Quantifying presupposition projection[1]

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Abstract. There is a long-standing debate in the literature on how presuppositions project from the scope of quantifiers. Some theories argue for universal projection while others for existential projection, or a combination of both. More recently, some theories have proposed more nuanced, quantifier-specific predictions, where the projected presupposition roughly aligns with the 'force' of the quantifier. Previous quantitative studies have helped clarify the empirical landscape, but their results do not fully distinguish between these theories. Building on their methodologies, we conducted two experiments to further investigate presupposition projection in quantificational contexts, focusing on the existence presupposition of definite descriptions, and gender presuppositions of pronouns. Our results show that theories integrating both universal and what we dub 'intermediate' projection, in addition to local accommodation, provide the strongest account of the data in both experiments. However, our results also reveal differences between existence and gender presuppositions which are not fully accounted for by existing theories. We suggest that this discrepancy partly arises from the differential availability of local accommodation across presupposition types and explore potential theoretical refinements to address this issue.

Keywords: presupposition projection, quantifiers, monotonicity, local accommodation, experimental semantics.

1. Introduction

One defining characteristic of presuppositions is their tendency to project through embedding operators. Example (1) illustrates this behavior in the case of negation, using both the existence and gender presuppositions associated with the description *the present in front of him/her*.

(1) **Jordan**$_k$ {opened, didn't open} the present in front of him$_k$/her$_k$.
   a. Existence: There was a present in front of Jordan
   b. Gender: Jordan is (identifies as) male/female

While the projection behavior illustrated in (1) is relatively uncontroversial and is predicted by all extant theories of presupposition projection, the situation becomes considerably less clear once we turn to quantificational environments. In this paper, we focus on quantificational sentences with the goal of clarifying the empirical landscape and contributing to the long-standing theoretical debate on presupposition projection in these environments. The sentences we investigate involve presupposition triggers in the *scope* of a quantifier, as schematized in (2).

[1]We thank Janek Guerrini, Danny Fox, Omri Doron, Jad Wehbe, Raven Zhang and the audience at SuB 30 for helpful comments and suggestions. This research was funded by the Deutsche Forschungsgemeinschaft (DFG, Projektnummer: RO6384/1-1) and the Fundação para a Ciência e a Tecnologia (FCT, Referência: 2023.06820.CEECIND/CP2891/CT0008 and UID/214/2025).

(2) QUANTIFIER of the four children λx [$\underbrace{x \text{ opened the present in front of him}_x/\text{her}_x}_{\substack{\text{existence: there is a present in front of } x \\ \text{gender: } x \text{ is (identifies as) male/female}}}$]

In what follows, we concentrate on three quantifiers: the universal quantifier *each*, the negative quantifier *none*, and the non-monotonic quantifier *exactly one*. For *exactly one*, we additionally vary whether the scope contains negation. The target sentences are summarized in (3a)–(3d).

(3) a. **Each**$_k$ of the four children opened the present in front of her$_k$. M-POS
b. **None**$_k$ of the four children opened the present in front of her$_k$. M-NEG
c. **Exactly one**$_k$ of the four children opened the present in front of her$_k$. NM-POS
d. **Exactly one**$_k$ of the four children **didn't** open the present in front of her$_k$. NM-NEG

On the empirical side, for each of these cases we aim to determine the force of the presupposition projecting from the scope—namely, whether it is universal (e.g., *each child has a present*), existential (e.g., *some child has a present*), or potentially intermediate between the two. On the theoretical side, projection theories must specify how the presuppositions of (2) are computed on the basis of the presuppositions of the scope and the semantic contribution of the quantifier. As we will see, theories diverge in their predictions for the cases above.

Disentangling these predictions is, however, far from straightforward. The task is complicated by a number of interacting factors, including independent entailments of the sentence, quantificational domain restriction, and mechanisms for suspending or accommodating presuppositions. Independent entailments may make strong presuppositions difficult to distinguish from weaker ones, while domain restriction and accommodation can make projection appear weaker than predicted. The cases in (3) are chosen precisely to control for these factors and to distinguish between competing theoretical options. In particular, as we discuss in detail below: (i) different projection theories are empirically indistinguishable on the basis of the M-POS sentences, due to their independent entailments; (ii) the M-NEG sentence and the NM sentences with *exactly one* allow us to distinguish between universal projection and theories that predict weaker projection patterns; and (iii) the NM-NEG sentences, involving negation, allow us to further distinguish between two types of weaker projection, namely existential projection and what we term *intermediate* projection.

