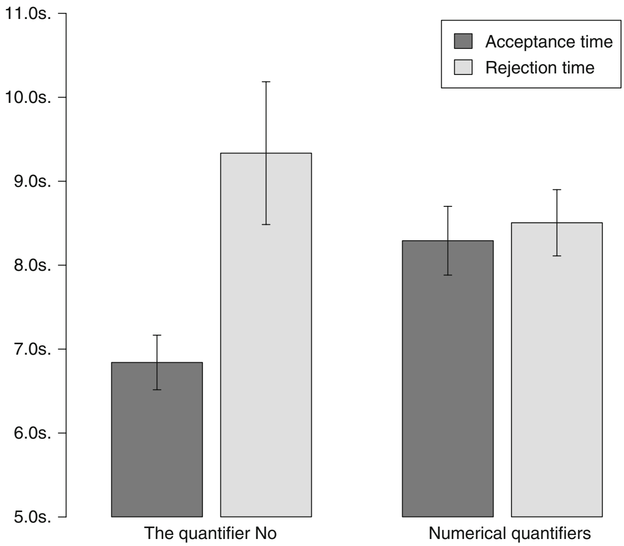


**Fig. 5** Response times (in seconds) for acceptance and rejection of universal inferences when the presuppositional items are embedded in the scope of either ‘no’ or numerical quantifiers

A cautious summary of these preliminary processing results is that they isolate further the universal inferences derived for ‘no’-sentences from similar inferences derived for other quantifiers. Less cautiously, we could argue that the universal inference derived for ‘no’-sentences comes straight from the presupposition whereas the universal inference in the other cases involves something more. The results from Experiment 2 will suggest that this something more is an independent probabilistic inferential process.

## 2.4 Intermediate summary

Inferences generated by a presupposition trigger embedded in the scope of a quantifier are sensitive to the quantifier: they are clearly universal for ‘no’ but much less so for numerical quantifiers (‘less than 3’, ‘more than 3’, and ‘exactly 3’).

This is a striking result. At the outset of this paper, I depicted two opposed theoretical positions—the existential camp and the universal camp—but the empirical picture seems to be more complex: the robustness of the universal presupposition varies with the quantifier. Universal theories fail to explain why the predicted universal presuppositions do not give rise to universal inferences in some cases and, conversely, existential theories fail to explain why existential presuppositions sometimes do give rise to universal inferences. These results seem to argue in favor of a different type of theory, such as the Similarity Theory discussed in Sect. 1.2.

However, there are various dimensions along which ‘no’ and the numerical quantifiers used in this experiment vary. For instance, the numerical quantifiers require a plural bound pronoun, and as a result, the corresponding sentences involve more ambiguities (see Appendix D.2). Numerical quantifiers are also more complex (primarily in syntactic terms but maybe also semantically, I come back to this idea below). Some of these considerations might explain away the results we observe independently from theories of presupposition.

In the second experiment, more quantifiers were tested and complexity considerations were tested more explicitly.

## 3 Experiment 2: more environments, graded judgments

The main goal of this experiment was to extend the previous investigations to more environments (more quantifiers, restrictors of quantifiers, and questions). The most important finding from the previous experiment was replicated and refined: the robustness of the universal inference depends on the quantifier.

In the course of it, I also compared the robustness variations with independent measures of difficulty or scalar implicature computations. Overall, the results argue in favor of a theory of presuppositions which allows for more options besides universal and existential presuppositions (see Sect. 1.2), coupled with an independent strengthening mechanism.

### 3.1 Methodology

The experimental setting was mostly the same as before, but two things were different: the type of responses expected from the subjects and the material (attention was restricted to universal inferences but triggered from more environments).

#### *3.1.1 Graded judgments*

In this experiment, the binary judgment task was replaced with a graded judgment task. The main relevant difference compared to the instructions for Experiment 1 was that participants were told (in French) to assess “to what extent it is natural from ⟨the premise⟩ to think that ⟨the conclusion⟩ is true”. The first training example was the same as before but now it looked as in Fig. 6. Participants were instructed

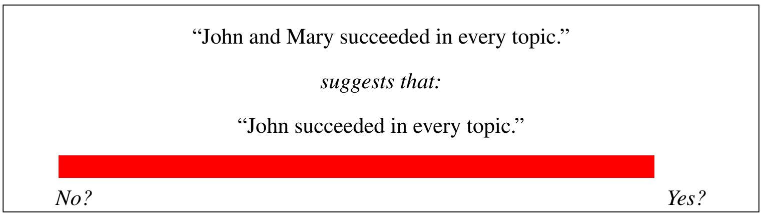


**Fig. 6** English gloss of training example for Experiment 2 (graded judgment)

that for such examples they would probably set the length of the red line (with the mouse) close to the maximum (close to Yes).[17]

Subjects' responses were coded as the percentage of the line filled in red, 0% corresponds to absolute No answers, 100% to Yes answers. I will call this measure *bare robustness* (of the corresponding inference). These responses were then normalized so that the grand mean and standard deviations for each subject equal the overall grand mean and standard deviation across subjects (66% and 38% respectively). I will refer to the resulting measure as the *robustness of the inference*.[18] This standard process of response normalization does not affect the reported results in any noticeable way (all statistical tests were run with both types of measures). It simply erases irrelevant variability (mainly for the graphical representations) coming from differences in the way various participants distributed their answers along the line (mean bare robustness varied from 44% to 82% across subjects).

In short: the higher the normalized robustness, the more participants are willing to endorse the inference. I will restrict my attention to (normalized) robustness unless otherwise stated.[19]

For validation, binary judgments like those prompted for Experiment 1 were collected from 10 other participants with the material for this new experiment. The results agreed with the robustness data except for the fact that they sometimes did not reach significance.

### *3.1.2 Participants*

As before, the experiment was carried out in French; 10 native speakers of French of age 18–25 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).

## 3.2 Material

The items had the same format as the items from Experiment 1 (cf. (22) above):

(33) $\text{“}E_1(I_1)\text{”} \rightsquigarrow E_2(I_2)$

[17] This paradigm resembles magnitude estimation as discussed for instance in Bard et al. (1996) and Cowart (1997) for its applications in syntax. The two main differences in the present experiment are that (1) the promoted judgments were judgments on the robustness of inferences (rather than grammaticality judgments of sentences), and (2) as in a standard magnitude estimation experiment, participants were explicitly instructed to represent with the line length the intuitive ratio between the stimulus and a reference point (modulus).

