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# Presupposition Projection out of Quantified Sentences: Strengthening, Local Accommodation and Inter-speaker Variation

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**Abstract.** Presupposition projection in quantified sentences is at the center of debates in the presupposition literature. This paper reports on a survey revealing inter-speaker variation regarding which quantifier yields universal inferences—which  $Q$  in  $Q(B)(\lambda x.C(x)_{p(x)})$  supports the inference  $\forall x \in B: p(x)$ . We observe an implication that if *some* yields a universal inference for a speaker, *no*, and *any* in a polar question do as well. We propose an account of this implication based on a trivalent theory of presupposition projection together with auxiliary assumptions suggested by [8].

**Keywords:** Presupposition Projection, Quantified Sentences, Trivalent Logic, Inter-speaker Variation

## 1 Introduction

The judgments regarding the presuppositions associated with quantificational sentences are often delicate, and different judgments are reported in the literature ([1, 4, 12]). In this paper we focus on three particular types of quantificational sentences that are illustrated in (1).

- (1) a. Some of the students drive their car to school
- b. None of the students drive their car to school
- c. Do any of the students drive their car to school?

We will refer to these three types of quantified sentence, an existential sentence, a negative existential sentence, and an existential polar question, respectively.

It is generally taken for granted that existential sentences like (1-a) do not have a universal inference,  $\forall x: p(x)$  (but see [3, 5]). According to some theories such as [16] (see also [12]), however, all quantifiers, including existential quantifiers, are predicted to give rise to a universal presupposition.

For negative existential sentences, [6] claims that it has a universal presupposition, while [1] contends that its presupposition is always existential, i.e.  $\exists x: p(x)$ . [1] goes one step further, and proposes a theory where the presupposition is existential for all quantificational determiners, not just *none*.

More recently [4] conducted experiments whose results suggest that there are subtle differences among quantifiers. In particular, [4] provides evidence that existential sentences with modified numerals indeed lack a universal inference, while negative existential sentences tend to have a universal inference. However, [4]’s evidence is based on data pooled from all subjects and thus is not informative on possible variations in judgment among speakers. As we will show, such variation exists and it is an important aspect of the phenomenon that calls for an explanation.

This paper presents the results of an online survey that aims to investigate the possibility of inter-speaker variation in the distribution of universal inferences across the three types of quantified sentences mentioned above. In particular, our results indicate the following implication: if an existential sentence yields a universal inference for a speaker, a negative existential sentence and an existential polar question do as well. We offer an account of this implication framed in a trivalent theory of presupposition projection ([2, 7–10], among others). Trivalent theories predict a disjunctive presupposition for the three types of quantified sentences. Following [8], we assume that this presupposition is pragmatically marked and that two strategies can be used to mitigate this markedness: (i) pragmatic strengthening and (ii) insertion of the A-operator (defined below). We will see that the first strategy always yields a universal inference, whereas the second strategy never yields a universal inference for existential sentences, but could yield a universal inference for the other two types of quantificational sentences. We will propose that speakers vary in the strategy they prefer to use, and demonstrate how this can account for the implication found in the survey.

The organization of the paper is as follows. The survey is presented in Section 2. Our theoretical assumptions are introduced in Section 3, and our theory regarding inter-speaker variation is proposed in Section 4.

## 2 Survey

We conducted an on-line survey on Amazon Mechanical Turk (MTurk)<sup>1</sup> whose main purpose was to investigate inter-speaker variation on which quantificational determiner yields a universal inference. We focus on the three types of sentences mentioned above, i.e. existential and negative existential sentences, and existential polar questions.

### 2.1 Design

We employed the ‘covered box’ method of [13]. The covered box method is a variant of the picture selection method. In each trial of our survey, participants saw a sentence and a pair of pictures, and were asked to pick the picture that the sentence was about. One of the pictures was covered and invisible, while the other picture was overtly displayed. Participants were instructed to choose

<sup>1</sup> <https://www.mturk.com/mturk/welcome>

the covered picture *only if the overt picture was not a possible match for the sentence*.