Previous experimental work (Chemla, 2009; Sudo et al., 2012; Zehr et al., 2016) has advanced our understanding of presupposition projection in quantificational contexts, but has not fully resolved the distinctions among competing theories. Building on the insights and methodologies of these works, we conducted two experiments to further probe presupposition projection in these environments. Both experiments tested the comprehension of sentences like those in (3). Experiment 1 focused on the existence presupposition, while Experiment 2 examined the gender presupposition associated with the constituent *the present in front of him/her*. Before presenting our experimental studies, we first survey the theoretical landscape of approaches to presupposition projection in quantificational sentences.

2. Theories and predictions

For ease of exposition, we focus in what follows on the existence presupposition, using example sentences in which the NP restrictor ensures that the gender presupposition is locally satisfied. The predictions discussed here, however, extend to the gender presupposition as well; we return to this presupposition in more detail in Section 2.5.

2.1. Universal projection

A number of approaches to presupposition projection—including, for example, Heim (1983)'s dynamic account and Schlenker (2009, 2008)'s explanatory successor theories—predict *uniform universal projection* (∀-proj) across quantifier types.[2] According to ∀-proj, if the scope of a quantifier presupposes that its argument x has some property π, then the quantified sentence presupposes that *each* individual in the restrictor set has property π. To illustrate, consider (4), which ∀-proj predicts to carry a universal presupposition.

(4) **Each**$_k$ of the four boys opened the present in front of him$_k$. M-POS
⇒ *Each of the four boys has a present in front of him* ∀-proj

This prediction is consistent with introspective judgments about what (4) entails. However, it has been noted that (4) is not particularly informative if we focus on entailments alone (see, e.g., Beaver, 2001): since (4) asserts that every individual in the restrictor set is true of the scope, it independently entails that every boy has a present in front of him. We therefore turn to the negative quantifier *none*, which has the potential to be more revealing:

(5) **None**$_k$ of the four boys opened the present in front of him$_k$. M-NEG
⇒ *Each of the four boys has a present in front of him* ∀-proj

If the presupposition *that x has a present in front of x* projects universally, then (5) is predicted to not be true as soon as one of the four boys has no present in front of him. Strictly speaking, ∀-proj predicts *presupposition failure* in such a case, rather than falsity. Since our study ultimately probes intuitions about the conditions under which a sentence is judged to be true, however, it will be convenient to collapse presupposition and assertion (see Fox 2013 for discussion). With this simplification in place, the predictions of uniform universal projection appear intuitively plausible for (5). For other quantifiers, however—particularly non-monotonic quantifiers—this is less clear:

(6) **Exactly one**$_k$ of the four boys opened the present in front of him$_k$. NM-POS
⇒ *Each of the four boys has a present in front of him* ∀-proj

Universal projection predicts that (6) can be true only if each of the four boys has a present in front of him (and exactly one of them opened it). While this may correspond to one possible

[2] We set aside one prominent approach to presupposition projection here, namely Strong Kleene trivalent semantics (Peters, 1979; Beaver and Krahmer, 2001). Strong Kleene semantics predicts intricate projection patterns for quantificational sentences, typically yielding complex disjunctive presuppositions. For the quantifiers considered in this paper, however, Strong Kleene predicts universal inferences once presuppositions and assertions are conjoined (see especially Fox 2013 for discussion). For present purposes, then, Strong Kleene can be grouped together with ∀-proj theories.

reading of (6), it has been noted—albeit infrequently in the literature—that these conditions may be too strong (George, 2008; Fox, 2013; Sudo, 2014). Consider the following context: *There are four boys—Sam, Frank, Mike, and Leo. Sam has a present in front of him and opened it; the other boys do not have presents*. ∀-proj predicts that (6) is not true in this context. We refrain from prejudging the status of (6) in such cases, but simply note that the predictions of ∀-proj are, at the very least, suspect.[3]

Before turning to other projection patterns, it is worth foreshadowing that there are independent ways of 'weakening' the predictions of ∀-proj. One such mechanism is *implicit domain restriction* (von Fintel, 1994). For instance, consider the minimally different sentence *Exactly one boy opened the present in front of him*. Even under ∀-proj, a weaker inference could be derived if the restrictor set is contextually restricted to a single salient individual—e.g., in a context in which only one boy is known to have a present. The sentences we are concerned with, however, and those used in our experiments, systematically specify the quantificational domain overtly via a partitive construction of the form '…of the four NPs'. Explicit reference to a fixed domain in this way has been shown to block implicit domain restriction (see Chemla, 2009, Appendix D.1, for discussion). Another way of 'weakening' the predictions of ∀-proj is through so-called *local accommodation*. This possibility deserves a more thorough discussion, which we defer until Section 2.5, turning first to other projection patterns.