[18] The relation between bare robustness R and normalized robustness $\hat{R}$ is given by: $\hat{R} = M + \frac{R - M_s}{SD_s} SD$, where M and SD represent the mean and standard deviation for the whole group of subjects (without subscript) or for the particular subject under study (with subscript s). M = .66 and SD = .38.

[19] Note that robustness is not constrained to vary between 0 and 1 although I report robustness as percentage scores.

The main difference is that more quantifiers were added, as well as two more radically different environments: restrictors of quantifiers and questions.

*3.2.1 Control presuppositional items: non-quantified environments*

Positive and negative environments similiar to (23) and (24) were included.[20] To complete the original paradigm in (1c), *yes/no*-questions were added and led to new presuppositional items of the following form:

(34) Est-ce que Jean ignore que son père va recevoir une lettre de félicitations.
Does John know that his father is going to receive a congratulation letter?
⇝ Le père de Jean va recevoir une lettre de félicitations.
John's father is going to receive a congratulation letter.

*3.2.2 Presuppositions: universal inferences from the scope of more quantifiers*

The target items included a presupposition trigger in the scope of a quantifier in the premise, and prompted the universal inference in the conclusion. These items are similar to (25)–(29) except that the list of quantifiers now includes the french equivalents of: 'each', 'no', 'most', 'few', 'many', 'less than 6', 'more than 6', 'exactly 6', 'who'.

Most of these quantifiers require bound pronouns in their scope to be plural; this was the case only for numerical quantifiers in the previous experiment. Notice also that the numerical quantifiers now involve the number 6 instead of the number 3. This modification removed potential worries about the felicity of low numbers in quantified expressions.[21] To counterbalance this choice, the explicit domain restriction over 10 students that was used in Experiment 1 was systematically replaced with a domain restriction over 20 students. Furthermore, this explicit domain restriction phrase was moved outside of the restrictor of the quantifier at the head of the sentence and realized as "Among these 20 students, ...". Finally, the addition of *qui* ('who') to the list of quantifiers lead to items of the following form:

(35) Parmi ces 20 étudiants, qui sait que son père va recevoir une lettre de félicitations?
Among these 20 students, who knows that his father is going to receive a congratulation letter?
⇝ Le père de chacun de ces 20 étudiants va recevoir une lettre de félicitations.
The father of each of these 20 students is going to receive a congratulation letter.

[20] An additional difference is that negation was achieved by adding *Il nést pas vrai que* ('It is not true that') in front of the positive counterparts (instead of the phrase *Je doute que* 'I doubt that' from Experiment 1).

[21] For instance, 'less than 3' might be deemed marked compared to the expression '1 or 2' (even though the two expressions are not strictly speaking equivalent, because without implicatures, 'less than 3' does not exclude 0, while 1 or 2 probably does).

### *3.2.3 Presuppositions: universal inferences from the restrictors of quantifiers*

New presuppositional items involved presupposition triggers in the restrictors of (the same list of) quantifiers and prompted the corresponding universal inference. Here are some relevant examples:

(36) Parmi ces 20 étudiants, chacun/aucun qui sait que son père va recevoir une lettre de félicitations fait de l'italien.
Among these 20 students, each/none who knows that his father is going to receive a congratulation letter takes Italian lessons.
⇝ Le père de chacun de ces 20 étudiants va recevoir une lettre de félicitations.
The father of each of these 20 students is going to receive a congratulation letter.

(37) Parmi ces 20 étudiants, la plupart/peu/beaucoup/moins de 6/plus de 6/exactement 6 qui savent que leur père va recevoir une lettre de félicitations font de l'italien.
Among these 20 students, most/few/many/less than 6/more than 6/exactly 6 who know that their father is going to receive a congratulation letter takes English lessons.
⇝ Le père de chacun de ces 20 étudiants va recevoir une lettre de félicitations.
The father of each of these 20 students is going to receive a congratulation letter.

(38) Parmi ces 20 étudiants, qui de ceux qui savent que leur père va recevoir une lettre de félicitations fait de l'italien?
Among these 20 students, who from those who know that their father is going to receive a congratulation letter takes English lessons?
⇝ Le père de chacun de ces 20 étudiants va recevoir une lettre de félicitations.
The father of each of these 20 students is going to receive a congratulation letter.

Notice that these examples are significantly more complex than the previous set of items: the whole content is now packed into the restrictor of the quantifier, and the nuclear scope presents additional material (having to do with various foreign language lessons). This additional complexity may unfortunately explain why the results for these items are almost flat and thus unrevealing.

### *3.2.4 Scalar implicatures*

As before, the material also included scalar items. The corresponding scalar inferences were embedded in the following environments: negation (for which the inference really is an implicature) and the scopes of the extended list of quantifiers (with the exception of 'who'). The corresponding items were thus very similar to cases of scalar implicatures from the previous experiment, except that only universal inferences were tested. These items were thus of the following type:[22]

(39) Il n'est pas vrai que Jean a raté tous ses examens.
It is not true that John missed all his exams.
Jean a raté plusieurs de ses examens.
John missed some of his exams.

(40) Parmi ces 20 étudiants, chacun/aucun/peu/la plupart… a/ont raté tous ses/leurs examens.
Among these 20 students, none/each/few/most… missed {singular/plural} all his/their exams.
$\rightsquigarrow$ Chacun de ces 20 étudiants a raté plusieurs de ses examens.
Each of these 20 students missed some of his exams.

### *3.2.5 Monotonicity inferences*

Another set of items prompted standard monotonicity inferences. These items were of the following form: two predicates $I_1$ and $I_2$ were embedded in the same environment E to obtain the premise and the conclusion; $E$ was either a non-quantified positive or negative environment or the scope of one of the quantifiers in the list (except 'who'); for each pair ($I_1$, $I_2$), one entailed the other asymmetrically[23] and both the inferences $E(I_1) \rightsquigarrow E(I_2)$ and $E(I_2) \rightsquigarrow E(I_1)$ were tested. The relevant examples are as follows (with the same quantifier in the premise and in the conclusion):

(41) Parmi ces 20 étudiants, aucun/chacun/peu/la plupart… n'est/est/sont français.
Among these 20 students, none/each/few/most… is/are French.
Aucun/Chacun/La plupart/Peu… de ces 20 étudiants n'est/est/sont européen(s).
None/Each/Few/Most… of these 20 students is/are European.