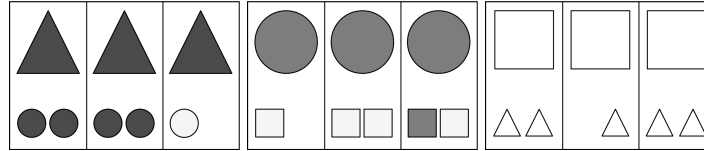
The survey consists of 3 target trials, 3 control trials and 18 filler trials. The sentences used in the target trials are given below. They all contain *both*, which presupposes that there are exactly two entities satisfying the restriction.

- (2)
- a. Some of these three triangles have the same color as both of the circles in their own cell
  - b. None of these three circles have the same color as both of the squares in their own cell
  - c. Do any of these three squares have the same color as both of the triangles in their own cell?

The overt picture in each of the target trials was designed in such a way that the universal inference is not satisfied in it. In addition for the trials with declarative sentences, the overt picture satisfies what is asserted (and implicated), e.g. some but not all of the three triangles have the same color as all of the circles in their own cell for (2-a).<sup>2</sup> Therefore, the prediction is that the covered picture will be chosen if and only if the speaker gets a universal inference.

The overt pictures for the target trials are given in Fig. 1.<sup>3</sup> Each picture contains three cells, each of which in turn contains exactly one restrictor figure (e.g. a triangle for (2-a)). Crucially, only two of the cells have exactly two nuclear scope figures (e.g. circles for (2-a)), and the remaining one has only one. For trials with a polar question such as (2-c), the overt picture is colorless, and participants were instructed to imagine that somebody who is incapable of distinguishing colors is asking the question, and guess which picture they are asking about.

**Fig. 1.** Overt pictures in the target items.



The three control items are identical in structure to the target items except for the following two points: the sentence mentions different restrictor and nuclear figures from the corresponding target item, and the overt picture satisfies the universal inference (i.e. all of the cells contain exactly two nuclear figures). Therefore all the participants are expected to choose the overt picture.

<sup>2</sup> The sentences had additional presupposition triggers besides *both*, namely the definite DPs *the ...* and *their own ...*, which are satisfied universally.

<sup>3</sup> The pictures are converted to gray scale here. In the original pictures, (3-a') contains blue triangles and blue and yellow circles, and (3-b') contains red circles and red and yellow squares.

The eighteen filler items involve non-ambiguous quantificational sentences, eight of which are polar questions. None of them contain *both* taking scope below another quantifier. For half of the filler trials the overt picture matches the sentence, and for the other half, the overt picture does not satisfy the assertion and/or the presupposition of the sentence.

## 2.2 Results

274 participants were employed on MTurk, among which 15 non-native speaker participants and 73 other participants whose accuracy rate for the filler items was less than 75% (i.e. 5 or more mistakes) are excluded from the analysis. All participants were paid \$0.20 for their participation, and 59 of them are paid additional \$0.25 for answering all of the filler items correctly.

As there are two possible answers for each of the three target trials, there are eight possible answer patterns. The data from 186 native speakers of English is summarized in Table 1, where  $\forall$  stands for the covered picture, and  $\exists$  stands for the overt picture.<sup>4</sup>

**Table 1.** Results of the survey.

	‘Some’	‘None’	‘?any’	# of Participants		‘Some’	‘None’	‘?any’	# of Participants
1	$\exists$	$\exists$	$\exists$	60	5	$\forall$	$\exists$	$\exists$	2
2	$\exists$	$\exists$	$\forall$	49	6	$\forall$	$\exists$	$\forall$	1
3	$\exists$	$\forall$	$\exists$	21	7	$\forall$	$\forall$	$\exists$	2
4	$\exists$	$\forall$	$\forall$	47	8	$\forall$	$\forall$	$\forall$	19

The distribution of participants across the answer patterns is clearly non-uniform. In particular, the patterns 5-7 are very small in number, compared to the others. From this observation, we draw the following generalizations.