2.2. Existential projection

While uniform universal projection is the *de facto* standard assumption in the literature, a weaker projection pattern has been advocated for by, among others, Beaver (2001): namely *uniform existential projection* (∃-proj). Consider again (6), together with an existential presupposition:

(6) **Exactly one**$_k$ of the four boys opened the present in front of him$_k$. NM-POS
⇒ *One of the four boys has a present in front of him* ∃-proj

Collapsing the presupposition and assertion of (6), ∃-proj predicts less stringent truth-conditions. Concretely, (6) is predicted to be true in a scenario in which one of the four boys has a present and opened it, while the others have no presents, since the existential presupposition is satisfied by the one boy with a present. As before, we refrain from prejudging whether this prediction is ultimately correct, but note that it differs in a substantive way from the prediction of ∀-proj.

As discussed above, universal quantifiers independently give rise to universal inferences, since they assert that the scope holds of every individual in the restrictor. Thus, for these quantifiers, a weaker-than-universal presupposition cannot be detected by looking only at the conditions under which the sentence is true. In other words, once presupposition and assertion are collapsed, the predictions of ∀-proj and ∃-proj are indistinguishable for universal quantifiers.

For other quantifiers, the predictions of ∃-proj are less intuitively compelling. Consider, for instance, (5), with an existential presupposition. While the precise predictions depend on the

[3]There are additional reasons to doubt that ∀-proj yields correct predictions for all quantifiers. Most prominently, it has been argued that existential quantifiers give rise to presuppositions that are weaker than universal. Since existential quantifiers are not investigated in the present study, we set these cases aside, but see Beaver (2001); Fox (2013); George (2008); Sudo (2014); Chemla (2009).

implementation of the theory, we may assume that *none* asserts that no individual in the restrictor set is true of the scope. Collapsing this assertion with an existential presupposition predicts that (5) may be true in a scenario in which, for instance, some of the boys don't have a present, provided that at least one boy has a present and didn't open it. Again, we do not prejudge this prediction, though introspectively, the universal reading appears more prominent.

(5) **None**$_k$ of the four boys opened the present in front of him$_k$. M-NEG
⇒ *One of the four boys has a present in front of him.* ∃-proj

A case in which ∃-proj yields a particularly implausible prediction arises when the polarity of the scope of a non-monotonic quantifier such as *exactly one* is reversed. To see this, consider the NM-NEG sentence in (7). As before, the scope carries an existential presupposition with respect to its argument x that there is a present in front x.

(7) **Exactly one**$_k$ of the four boys **didn't** open the present in front of him$_k$. NM-NEG
⇒ *One of the four boys has a present in front of him* ∃-proj

Suppose that (7) asserts that the scope is not true of exactly one individual in the restrictor set. Collapsing this assertion with the existential presupposition thereby predicts that (7) may be true in a scenario in which one boy doesn't have a present in front of him (therefore, the scope is not true of him), while the other three boys have open presents in front of them.

Intuitively, what underlies this counterintuitive prediction is that ∃-projection does not discriminate between restrictor individuals: any individual may, in principle, satisfy the existential presupposition. Suppose instead that we are in a scenario in which one of the boys has a present and did not open it, while the other boys do not have presents. In this scenario, we might expect (7) to be true, parallel to (6).

We have seen that the predictions of uniform universal and existential projection vary in plausibility across quantifier types. Chierchia (2009) suggests that *both* projection strategies are available, such that the examples discussed above are systematically ambiguous between ∀-proj and ∃-proj. This is a theoretical option worth considering. However, on this view, there is no expectation of an interaction between quantifier type and projection pattern, which runs counter to the prevailing view in the literature. Furthermore, as we have seen, ∃-proj on its own is insufficient to derive a plausible weaker-than-universal reading for (7). This motivates a third family of theories that allow for a more fine-grained distinction, to which we now turn.