(42) Parmi ces 20 étudiants, aucun/chacun/peu/la plupart… n'est/est/sont européen(s).
Among these 20 students, none/each/few/most… is/are European.
$\rightsquigarrow$ Aucun/Chacun/La plupart/Peu… de ces 20 étudiants n'est/est/sont français.
None/Each/Few/Most… of these 20 students is/are French.

[22] Notice that the negation was a standard negation for these cases of implicatures.

[23] Extending the notion of entailment to predicates in a fully standard way.

#### *3.2.6 Others*

Finally, more cases of scalar implicatures (with weak and strong scalar items) in non-quantified environments were added. These were mere fillers, although the results were analyzed. Scalar implicatures were derived as expected.

### 3.3 Results

#### *3.3.1 Control results*

Presuppositional items in non-quantified environments lead to very high robustness (95% overall; positive environments: 97%, negative environments: 93%, questions: 95%), as expected given the discussion in Sect. 1.1 above.[24]

Global responses to monotonicity inferences confirm that subjects performed the task appropriately. To see this we need to take into account "correct robustness". Correct robustness measures the accuracy of the answer depending on the validity of the inference, it can be defined as robustness when the monotonicity inference is valid (accurate answers correspond to high robustness for these cases) and as the reverse of robustness ($= 1-$ robustness) when the monotonicity inference is invalid (here accurate answers are rejections and correspond to robustness being close to 0). In short, correct acceptances and rejections yield high correct robustness. Mean correct robustness is high: 80% overall and 85% for non-quantified items (corresponding bare robustness: 79% and 83%).

As in the case of Experiment 1, there was no distinction between the two halves of the experiment. The interaction between the three types of inferences (presuppositions, scalar implicatures, and entailments), the 30 environments, and the two halves of the experiment is not significant: $F(9, 81) = .805$, $p = .613$.

These results validate the overall paradigm. Crucially, this experiment also replicates previous findings from Experiment 1, as discussed below.

#### *3.3.2 Presuppositions and differences between quantifiers*

Figure 7 reports the mean robustness of universal inferences when a presupposition trigger is embedded in the nuclear scope or the restrictor of various quantifiers.

*Scope of quantifiers*

Most importantly, the previous finding is replicated: the robustness of the universal presupposition varies when the trigger occurs in the scope of various quantifiers. The effect of the quantifier is significant: $F(8, 72) = 4.97, p < .05$. In fact, the bars in the figure entirely replicate the data in Fig. 4a.[25]

[24] Unsurprisingly, bare robustness yields close scores: 94% overall (positive environments: 96%, negative environments: 92%, questions: 94%).

[25] The previous difference between 'each' and 'no' on the one hand and numerical quantifiers on the other is also significant: $F(1, 9) = 8.2, p < .05$.

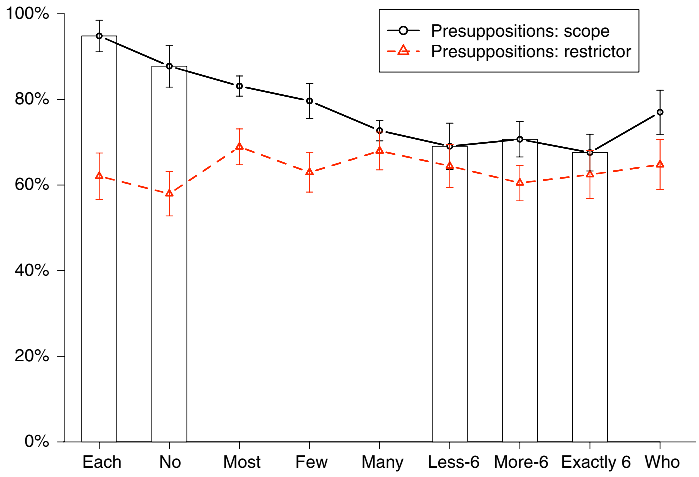


**Fig. 7** Mean (normalized) robustness of universal inferences when presuppositional items are embedded in the scope or restrictor of the quantifiers 'each', 'no', 'most', 'few', 'many', 'less than 6', 'more than 6', 'exactly 6', and 'who'. The bars in this graph highlight the replication of results from Experiment 1 (see Fig. 4a)

*Restrictors of quantifiers*

Overall, universal inferences are less robust when the presupposition trigger is in the restrictor of a quantifier than when it is in the scope of the same quantifier [$F(1,9) = 22.5, p < .05$]. Furthermore, there is no effect of quantifier in these cases [$F(8,72) = 1.35, p = .23$] and the interaction between quantifier and position of the presupposition trigger (scope versus restrictor) is significant: $F(8,72) = 4.69$, $p < .05$.

As mentioned in Sect. 3.2.3, these sentences were significantly more complex than the rest of the items. In the absence of effect, it is difficult to draw any firm conclusion for these cases. I will focus my attention on the data for presuppositions triggered from the scope of various quantifiers.

*No difference between triggers*

In Experiment 1, I reported an interaction between environment and type of trigger (Fig. 4b). This effect is not reproduced here; there was no difference between triggers. The interaction (restricted to the quantified environments) yields: $F(68,612) = 1.11$, $p = .26$.