- (3) For a given speaker,
- if the existential sentence has a universal inference, then the negative existential sentence and the existential polar question do too (i.e. 8 vs. 5-7);
  - if the existential sentence does not have a universal inference, then the negative existential sentence and the existential polar question can but need not have a universal inference (i.e. 1-4)

<sup>4</sup> The error rate for the filler items is rather high, but inclusion of more subjects by lowering the cutoff accuracy rate does not undermine our results. Specifically, by lowering the cutoff accuracy to 70% (5 or less mistakes are allowed), 221 among the 259 native speaker participants, and by lowering it to 65% (6 or less mistakes are allowed), 234 subjects remain. In both cases, all the patterns but 5-7 show an increase in number roughly proportionate to the number of the additional subjects, while 5-7 do not exceed 2.

It should also be remarked that 24 out of 186 participants chose the covered picture for the existential sentence, indicating that they obtained a universal inference for it. As remarked at the outset, it is generally considered that existential sentences have non-universal inferences, and our data shows a clear tendency in line with this intuition (see also [4]). Nonetheless, the existence of speakers preferring a universal reading is theoretically interesting, and as we will demonstrate, our theory accounts for both types of speakers.

The results of the control items are as follows. Recall that the overt picture satisfies the universal inference and hence is expected to be chosen uniformly. In fact only 3 participants chose the covered picture for the existential sentence, and 15 subjects did so for the existential polar question. However, contrary to our expectation, the covered picture was chosen for the negative existential sentence by 43 out of 186 subjects. Although we cannot offer an explanation for this unexpectedly high figure for the negative existential sentence, it does not undermine the above observations, since excluding these subjects still indicates the same implicational patterns (the numbers are omitted for reasons of space).<sup>5</sup>

### 3 Trivalent Theory of Presupposition Projection

#### 3.1 Three Truth Values and the Felicity Condition

In the rest of this paper, we will offer a theoretical explanation of the implicational generalizations in (3) framed in a trivalent theory of presupposition projection.<sup>6</sup> Trivalent theories ([2, 7–10, 15]) postulate three, rather than two, truth values, denoted here by 0, 1 and #. The projection property of a given sentence is predicted via a pragmatic principle that requires a sentence to denote either 0 or 1 in each of the possible worlds in the current context set (in the sense of [19]). This pragmatic principle is stated as in (4).

(4) **Felicity Condition**

A (declarative) sentence  $S$  can be felicitously used given a context set  $C$  only if for all  $w \in C$ ,  $\llbracket S \rrbracket(w) \neq \#$

The Felicity Condition can be given a pragmatic motivation. It can be thought of as a consequence of a principle of conversation demanding that an utterance

<sup>5</sup> An anonymous reviewer of the Amsterdam Colloquium worried that this could indicate that there is a stronger bias toward the covered picture for negative existential sentences than for the other types of sentences. This suggests a possibility that for the negative existential sentence, a choice of the covered picture does not necessarily imply the universal inference, and hence the figures for the patterns 3, 4, 7 and 8 are overestimated to some extent. Crucially, however, the asymmetry between the patterns 1-4 and the patterns 5-8 will remain even if we correct for a tendency to choose the covered box for negative existentials.

<sup>6</sup> A reviewer suggested the possibility that the distribution of facts follows directly from a probabilistic theory of presupposition projection. We think that this is a potentially interesting avenue to investigate. However, we were unable to come up with a predictive general theory of projection that would derive the needed probabilities.

of a declarative sentence tell the conversational participants which worlds in the context to retain and which ones to discard. This demand will not be met if in any of the worlds in the context set the declarative sentence is neither true nor false (cf. [19]).

In this system, the presupposition of a declarative sentence is the proposition that needs to be true for the sentence to denote either 0 or 1. As an illustration, consider the simple example below, and imagine that the existence presupposition of the possessive is the only presupposition.

- (5) John drives his car to school

The denotation of this sentence is as in (6).

$$(6) \quad \lambda w. \begin{cases} 1 & \text{if John has a car and drives it to school in } w \\ 0 & \text{if John has a car and does not drive it to school in } w \\ \# & \text{otherwise} \end{cases}$$

According to the Felicity Condition in (4), for an utterance of (5) to be felicitous, it is required that John have a car in all of the possible worlds in the context set. Therefore (5) presupposes that John has a car.