2.3. Intermediate projection

Thus far, the projection theories we have considered do not predict any interaction between quantifier type and the strength of the projected presupposition. A different kind of projection theories has been developed by Chemla (2009), George (2008) and Sudo (2014), with the explicit goal of deriving different projection patterns for different quantifiers. For ease of exposition, we use here Sudo's theory as an exemplar.

Sudo develops an account of presupposition projection that relates projection behavior to a quantifier's *anaphoric potential*. It is well known that different quantifiers license different kinds of

(plural) pronouns (van den Berg, 1996; Nouwen, 2003). Universal and negative quantifiers, for instance, license plural pronouns that refer to the entire restrictor set—so-called *maxset* anaphora—as illustrated in (8a). Existential quantifiers, by contrast, license not only maxset anaphora, as in (8b-i), but also plural pronouns that refer to the subset of restrictor individuals that satisfy the scope predicate—so-called *refset* anaphora—as in (8b-ii). On Sudo's proposal, quantifiers that license only maxset anaphora give rise to universal projection, quantifiers that only license refset anaphora allow for weaker-than-universal projection, whereas quantifiers which license both kinds of anaphora are compatible with both universal and weaker-than-universal projection. This predicts universal projection for universal and negative quantifiers, but both universal and weaker-than-universal projection for existential quantifiers.

(8) a. **Each/None** of the four boys has a present. They[=*the four boys*] are happy/sad.
b. **Some** of the four boys have a present.
(i) They[=*the four boys*] are not equally fortunate. *maxset*
(ii) They[=*the boys with a present*] are happy. *refset*

Turning to non-monotonic quantifiers, Sudo (2014) observes that they license both maxset and refset anaphora, as illustrated in (9). Notably, refset anaphora is available regardless of the polarity of the scope.

(9) **Exactly one** of the four boys {has, doesn't have} a present.
a. They[=*the four boys*] are not equally fortunate. *maxset*
b. He[=*the boy with/without a present*] is happy/sad. *refset*

The technical details of Sudo's proposal will not be important for our purposes. What matters is the core intuition: maxset anaphora allows for a universal presupposition, and refset anaphora allows for a weaker-than-universal presupposition. The intuition behind the latter is that the presupposition of the scope need only hold of those restrictor individuals who witness the truth of the quantificational statement. Crucially, the refset inference associated with the NM-NEG sentence in (7) is false in precisely the type of scenario that posed a problem for ∃-proj—namely, one in which one of the boys doesn't have a present, while the others opened their presents. To distinguish this kind of refset inference from ∃-proj, we use the label 'Λ-proj'.

(6) **Exactly one**$_k$ of the four boys opened the present in front of him$_k$. NM-POS
⇒ *He has a present* Λ-proj

(7) **Exactly one**$_k$ of the four boys **didn't** open the present in front of him$_k$. NM-NEG
⇒ *He has a present* Λ-proj

Chemla (2009) and George (2008) make predictions similar to those of Sudo (2014) with respect to the weaker inferences illustrated above, although their accounts rest on quite different theoretical foundations. One subtle difference is that Sudo's theory predicts—due to the independent availability of maxset anaphora—that sentences involving non-monotonic quantifiers are in fact *ambiguous* between a universal reading, and a weaker-than-universal reading.

2.4. Intermediate summary

We have presented the predictions of different projection patterns across quantifier types, considering in turn the universal quantifier *each*, the negative quantifier *none*, and the non-monotonic quantifier *exactly one* with both positive and negated scopes. These projection patterns can be distinguished on the basis of the entailments they predict, and correspondingly on the conditions under which a quantificational statement can be true. In brief, all projection patterns yield the same inference for M-POS sentences with the universal quantifier. M-NEG sentences with the negative quantifier distinguishes ∃-proj, which predicts a weaker reading, from the other projection patterns. NM-POS sentences distinguishes ∀-proj, which predicts a stronger reading, from the other projection patterns. Finally, NM-NEG sentences distinguishes all three projection patterns.