### *3.3.3 Monotonicity and difficulty*

Let me entertain (and object to) a simple source for the variation between quantifiers. These differences might simply stem from irrelevant differences between the quantifiers themselves. More precisely, maybe presuppositions project universally across the board but participants have more or less difficulty to see this. For instance, it is natural to propose that numerical quantifiers are harder to compute

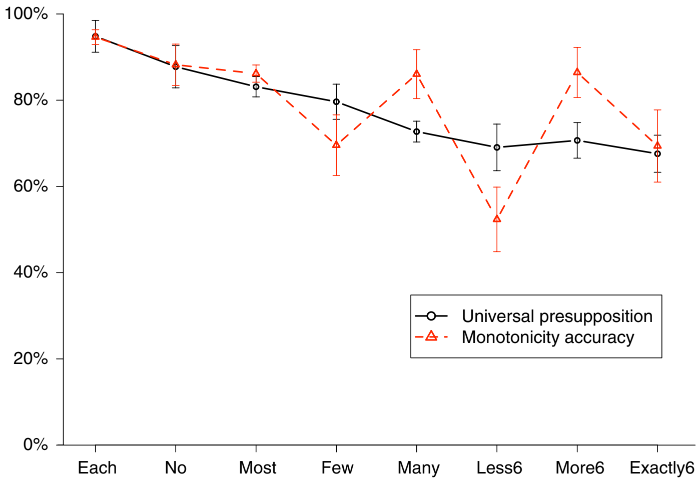


**Fig. 8** Mean correct robustness of monotonicity inferences. Mean correct robustness of monotonicity inferences with various quantifiers: 'each', 'no', 'most', 'few', 'many', 'less than 6', 'more than 6', 'exactly 6'. Previous robustness results of universal inferences with presupposition triggers in the same position are reported for convenience

than 'no' and that this relative difficulty explains why universal presuppositions are less acknowledged for numerical quantifiers.

Success with monotonicity inferences can help quantify *some* difficulty associated with each quantifier (see Geurts 2003). Figure 8 reports the correct robustness results across quantifiers in a monotonicity inference task. The robustness results for universal presuppositions are reported for convenience, the goal here is to examine the idea that the variation of one could explain the other.

The correct robustness of monotonicity inferences depends on the quantifier [$F(7, 63) = 7.33, p < .05$]. This makes it a good candidate to explain the variation in the case of presupposition but, unfortunately, it is obvious from Fig. 8 that the variations we observe do not follow the right pattern. In statistical terms, there is an interaction between quantifier and type of inference (universal presupposition versus monotonicity inferences): $F(7, 63) = 3.07, p < .05$. More specifically, if we try to fit the data for universal presuppositions across quantifiers with a linear model based on the mean results for monotonicity inferences for each quantifier (with subjects as a covariate), we obtain a rather low adjusted value, $R^2 = .098$ [$F(19, 50) = 1.40, p = .17$]. This model accounts for less than 10% of the variability.

Hence, it is not an easy task to defend the idea that presuppositions project universally across the board and that apparent discrepancies come from irrelevant difficulties. In fact, one would probably have to rely on a notion of complexity arising from the interaction between the quantifiers and the accommodation process (rather than complexity coming from the quantifier alone). This task requires a manageable implementation of the accommodation process. I report a partial

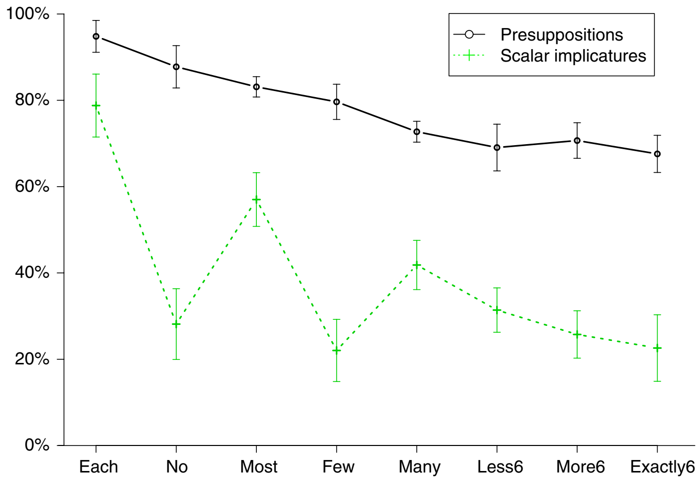


**Fig. 9** Mean correct robustness of universal inferences driven by scalar items. For comparison, previous robustness results of universal inferences with presupposition triggers in the same position are also reported

attempt in that direction in Appendix F, based on Schlenker's (2008) Transparency Theory, to illustrate the architecture of the resulting system.

### *3.3.4 Scalar implicatures*

The cases of scalar implicatures will help understand the results.

Figure 9 reports the robustness rates of universal inferences when the premise contains a (strong) scalar item in the scope of various quantifiers. Note first that the universal inference is expected only for 'each' sentences where the inference is actually an entailment of the sentence. For all other quantifiers, nothing in the theory of scalar implicatures leads to these universal inferences (see the exact predictions in (14)–(21)). However, participants did not reject the universal inference altogether and familiar differences show up between the quantifiers. (The effect of the quantifier is significant, $F(8, 72) = 16.08, p < .05$; the same effect but excluding 'each' from the analysis remains significant, $F(7, 63) = 12.04, p < .05$.)

In fact, if we try to fit the scalar implicature data with the predictions in (14)–(21), we obtain a reasonable estimation of the data: $R^2 = .66$ [$F(19, 60) = 8.91, p < .05$]. In other words: the stronger the inference, the more participants endorsed the universal inference.

This suggests a natural interpretation of what robustness represents. Imagine that you prepare yourself to inspect a set of 20 people. When you find out that the first one satisfies property $P$, you will not yet be willing to conclude that each of the 20 people satisfies property $P$. As you go along and discover that 2, 3, ... most of them satisfy $P$, it becomes more and more likely that all of them do. The same goes for the present cases. For 'no'-sentences, participants have evidence from the scalar inference that (at least) one individual satisfies property $P$. At this point, there is no strong reason to endorse the universal inference and they basically reject it. For 'most'-sentences, on the other hand, participants have evidence that most individuals satisfy $P$ and are thus much more willing to grant that the universal inference is likely to be correct.[26]

### *3.3.5 Variable presuppositions*

The situation for scalar implicatures is compelling: theories predict variable inferences and the robustness of the universal inference follows the strength of these predictions. Interestingly, this compelling situation can be extended to presuppositions.

A first attempt could be to argue that presuppositions project like scalar implicatures, but as is clear from Fig. 9, the two patterns seem very different. In statistical terms, if we try to fit the presupposition data with the predictions from a scalar theory, we obtain a rather low value: $R^2 = .13$ [$F(19, 60) = 1.65, p = .074$].