### 3.2 Extension to Polar Questions

We now extend the above theory to polar questions. Following [14], we assume that questions denote sets of propositions. Notice that the Felicity Condition in (4) does not apply to question denotations, and therefore we postulate a separate pragmatic condition for the use of questions.<sup>7</sup> We hypothesize the weakest possible condition in (7).<sup>8</sup>

- (7) **Felicity Condition for Questions**

A question  $Q$  can be felicitously used given a context set  $C$  only if for all  $w \in C$ , there is  $q \in \llbracket Q \rrbracket$  such that  $q(w) \neq \#$

This is evidently not meant to be the only condition on a felicitous use of a question. Other conditions include, for example, that the answer is not known yet, and that all propositions in the denotation are not known to be false, which amounts to requiring that for all  $q \in \llbracket Q \rrbracket$ , there is  $w \in C$  such that  $q(w) = 1$ . But as it turns out, only (7) matters for our purposes at hand.

In (8) we give a simple example for illustration.

- (8) Does John drive his car to school?

<sup>7</sup> [8] suggests a bivalent reformulation of the theory using the notion of relevance with the aim of giving declarative sentences and questions a uniform treatment. We will not pursue this alternative in this paper.

<sup>8</sup> Note that if we strengthen the condition to a universal requirement, this won't affect our results since the two are equivalent for polar questions, given that the two members of the question denotation have the same presupposition.

Suppose that the denotation of this question is in (9).

$$(9) \quad \{\llbracket \text{John drives his car to school} \rrbracket, \neg \llbracket \text{John drives his car to school} \rrbracket\} \\ = \{\llbracket (5) \rrbracket, \neg \llbracket (5) \rrbracket\}$$

The condition in (7) demands that in each world  $w$  in the context set, either  $\llbracket (5) \rrbracket(w) = 1$  or  $\llbracket (5) \rrbracket(w) = 0$ . Therefore, (8) has the same presupposition as (5), namely that John owns a car.

### 3.3 Disjunctive Presuppositions for Quantified Sentences

As we will demonstrate in this subsection, trivalent theories assign a disjunctive presupposition to all of the three types of quantified sentences that we are interested in in the present paper.<sup>9</sup> For ease of exposition, we schematically represent the meanings of quantificational sentences as in (10).

$$(10) \quad Q(B)(\lambda x.C(x)_{p(x)}) \text{ where} \\ \begin{array}{ll} \text{a.} & Q \text{ is a determiner denotation} \\ \text{b.} & B \text{ is the restrictor of } Q \\ \text{c.} & \lambda x.C(x)_{p(x)} \text{ is the nuclear scope of } Q \text{ with the presupposition } p(x) \end{array}$$

The predicted presupposition of the three types of quantificational sentences that we are after is  $[\exists x \in B: p(x) \wedge C(x)] \vee [\forall x \in B: p(x)]$ . Let us look at the three cases in turn.

Firstly, the truth conditions of an existential sentence are given in (11).

$$(11) \quad \llbracket \text{some} \rrbracket(B)(\lambda x.C(x)_{p(x)}) \\ = \lambda w. \begin{cases} 1 & \text{if } \exists x \in B: p(x) \wedge C(x) \text{ in } w \\ 0 & \text{if } [\forall x \in B: p(x)] \wedge [\neg \exists x \in B: p(x) \wedge C(x)] \text{ in } w \\ \# & \text{otherwise} \end{cases}$$

The Felicity Condition requires that for each possible world  $w$  in the context set, either  $\exists x \in B: p(x) \wedge C(x)$  or  $[\forall x \in B: p(x)] \wedge [\neg \exists x \in B: p(x) \wedge C(x)]$ . Thus the presupposition of (11) is the disjunction of these two propositions, i.e.  $[\exists x \in B: p(x) \wedge C(x)] \vee [\forall x \in B: p(x)]$ .