(4) **Each**$_k$ of the four boys opened the present in front of him$_k$. M-POS
True if *each of the four boys has a present* ∀-proj, ∃-proj, Λ-proj

(5) **None**$_k$ of the four boys opened the present in front of him$_k$. M-NEG
a. True if *each of the four boys has a present; none opened it* ∀-proj, Λ-proj
b. True if *none of the four boys have an open present; one has a present* ∃-proj

(6) **Exactly one**$_k$ of the four boys opened the present in front of him$_k$. NM-POS
a. True if *each of the four boys has a present; just one opened it* ∀-proj
b. True if *just one boy has an open present* ∃-proj, Λ-proj

(7) **Exactly one**$_k$ of the four boys **didn't** open the present in front of him$_k$. NM-NEG
a. True if *each of the four boys has a present; just one didn't open it* ∀-proj
b. True if *just one of the four doesn't have an open present; one has a present* ∃-proj
c. True if *just one of the four boys has a closed present* Λ-proj

Before turning to our experimental studies, we turn to the gender presupposition associated with a bound gendered pronoun, as well as an additional factor that may affect projection behavior, namely local accommodation.

2.5. Gender and local accommodation

So far, we have illustrated the landscape of projection theories by focusing on the existential presupposition associated with the phrase *the present in front of him/her*. As noted, this phrase also involves a gendered pronoun (*him* or *her*), which gives rise to the inference that the referent is or identifies as male or female. This inference has also been analyzed as a presupposition (see, e.g., Sudo 2012). With a small modification to the NP restrictor (e.g., using *children* in place of *boys/girls*), we can therefore use the same basic examples to examine the projection behavior of this presupposition as well. This is illustrated below for the negative quantifier:

(3b) **None**$_k$ of the four children opened the present in front of her$_k$. M-NEG
⇒ *Each of the four children is/identifies as female.* ∀-proj
⇒ *One of the four children is/identifies as female* ∃-proj

It is important to examine projection across different presupposition triggers, since previous studies have raised the possibility that projection behavior may vary by trigger type (Simons

2001; Abusch 2002, 2010). Crucially for our purposes, there appears to be substantial variability in the extent to which different presuppositions can be *locally accommodated*. In particular, it seems that the gender presupposition—unlike the existential presupposition—resists local accommodation (Sudo, 2012: §2.2.2). This contrast is illustrated in (10). The point is important because the availability of local accommodation (LocA) can independently give rise to weaker inferences, irrespective of the projection theory assumed.

(10) **Jordan**$_k$ didn't open the present in front of her$_k$.
a. …since she didn't have a present.
b. ??…since Jordan isn't a 'she'.

What will matter for our purposes is the possibility of local accommodation at the scope of a quantificational phrase. To illustrate the effects of LocA, consider again the presupposition of existence with the negative quantifier, (11). Local accommodation at the scope of the quantifier, (11b), yields the weaker inference in (11c). Notably, this inference is true even if none of the boys has a present, unlike the reading predicted by ∃-proj.

(11) a. $\lambda x.\ \overbrace{x \text{ opened the present in front of him}_x}^{\text{existence: } x \text{ has a present}}$
b. $\lambda x.\ \mathscr{A}\ [x \text{ opened the present in front of him}_x] \equiv \lambda x.\ [x \text{ has a present and opened it}]$
c. **None**$_k$ of the four boys [$\mathscr{A}$ opened the present in front of him$_k$]
⇒ *None of the four boys has a present and opened it* LocA

For *exactly one*, the weakening effects of local accommodation at the scope are illustrated below. Note that the resulting inferences are identical to those predicted by Λ-proj.

(12) a. **Exactly one**$_k$ of the four boys [$\mathscr{A}$ opened the present in front of him$_k$].
⇒ *Exactly one of the four boys has a present and opened it* LocA
b. **Exactly one**$_k$ of the four boys [$\mathscr{A}$ **didn't** open the present in front of him$_k$].
⇒ *Exactly one of the four boys has a present and didn't open it* LocA

Importantly, the presence of *negation* in the scope makes available an additional accommodation site, as schematized below, which gives rise to a distinct and even weaker inference. This reading is predicted to be true, for example, in a scenario in which one boy has no presents, while the other boys have open presents, much like the prediction of ∃-proj.

(13) **Exactly one**$_k$ of the four boys [**not** [$\mathscr{A}$ opened the present in front of him$_k$]].
⇒*Exactly one of the four boys either has no present, or has a closed present* LocA

3. Experiments

We now turn to our experiments, which assessed the predictions of different projection patterns across quantifiers. Specifically, Exp.1 examined how the existence-related property associated with there being a present in front of x projects under the quantifiers of interest, while Exp.2 examined projection of the gender-related property that x is (identifies as) female.