However, the Similarity Theory provides another way to have the presuppositions vary with the quantifier. In fact, if we fit the results with the predictions from this theory (see Sect. 1.2 or Appendix B) we obtain a much better fit: $R^2 = .68$ [$F(19, 60) = 6.65, p < .05$].

Overall, a visual comparison of Fig. 1 (predictions from various theories) and Fig. 9 (the corresponding results) can sum up the results very efficiently: the scalar implicature results mimic the corresponding (uncontroversial) theoretical predictions in the same way that the presupposition results mimic the predictions from the Similarity Theory.

## 3.4 Summary

The main results from this experiment confirm and refine the results from Experiment 1.

Most importantly, presuppositions triggered from the scope of different quantifiers raise universal inferences which can be more or less robust depending on the quantifier (Sect. 3.3.2). The results from Sect. 3.3.3 show that these variations do not rely on some intrinsic complexity of the quantifier which may weaken the otherwise homogeneously universal presuppositions.

The robustness of universal inferences associated with scalar implicatures patterns as follow: the closer to universal the prediction, the higher participants rate the universal inference (Sect. 3.3.4). This result suggests that robustness immediately reflects the (logical) strength of the underlying inference. Robustness thus seems to reflect the likelihood of the universal inference based on the information obtained

[26] The way the information 'Most people satisfy $P$' is conveyed matters. For instance, if someone *asserts* "Most of them are happy", this comes with a scalar implicature that not all the people involved are happy and this blocks the universal inference from the start. When the information that 'Most people satisfy $P$' comes from non-linguistic information or from an implicature, it does not come with the not-all implicature which overrides any probabilistic reasoning about the universal inference.

from the scalar implicature.[27] Most importantly for our purposes, the presuppositional data fall under the exact same schema if we abandon the universal/existential distinction and accept finer-grained predictions (Sect. 3.3.5). These results are visible from the comparison of Fig. 1 (predictions from various theories) and Fig. 9 (the corresponding results).

## 4 General discussion

The present data suggest that (1) different presuppositions are associated with different quantifiers, and (2) a general probabilistic mechanism strengthens pragmatic inferences. The latter aspect is not problematic; I showed that such a mechanism applies independently to scalar implicatures. But the former aspect goes against current leading theories of presupposition projection.

In Sect. 4.1, I discuss the types of amendments needed to reconcile theories predicting homogeneously existential or universal presuppositions with the present data. I end the discussion with a list of remaining issues.

### 4.1 Possible theoretical amendments to maintain homogeneous predictions

Presuppositions yield robust universal inferences when triggered from the scope of ‘no’; much less so for other quantifiers. Can we accommodate these data starting from homogeneously existential or universal presuppositions?

#### *4.1.1 Enriching existential presuppositions*

Let us first consider that presuppositions are existential for every quantifier: this is the weakest possible prediction and might thus be the safest. Note that theories of enrichment of presuppositions are needed independently: 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 van Rooij 2007 and Pérez Carballo 2006).

However, to account for the present set of data starting from existential presuppositions, one would need to defend an enrichment mechanism along the lines of (43):

(43) Requirements for an enrichment mechanism for existential presuppositions:
  a. It should turn weak existential presuppositions into universal inferences when they stem from certain quantifiers (e.g., ‘no’) but not others.
  b. It should not apply to scalar implicatures in the same way (the robustness of the universal inference for ‘no’-sentences remains low if we start with an existential scalar implicature rather than a presupposition).
  c. It should ideally account for the variations observed with quantifiers other than ‘no’.

[27] This does not mean that the underlying reasoning is done explicitly. The derivation of scalar implicatures is not a conscious process and there is no reason why this probabilistic evaluation of the universal inference should be explicit either.

The weakest assumption needed to enrich an existential presupposition into a universal presupposition is a "homogeneity assumption" among the individuals involved in the utterance. If $x$ satisfies the property $P$ (existential presupposition) and if all relevant individuals are similar to $x$ (homogeneity assumption), we can conclude that each individual satisfies $P$.[28] Interestingly, this assumption may apply differently to the quantifiers 'each' and 'no' on the one hand and to the rest of the quantifiers on the other: stating that only a subset of students in a group (e.g., exactly 6) satisfy a property $P'$ casts doubt on the homogeneity assumption (even about another property $P$). In other words, there might be ways to fulfill the first requirement in (43a).

Unfortunately, it is difficult to see how to address the other requirements in (43). For instance, if the homogeneity assumption is a general pragmatic assumption or if it is somehow associated with quantified expressions, existential scalar implicatures should also lead to universal inferences (in the case of 'no'), contrary to requirement (43b). Similarly, this hypothesis offers no solution to (43c): inferences should be either universal or existential—nothing else.

#### *4.1.2 Limiting the accommodation of universal presuppositions*

Let us now consider that presuppositions are universal. Are we in a better position? The challenge is now mainly to explain why presuppositions are weakened (or not accommodated) in a systematic range of cases.

First, note that scalar implicatures do not interfere as above in (43b): the question of whether scalar implicatures are subject to the same weakening mechanism as presuppositions does not arise because scalar implicatures are not claimed to be universal to begin with. Second, the data for the quantifier 'no' go as expected and there only remains to explain why universal presuppositions are weakened (or not accommodated) for the other quantifiers.

One possibility is to resort to an explanation in terms of complexity: there is something difficult about some quantifiers which prevents the accommodation process to deliver the full universal presuppositions.[29] Results from Sect. 3.3.3 suggest that the type of difficulty involved should come from the interaction between the quantifier and the accommodation process. Schlenker (2007) describes

[28] Schwarzschild (1993), Löbner (2000), Beck (2001), and Gajewski (2005, 2007) argued that such an assumption could come out as a regular presupposition of plural definite NPs.