Given that a negative existential sentence is the negation of the corresponding existential sentence, i.e. (12), the exact same presupposition is predicted for negative existential sentences.

$$(12) \quad \llbracket \text{none} \rrbracket(B)(\lambda x.C(x)_{p(x)}) \\ = \lambda w. \begin{cases} 1 & \text{if } \llbracket \text{some} \rrbracket(B)(\lambda x.C(x)_{p(x)})(w) = 0 \\ 0 & \text{if } \llbracket \text{some} \rrbracket(B)(\lambda x.C(x)_{p(x)})(w) = 1 \\ \# & \text{otherwise} \end{cases}$$

<sup>9</sup> As demonstrated in [2, 7] and in particular in [9, 10], a trivalent theory makes predictions for the entire language, including various kinds of connectives, but as they are not our central concern, we will ignore them here.



Furthermore, an existential polar question has the same disjunctive presupposition, if we assume the denotation of  $\llbracket ? \rrbracket \llbracket \text{any} \rrbracket (B)(\lambda x.C(x)_{p(x)})$ , where ‘?’ is the question operator, to be the set  $\{\llbracket \text{some} \rrbracket (B)(\lambda x.C(x)_{p(x)}), \llbracket \text{none} \rrbracket (B)(\lambda x.C(x)_{p(x)})\}$ . The Felicity Condition demands that for each possible world in the context set, either of these propositions is true, i.e.  $[\exists x \in B: p(x) \wedge C(x)] \vee [\forall x \in B: p(x)]$  must be true in each world. Therefore the same disjunctive presupposition  $[\exists x \in B: p(x) \wedge C(x)] \vee [\forall x \in B: p(x)]$  is predicted.

### 3.4 Two Strategies

Following [8], we assume that the disjunctive presupposition  $[\exists x \in B: p(x) \wedge C(x)] \vee [\forall x \in B: p(x)]$  is pragmatically marked and triggers one of two repair strategies: (i) pragmatic strengthening or (ii) insertion of the operator that turns a trivalent proposition into a bivalent one, which we call the A-operator following [2].

Again following [8], we furthermore assume that when applied to the disjunctive presupposition, pragmatic strengthening yields the universal inference  $\forall x \in B: p(x)$ .<sup>10</sup> Since three types of quantified sentences we are interested in here have the same disjunctive presupposition as shown in the previous subsection, pragmatic strengthening invariably yields the universal inference for all of them.

On the other hand, the A-operator can result in a universal or weaker inference depending on its scope and the quantifier. The denotation of the operator is given in (13).

$$(13) \quad \llbracket A \rrbracket = \lambda p_{\langle s, t \rangle}. \lambda w. \begin{cases} 1 & \text{if } p(w) = 1 \\ 0 & \text{if } p(w) = 0 \text{ or } p(w) = \# \end{cases}$$

We assume that the A-operator is a phonologically null operator that may appear in any syntactic position where the sister constituent is of the propositional type  $\langle s, t \rangle$ .<sup>11</sup> Let us now examine what the A-operator yields for the three types of quantified sentences.

Consider first an existential sentence with the A-operator above the quantifier, i.e.  $\llbracket A \rrbracket (\llbracket \text{some} \rrbracket (B)(\lambda x.C(x)_{p(x)}))$ .

$$(14) \quad \lambda w. \begin{cases} 1 & \text{if } \llbracket \text{some} \rrbracket (B)(\lambda x.C(x)_{p(x)})(w) = 1 \\ 0 & \text{otherwise} \end{cases}$$

This does not have a universal inference, and only entails an existential inference,  $\exists x \in B: p(x)$ . Also it is easy to see that the predicted denotation is the same, when the A-operator is applied below the quantifier,  $\llbracket \text{some} \rrbracket (B)(\lambda x. \llbracket A \rrbracket (C(x)_{p(x)}))$ .

<sup>10</sup> See [8] for discussion of the way issues pertaining to the proviso problem ([11, 17, 18]) arise in this context and how they might be dealt with.