3.1. Participants

A total of 152 adult native speakers of UK/US English (76 female; median age = 40 years) were recruited online via Prolific and assigned to Exp. 1 (n = 76) or Exp. 2 (n = 76). Eligibility criteria required participants to be born in and hold nationality from the UK or US, to report English as their first and primary language, and to have a minimum approval rate of 99% on the platform. Participants were compensated £1.50; median completion time was approximately 9 minutes. Written informed consent was obtained from all participants.

3.2. Material and method

The materials and methods for both experiments were developed jointly to minimize unintended differences across experiments, while allowing for adjustments required by the presupposition type tested in each case. All items consisted of a sentence presented above a picture. Each sentence involved a subject featuring a partitive of the form 'QUANTIFIER of the four NPs', and each picture depicted only the four relevant individuals denoted by the embedded definite description. These design choices were intended to discourage (implicit) domain restriction, which as discussed in the previous section has been argued to interfere with judgments about presupposition projection from quantifiers.

The sentences tested in Exp. 1 and Exp. 2 are shown in Table 1. Target sentences followed the same sentence frame as the M-POS, M-NEG, NM-POS, and NM-NEG sentences illustrated in (3)—namely, 'QUANTIFIER of the four NPs opened the present in front of PRONOUN'—with minimal lexical variation in the choice of NP and pronoun. Specifically, target sentences in Exp. 1 used the NP *children* and the masculine pronoun *him*, whereas those in Exp. 2 used the NP *recipients* and the feminine pronoun *her*. The former were designed to examine how the existence-related property associated with a present being in front of x projects under the quantifiers of interest, and the latter to examine projection of the gender-related property that x is female. For each target sentence, we constructed a control sentence involving the same quantifier and NP but asserting, rather than presupposing, the target property. These controls were included to ensure that participants understood the quantifiers independently of the presuppositions under investigation and attended to the relevant property throughout the task.

Example pictures are shown in Table 2. All pictures depicted four distinct child characters, horizontally aligned, with their names displayed below each portrait. In Exp.1, the four characters were always male but they didn't always have a present in front of them. Specifically, the pictures in Exp.1 manipulated both the number of children with a present in front of them and the number of present recipients who opened their present. In Exp.2, by contrast, the four characters always had a present in front of them, but they weren't always all female. Accordingly, the pictures manipulated both the number of present recipients who were female and the number of present recipients who opened their present. To further facilitate the distinction between male and female characters in Exp.2, all boys were depicted wearing glasses, whereas girls were not. Picture properties irrelevant to the experimental manipulation were randomized on a trial-by-trial basis. These included the spatial position of male and female characters, the distribution of presents across characters, and whether presents were depicted as open or closed.

In both experiments, each target sentence was paired with four picture types (see Table 2 for

Exp.1 – Existence	TARGET		
		M-POS	Each of the four children opened the present in front of him.
		N-NEG	None of the four children opened the present in front of him.
		NM-POS	Exactly one of the four children opened the present in front of him.
		NM-NEG	Exactly one of the four children didn't open the present in front of him.
	CONTROL		
		C1	Each of the four children had a present in front of him.
		C2	None of the four children had a present in front of him.
		C3	Exactly one of the four children had a present in front of him.
		C4	Exactly one of the four children didn't have a present in front of him.
Exp.2 – Gender	TARGET		
		M-POS	Each of the four recipients opened the present in front of her.
		M-NEG	None of the four recipients opened the present in front of her.
		NM-POS	Exactly one of the four recipients opened the present in front of her.
		NM-NEG	Exactly one of the four recipients didn't open the present in front of her.
	CONTROL		
		C1	Each of the four recipients was a girl.
		C2	None of the four recipients was a girl.
		C3	Exactly one of the four recipients was a girl.
		C4	Exactly one of the four recipients was not a girl.