[29] Bart Geurts (p.c.) suggests an alternative approach. Quantifiers other than 'each' and 'no' might introduce a discourse referent which is a subset of the individuals involved. The (still universal) presupposition might then apply either to this subset of students or to the whole group of students. This type of account would be such that presuppositions vary with the quantifiers; it is exactly my point to argue in favor of this general class of theories (against existential or universal theories). Turning this suggestion into a working proposal would require to explain how discourse referents are associated with quantifiers (and in particular downward entailing quantifiers like 'few' which seems to pattern like 'most') and why, for instance, universal inferences associated with 'most' and 'few' seem more robust than universal inferences associated with numerical quantifiers.

the technical details of a theory of presupposition projection which might help elaborate the relevant measure of complexity. Appendix F shows that in Schlenker's system, the accommodation process of a universal presupposition in the case of numerical quantifiers may involve several computational steps which are not necessary with the quantifier 'no'. In other words, accommodation could be computationally harder for quantifiers other than 'no' and this could explain why universal inferences are sometimes rejected in these cases.

This is an interesting possibility, but at this stage more investigations are needed to check, for instance, whether we obtain a binary distinction between quantifiers or finer-grained variations as in Fig. 9.

## 4.2 Conclusion and remaining issues

This work was motivated by an empirical controversy arising from formal investigations of presupposition. I argued that the dilemma should be tackled with empirical means and proposed an experimental paradigm relying on accommodation. The results show that universal inferences associated with presuppositions in quantified sentences are not homogeneous: universal inferences are more or less robust depending on the quantifier (see Fig. 9). I discussed possible amendments to universal or existential theories of presupposition projection. However, I argued that if we drop the idea that presuppositions project homogeneously from every quantifier we could offer a natural account for the variations we observe. This line of explanation is also independently motivated by the results obtained for scalar implicatures.

In this section I review some issues which require further theoretical developments as well as refinements of the present empirical investigations.

### *4.2.1 Presuppositions in questions*

The list of quantifiers in Experiment 2 included *qui* 'who'. The corresponding data were not fully discussed because in the absence of an equivalence relation between questions, it is difficult to decide what predictions follow from the Similarity Theory (as well as from others, see discussion in Schlenker 2009). Empirically speaking, there is also too much variability to tell whether universal inferences associated with questions are as robust as those of 'no'-sentences or if they are closer to those associated with numerical quantifiers. This calls for more experimental and theoretical work.

### *4.2.2 Restrictors of quantifiers*

The data obtained for restrictors of quantifiers are difficult to interpret. If anything, it seems that universal inferences are less robust than in the corresponding cases where a presupposition trigger appears in the scope of a quantifier. If this tendency were confirmed, it would be an important challenge for explanatory theories of presuppositions whose predictions rely solely on the bare semantics of the environment in which a presupposition trigger is embedded. The problem is best illustrated with the symmetrical quantifier ‘no’ (see discussion in the appendix of Schlenker 2008). If we exchange the restrictor and the nuclear scope we obtain semantically equivalent sentences with potentially very different presuppositions:[30]

(44) $[\text{No } x\text{: } R(x)]S_p(x)$ (robust universal inference)

(45) $[\text{No } x\text{: } S_p(x)]R(x)$ (less robust universal inference)

Here again, further empirical investigation and theoretical work is needed. It is worth mentioning that while the Similarity Theory does not distinguish between (44) and (45), George’s (2008) theory does.

*4.2.3 Differences between triggers*

Charlow (2008) argues that anaphoric triggers (*too* and *again*) project universal presuppositions in all quantified sentences:

(46) Less than 6 of these students SMOKE too.
(Robust?) universal inference: Each of the students involved drinks (for instance).

Although examples are difficult to construct, Benjamin Spector (p.c.) suggests that *it*-clefts also have this property:

(47) For less than 6 of these students, it is in maths that they have difficulties.
Robust universal inference: Each of “these students” have difficulties in some topic.

(48) Less than 6 of these students for whom it is in maths that they have difficulties came to the library yesterday.
(Robust?) universal inference: Each of “these students” have difficulties in some topic.

This echoes the discussion about Fig. 4b: change of state predicates might be different from definite descriptions and factive verbs. Even though these results were not replicated in Experiment 2, there could be different classes of presupposition

[30] In Experiment 2, the relevant items were less minimally different:

(i) $[\text{No } x\text{: student}(x)S_p(x)$
Universal inference tested: $[\forall x\text{: student}(x)]\ p(x)$

(ii) $[\text{No } x\text{: student}(x) \text{ and } S_p(x)]\ R(x)$
Universal inference tested: $[\forall x\text{: student}(x)]\ p(x)$
(Note that the following is also a universal candidate: $[\forall x\text{: student}(x)$ and $R(x)]\ p(x))$

triggers which induce different presuppositions (or at least yield different inferences). Charlow suggests that for each trigger, the strength of the presupposition in quantified sentences correlates with the difficulty to accommodate the presupposition in general. Note, however, that the differences between quantifiers would remain an independent puzzle for at least some presupposition triggers.[31]

More generally, this discussion raises the question of the homogeneity of the phenomenon of presupposition per se. This is an old debate which I think has not been properly resolved yet.[32] Combined experimental and theoretical investigations of the distinct projection behavior of various triggers should allow us to make significant progress in our understanding of presuppositional phenomena.

#### *4.2.4 More processing results*

Finally, I believe that it could be very informative to obtain more processing results (see the preliminary results in Fig. 5). This type of results could provide important arguments in favor of accounts based on enrichments of non-universal presuppositions or in favor of accounts based on non-derivations of universal presuppositions. In particular, if we had a psycholinguistic marker of local accommodation (in terms of response times pattern or a particular aspect of the ERP signal, for instance), we could more easily address issues as abstract as Charlow's hypothesis about the correlation between the strength of a projected presupposition and the difficulty to accommodate this presupposition.

## Appendices

## A Deriving universal/existential presuppositions

How can we derive the presupposition of a quantified sentence such as (49) from the presupposition $p(x)$ of $S_p(x)$? In this appendix, I repeat Heim's (1983) and Beaver's (2001) solutions, see Kadmon (2001, Chap. 10) for discussion.

(49) $[Qx : R(x)]S_p(x)$

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

Heim (1983) predicts universal presuppositions: *every* individual which satisfies the restrictor should satisfy the presupposition of the scope: $[\forall x : R(x)]p(x)$. This

[31] Unless one makes the claim that the differences we observe are due to the fact that accommodation is easier for some quantifiers. This claim may weaken the predictive power of our theory of presupposition, and of course it would have to be motivated independently.