<sup>11</sup> Unlike [2], we do not impose any other condition on the use of the A-operator here, although ultimately some notion of preference among different scopes might be necessary.

Therefore if the A-operator is present, the existential sentence has only an existential entailment.

For a negative existential sentence, on the other hand, insertion of the A-operator still can result in a universal inference. Consider  $\llbracket A \rrbracket(\llbracket \text{none} \rrbracket(B)(\lambda x.C(x)_{p(x)}))$  whose denotation is given in (15).

$$(15) \quad \lambda w. \begin{cases} 1 & \text{if } \llbracket \text{none} \rrbracket(B)(\lambda x.C(x)_{p(x)})(w) = 1 \\ 0 & \text{otherwise} \end{cases}$$

This entails the universal statement  $\forall x \in B: p(x)$ . In addition, there is a second use of the A-operator which gives rise to a weaker inference: when it applies below the quantifier, i.e.  $\llbracket \text{none} \rrbracket(B)(\lambda x.\llbracket A \rrbracket(C(x)_{p(x)}))$ , the sentence is true in  $w$  iff  $\neg \exists x \in B: [p(x) \wedge C(x)]$  is true in  $w$ , from which neither an existential nor a universal inference is derived.

Finally the A-operator can yield a universal inference for an existential polar question too. When it is applied above the question operator, the predicted meaning is  $\{\llbracket A \rrbracket(\llbracket \text{any} \rrbracket(B)(\lambda x.C(x)_{p(x)})), \llbracket A \rrbracket(\neg \llbracket \text{any} \rrbracket(B)(\lambda x.C(x)_{p(x)}))\}$ . Since the presupposition of a polar question is that either of the answers is true in each world in the context set, the presupposition is the disjunction  $[\exists x \in B: p(x) \wedge C(x)] \vee [\forall x \in B: p(x)]$ . Thus the A-operator used in this way still results in the disjunctive presupposition. Because the disjunctive presupposition is marked and needs to be remedied, and pragmatic strengthening is still available, a universal inference ensues in this case. Alternatively, the A-operator may take lower scope, yielding  $\{\llbracket A \rrbracket(\llbracket \text{any} \rrbracket(B)(\lambda x.C(x)_{p(x)})), \neg \llbracket A \rrbracket(\llbracket \text{any} \rrbracket(B)(\lambda x.C(x)_{p(x)}))\}$ . Since this is a bipartition of any set of possible worlds, the presupposition is trivial. Similarly, when the A-operator takes scope below the quantifier, the resulting set,  $\{\llbracket \text{any} \rrbracket(B)(\lambda x.\llbracket A \rrbracket(C(x)_{p(x)})), \neg \llbracket \text{any} \rrbracket(B)(\lambda x.\llbracket A \rrbracket(C(x)_{p(x)}))\}$ , is a bipartition of any set of possible worlds and only a trivial presupposition is predicted.

To sum up, pragmatic strengthening invariably yields a universal inference for all of the three types of quantified sentences. The A-operator, on the other hand, may give rise to weaker inferences depending on its scope and the quantifier. More specifically, existential sentences are never associated with a universal inference regardless of the scope of the A-operator, while negative existential sentences and existential polar questions can but do not have to have a universal inference.

## 4 Account of the Generalizations

The generalizations in (3) found in the survey are repeated here.

- (3) For a given speaker,
- a. if the existential sentence has a universal inference, then the negative existential sentence and the existential polar question do too
  - b. if the existential sentence does not have a universal inference, then the negative existential sentence and the existential polar question can but need not have a universal inference

In order to account for these generalizations, we propose that there are two types of speakers: (i) those who use the A-operator in one way or another for all three sentences, and (ii) those who never do. This explains the implication (3) as follows. Those who do not use the A-operator always resort to pragmatic strengthening, obtaining a universal inference for all of the three cases. This accounts for the implicational generalization in (3-a). On the other hand, those who use the A-operator never get a universal inference for existential sentences, but may get a universal inference for negative existential sentences and existential polar questions, depending on where it is inserted. This accounts for the generalization in (3-b).

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