Table 1: Target and control sentences used in Experiments 1 and 2.

examples). The TRUE and FALSE pictures served as baselines for acceptance and rejection. They depicted situations in which all characters systematically had a present (Exp.1) or were female (Exp.2), thereby ensuring that the relevant presupposition was universally satisfied, and differed only in whether the asserted content was true or false. By contrast, in the TARGET-1 and TARGET-2 pictures the presupposition was never universally satisfied. These picture types were designed to tease apart, where possible, the different interpretive options that yield weaker-than-universal readings (see Table 2 for a summary of predictions). Crucially for our purposes, TARGET-2 pictures rendered the M-NEG sentences acceptable under all weaker-than-universal interpretations, whereas TARGET-1 pictures did so only if the presupposition is locally accommodated, thus providing a direct test of the availability of LOCA. In addition, TARGET-1 and TARGET-2 pictures rendered the NM-NEG sentences equally (un)acceptable under all interpretations except Λ-proj: under Λ-proj, NM-NEG sentences are unacceptable with TARGET-1 pictures but acceptable with their TARGET-2 counterparts. Consequently, higher acceptability of NM-NEG sentences with TARGET-2 than with TARGET-1 pictures would provide evidence for Λ-proj.

Each target sentence–picture-type combination was instantiated four times by randomly varying visual features irrelevant to the experimental manipulation (e.g., the position of characters, which character had a present, which recipient opened their present), yielding 64 target items. The item set further included 16 control items, obtained by pairing each control sentence with pictures that rendered them plainly true or plainly false; each control combination was instantiated twice using analogous random variation of picture contents.

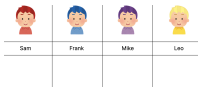
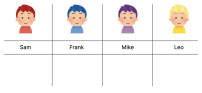
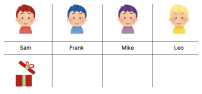
		FALSE	TARGET-1	TARGET-2	TRUE
Exp.1 – Existence	M-POS	 ∀:0 ∃:0 Λ:0 LocA:0	 ∀:0 ∃:0 Λ:0 LocA:0	 ∀:0 ∃:0 Λ:0 LocA:0	 ∀:1 ∃:1 Λ:1 LocA:1
	M-NEG	 ∀:0 ∃:0 Λ:0 LocA:0	 ∀:0 ∃:0 Λ:0 LocA:1	 ∀:0 ∃:1 Λ:0 LocA:1	 ∀:1 ∃:1 Λ:1 LocA:1
	NM-POS	 ∀:0 ∃:0 Λ:0 LocA:0	 ∀:0 ∃:1 Λ:1 LocA:1	 ∀:0 ∃:1 Λ:1 LocA:1	 ∀:1 ∃:1 Λ:1 LocA:1
	NM-NEG	 ∀:0 ∃:0 Λ:0 LocA:0	 ∀:0 ∃:1 Λ:0 LocA:1	 ∀:0 ∃:1 Λ:1 LocA:1	 ∀:1 ∃:1 Λ:1 LocA:1
Exp.2 – Gender	M-POS	 ∀:0 ∃:0 Λ:0 LocA:0	 ∀:0 ∃:0 Λ:0 LocA:0	 ∀:0 ∃:0 Λ:0 LocA:0	 ∀:1 ∃:1 Λ:1 LocA:1
	M-NEG	 ∀:0 ∃:0 Λ:0 LocA:0	 ∀:0 ∃:0 Λ:0 LocA:1	 ∀:0 ∃:1 Λ:0 LocA:1	 ∀:1 ∃:1 Λ:1 LocA:1
	NM-POS	 ∀:0 ∃:0 Λ:0 LocA:0	 ∀:0 ∃:1 Λ:1 LocA:1	 ∀:0 ∃:1 Λ:1 LocA:1	 ∀:1 ∃:1 Λ:1 LocA:1
	NM-NEG	 ∀:0 ∃:0 Λ:0 LocA:0	 ∀:0 ∃:1 Λ:0 LocA:1	 ∀:0 ∃:1 Λ:1 LocA:1	 ∀:1 ∃:1 Λ:1 LocA:1

Table 2: Example pictures used with the M-POS, M-NEG, NM-POS, and NM-NEG sentences to create the target items in Exp.1 and Exp.2, along with the predicted responses (1: accept, 0: reject) for each of the four relevant interpretive options (∀, ∃, Λ and LocA).

3.3. Procedure

Exp.1 and 2 followed the same procedure. In the instructions, participants were introduced to the relevant characters through a short cover story (reproduced below), designed to provide a natural and coherent context for the materials shown during the experiment.

> **Experiment 1: cover story**
> In this study, we will ask you about certain types of sentences in English. These sentences will involve the four boys of the Smith family. Here they are, along with their parents:

The Smith parents subscribed their boys to a gift service. Over the past three months, the company has been sending them small, personalized presents. On any given day, any of the four boys may or may not receive a present. Sometimes they get a present; sometimes they don't. Sometimes they open it right away; sometimes they don't open it at all.