[32] This issue arose e.g. in discussions between Karttunen (1973) and Stalnaker (1974) about the differences between factive and semi-factive verbs. See also my work where I dispute the rigid boundary between presuppositions and other types of inferences (Chemla 2009a,b,c).

follows from the general admittance condition for any sentence $S_p$ with presupposition $p$ in a context $C$ in (50), where $\langle g, w \rangle$ is a pair of assignment function $g$ and world $w$:

(50) $\forall \langle g, w \rangle \in C, \exists g' \supseteq g \text{ s.t.} \langle g', w \rangle \in C + p$

This admittance condition then applies incrementally to sentences of the form (49). For the presupposition triggered in the scope of the quantifier to be harmless, it must be admissible in the initial context $C$ updated with the restrictor: $C + R(x)$:

(51) $\forall \langle g, w \rangle \in C + R(x), \exists g' \supseteq g \text{ s.t.} \langle g', w \rangle \in (C + R(x)) + p(x)$

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)

The phrase "$\exists g' \supseteq g$" is absent from Beaver's (2001) admittance condition (see (52)). This new rule leads to the admittance condition in (53) for sentences like (49) in a context $C$. A set of individuals can produce an assignment function $g'$ that satisfies (53) if it contains at least one individual which statisfies both the restrictor and the presupposition of the scope.

(52) $\forall \langle g, w \rangle \in C, \exists g' \text{ s.t.} \langle g', w \rangle \in C + p$

(53) $\forall \langle g, w \rangle \in C + R(x), \exists g' \text{ s.t.} \langle g', w \rangle \in (C + R(x)) + p(x)$

## B Similarity Theory

As a first approximation, the Similarity Theory requires that presuppositions and their negations be locally trivial. Formally, this amounts to the following two principles, for a sentence with a presuppositional $S_p$ in an environment $E$:

(54) $E(S_p)$ presupposes that:
a. $E(p) \Leftrightarrow E(\top)$
b. $E(\neg p) \Leftrightarrow E(\bot)$

Here are two representative applications:

(55) John does not know that he's lucky.
Schematically: $\neg(S_p)$
a. $\neg(p) \Leftrightarrow \neg(\top)$ i.e. $p$ is true
b. $\neg(\neg p) \Leftrightarrow \neg(\bot)$ i.e. $p$ is true

(56) No student knows that he's lucky.
Schematically: [No $x$: student($x$)]$S_p(x)$
a. [No $x$: student($x$)]$p(x)$ $\Leftrightarrow$ [No $x$: student($x$)]$\top(x)$
The right-hand side is false; hence this is equivalent to:
$\neg$([No $x$: student($x$)]$p(x)$),
i.e., Some student satisfies $p$.
b. [No $x$: student($x$)]$\neg p(x)$ $\Leftrightarrow$ [No $x$: student($x$)]$\bot(x)$
The right-hand side is true; hence this is equivalent to:
[No $x$: student($x$)]$\neg p(x)$,
i.e., All students satisfy $p$.

## C Instructions

I reproduce the instructions provided to the participants before Experiment 1. The context provided and the way the word *suggérer* is clarified are the methodological points of main importance.

### 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 have 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 says 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 the teachers involved here are well informed, you will very likely answer YES in this case.

However, the examples will not all be so clear and we are asking you for your own intuitive judgment. To take another 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 that is indeed your feeling, you will press YES). This need not necessarily be 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 the examples to be absolutely independent. You must forget them as the experiment goes on and provide your intuition only on the basis of the sentence uttered (and the general context described above). Do not let previous trials or your own previous responses influence your responses.
- With some examples you might think that you have seen them before (many examples look like each others). This is not important, just 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 pronounced stressed.
- Position your hands to be ready to push the appropriate key as soon as you have made up your mind. You are going to see many examples. This is an additional reason to answer quickly following your first intuition (avoiding excessive haste, of course).

## D Orthogonal issues

The empirical disagreement schematized in (2) might suffer from independent complications. I review them in this section and explain my attempt to stay away from these (interesting) problems in the actual experimental items.

### D.1 Implicit domain restriction

A bare noun in the restrictor of a quantifier typically does not fix the domain of individuals involved in a quantified sentence. This domain is most often implicitly restricted via contextual assumptions. For instance, given the context in (57), the noun *Italian* in (57a) is used to refer to a particular subset of Italians, without any explicit linguistic indication of this fact.

(57) Context: John is a teacher and, while he is talking about his new students, he says:
   a. Every Italian is tall.
   b. Meaning: Every Italian (among my new students) is tall.

This implicit operation of domain restriction is extremely common and powerful. In (58a), the phrase *Every Italian* occurs twice within the very same sentence, yet these two occurrences are subject to two different implicit domain restrictions.

(58) 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. Meaning: Every Italian (who is in the committee) voted for every Italian (who is an applicant).

(from Schlenker 2004, after D. Westerståhl)

To understand the importance of implicit domain restrictions for the purposes of the present study, consider example (3), *No student knows that he's lucky*, and its schema in (2) 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 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 (59) is a possible outcome of domain restriction, where the phrase in parentheses mimics the implicit domain restriction. In this case, the potential universal inference in (59a) is simply tautologous.[33]

(59) 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 or 20 particular students. Thus, sentences in (60) are versions of (3) which might qualify for the present experiments;

(60) a. None of these 10 students knows that he is lucky.
b. Among these 20 students, no(o)ne knows that he is lucky.[34]

The following examples confirm that explicit mentions of a specific domain of individuals block implicit domain restrictions (compare (61) to (57) and (62) to (58)):

(61) Each of these 10 Italians is tall.

(62) Context: A committee must select some applicants. Five 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.

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

[34] The English version is a bit marked, but the sentence sounds perfect to me in French: *Parmi ces 20 étudiants, aucun ne sait qu'il a de la chance.*

Admittedly, I did not prove that domain restrictions are impossible in sentences where a domain of individuals is specified overtly. Nonetheless, I hope that the data in (60)–(62) convincingly show that unmotivated implicit domain restrictions are now at least disfavored.

D.2 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 (63). The two potential interpretations are paraphrased in (63a) and (63b).

(63) 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. Less than 3 of these students are X's such that X knows that X (himself) is lucky.

Under the reading paraphrased in (63a), the complement of the verb *know* 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 is always the same statement, that all the students involved are lucky. As a result, the two predictions (existential or universal) schematized in (2) collapse into 'All of these 10 students are lucky'. To understand why the predictions collapse in the absence of free variables, consider example (64).

(64) 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.

In sentence (64), the proposition expressed in the complement of the verb *know* does not contain any free variable: the weather does not depend on any property of the students under discussion. As a result, the existential and universal versions of the presupposition of this sentence (spelled out in (64a) and (64b)) are equivalent.[35]

The examples used in the experiments were designed to disfavor the unfortunate bound reading described in (63a). This is exemplified in (65): *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 does not correspond to the natural situation one might construct to interpret this example. The bound reading is thus strongly favored.

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

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

## E Material

The material was constructed by combining pairs of linguistic environments with inferences. For illustration, below I provide the list of inferences used in Experiment 1 embedded under the pair of environments ⟨John___, John___⟩. The rest of the items can be constructed from this sample set by extracting the inference and embedding it under the other environments. The material for Experiment 2 was similar, except for the differences described in Sect. 3.2.

(66) a. Non-quantified environments:
⟨John___, John___⟩, ⟨I doubt that John___, John___⟩
b. Environments testing a universal inference:
⟨Each, Each⟩, ⟨No, Each⟩, ⟨More than 3, Each⟩, ⟨Less than 3, Each⟩, ⟨Exactly 3, Each⟩
c. Environments testing a scalar inference:
⟨No, (At least) one⟩, ⟨More than 3, More than 3⟩ , ⟨Less than 3, (At least) 3⟩

Formally, when the embedding environment involved a quantifier, *John* was replaced by a free variable which was bound in the scope of the quantifier.

(67) Definite description
a. "Jean prend soin de son ordinateur." ⇝ Jean a un ordinateur.
'John takes good care of his computer.' ⇝ John has a computer.
b. "Jean maltraite son ordinateur." ⇝ Jean a un ordinateur.
'John takes bad care of his computer.' ⇝John has a computer.

(68) Factive verb
a. "Jean sait que son père va être convoqué." ⇝ Le père de Jean va être convoqué.
'John knows that his father is about to be summoned.' ⇝ John's father is about to be summoned.
b. "Jean sait que son père va recevoir une lettre de félicitations." ⇝ Le père de Jean va recevoir une lettre de félicitations.
'John knows that his father is about to receive a congratulation letter.' ⇝ John's father is about to receive a congratulation letter.
c. "Jean ignore que son père va être convoqué." ⇝ Le père de Jean va être convoqué.
'John is unaware that his father is about to be appointed.' ⇝ John's father is about to be appointed.
d. "Jean ignore que son père va recevoir une lettre de félicitations." ⇝ Le père de Jean va recevoir une lettre de félicitations.
'John is unaware that his father is about to receive a congratulation letter.' ⇝ John's father is about to receive a congratulation letter.

(69) Change of state predicate

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

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

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

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

(70) Scalar implicature

a. "Jean a réussi tous ses examens." ⇝ Jean a réussi plusieurs de ses examens.
'John passed all his exams.' ⇝ John passed several of his exams.

b. "Jean a raté tous ses examens." ⇝ Jean a raté plusieurs de ses examens.
'John failed all his exams.' ⇝ John failed several of his exams.

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

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

e. "Jean est excellent." ⇝ Jean est bon.
'John is excellent.' ⇝ John is good.

(71) Scalar implicature with "focus"

a. "Jean a réussi TOUS ses examens." ⇝ Jean a réussi plusieurs de ses examens.
'John passed ALL his exams.' ⇝ John passed several of his exams.

b. "Jean a raté TOUS ses examens." ⇝ Jean a raté plusieurs de ses examens.
'John failed ALL his exams.' ⇝ John failed several of his exams.

c. "Jean a lu le cours ET fait un exercice." ⇝ Jean a fait (au moins) l'un des deux.
'John read the class notes AND did an exercise.'
⇝ 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.

(72) 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).

(73) 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.

## F The transparency theory

Schlenker's (2007) projection theory of presupposition, the transparency theory, predicts that a sentence of the form in (74) presupposes (75) (the equivalence is supposed to be a contextual equivalence).

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

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

This formula states that replacing a presuppositional expression $S_p$ 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. In other words, the contribution of the presupposition is null.

The prediction in (75) 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, on the other. (I will only show that this prediction entails the universal presupposition here.)

### F.1 The quantifier 'no'

To recognize that (75) entails the universal presupposition when the quantifier $\mathcal{Q}$ is 'no', one only has to replace $\beta$ by the predicate $\neg p$. This is proved in (76).

(76) a. Prediction: $\forall\beta$, $[\text{No}\, x : R(x)]\beta(x) \Leftrightarrow [\text{No}\, x : R(x)](p \wedge \beta)(x)$
b. If we take $\beta = \neg p$, we obtain:
$[\text{No}\, x : R(x)]\neg p(x) \Leftrightarrow [\text{No}\, x : R(x)](p \wedge \neg p)(x)$
The right-hand side of the equivalence is true (no individual satisfies both $p$ and $\neg p$), and we thus obtain that the left-hand side of the equivalence is true as well:
$[\text{No}\, x : R(x)]\neg p(x)$ i.e. $[\forall x : R(x)]p(x)$

In other words, the universal presupposition is retrieved in one step by instantiating the predicate $\beta$ with $\neg p$.

### F.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 concentrate on the quantifier 'less than 3' (other quantifiers like 'more than $x$' and 'exactly $x$' behave similarly). The prediction is given in (77).

(77) 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 leads 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 (77) 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 the universal presupposition is given in (78). A proof that no single instantiation of $\beta$ can provide the universal presupposition is not available at this point.

(78) Full derivation of the universal presupposition from (77):
Let $\beta_1$ designates a set of three specific individuals who satisfy $R$. If we take $\beta$ to be this $\beta_1$ in (77), the left-hand side of the equivalence is false. 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 of (77). If we do this with enough triplets of individuals like $\beta_1$, we obtain that all the individuals who satisfy $R$ also satisfy the presupposition $p$.

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