Experiment 2: cover story
In this study, we will ask you about certain types of sentences in English. These sentences will be about the grandchildren of the Smith family. Grandpa and Grandma Smith have 8 grandchildren, 4 girls and 4 boys. Here they are, along with their grandparents:

The Smith grandparents subscribed to a gift service. For the past three months, the company has been sending small, personalized presents to half of their grandchildren each day. Most of the time, the gifts were sent to the granddaughters, but the grandsons were also frequently included. Sometimes the children opened the present right away; sometimes they left it unopened.

Participants were informed that they would see snapshots from different days, each accompanied by a sentence describing it. Depending on the experiment, the instructions emphasized that the snapshots would reveal either whether each child received a present (Exp.1) or which of the granddaughters and grandsons received a present (Exp.2), as well as whether they opened it on a given day over the past three months. Participants were asked to judge whether the sentence was a good or a bad description of the snapshot. As part of the instructions, participants were guided through two example trials illustrating the response procedure.

Following the instructions, participants completed a short training phase (8 trials in Exp. 1; 16 in Exp. 2). The training trials featured the control sentences (C1, C2, C3 and C4) paired with TRUE and FALSE pictures (8 items). In Exp.2, the practice phase additionally included simple non-quantificational sentences (e.g., *{Frank, Jenny} opened the present in front of {him, her}*) to highlight the role of the pronoun in distinguishing male and female characters in the design and raise awareness to possible gender mismatch. Participants received feedback on response accuracy during training; incorrect responses required the trial to be repeated. Participants could not proceed to the test phase until all training trials were answered correctly

After completing the training phase, participants were informed that feedback would no longer be provided and proceeded to the 80 test trials, which were presented in random order. On each trial, participants responded by clicking one of two buttons labeled 'Good' and 'Bad', respectively. Each item remained on the screen until a response was recorded.

3.4. Data availability

Data files and analysis output are available open access on the Open Science Framework platform at `https://osf.io/46vef`. Data analyses were carried out in the R statistical environment (R Core Team, 2023) using the following packages: `DHARMa` (Hartig, 2022), `dplyr` (Wick-

ham et al., 2023), `fmsb` (Nakazawa, 2024), `ggplot2` (Wickham, 2016), `Hmisc` (Harrell, 2023), `lme4` (Bates et al., 2015), `performance` (Lüdecke et al., 2021), `see` (Lüdecke et al., 2021).

3.5. Data preparation

Two participants in Exp.1 and five in Exp.2 were excluded from the analyses for failing to meet an accuracy threshold of 80% on the control items (i.e., fewer than 13 out of 16 correct responses). The remaining participants (n = 74 in Exp.1; n = 71 in Exp.2) performed well on these items, indicating no difficulty in interpreting the pictures or understanding the relevant quantifiers in versions of the target sentences that lacked the presuppositions under investigation.

3.6. Results

Acceptance rates for the target sentences are shown in Figure 1. Overall, results from both experiments provide evidence for both universal and weaker-than-universal readings. Evidence for ∀-proj comes from the higher acceptance of M-NEG, NM-POS, and NM-NEG with TRUE pictures compared to TARGET pictures.[4] Evidence for weaker-than-universal readings is provided by the acceptance rates for these same sentences with TARGET-2 pictures. While these rates are lower than those observed with TRUE pictures, they are reliably higher than those observed with the corresponding FALSE pictures and those observed for M-POS sentences with TARGET-2 pictures.

While these general results do not identify which weaker-than-universal option is available, more targeted comparisons allow us to refine these initial observations. First, evidence for LocA emerges from the acceptance rates of M-NEG with TARGET-1 pictures, the only experimental condition that is acceptable exclusively under LocA. Acceptance in this condition (30% in Exp.1 and 20% in Exp.2) exceeds that observed for M-NEG with FALSE pictures (1% in Exp.1 and 4% in Exp.2) and for M-POS with the same TARGET-1 pictures (13% in Exp.1 and 12% in Exp.2). Second, for NM-NEG sentences, the critical result is the clear acceptability contrast between TARGET-1 and TARGET-2 pictures in both Exp.1 (13 vs. 50%) and Exp.2 (13 vs. 73%); such contrasts are expected only if Λ-proj is available.

To test the predictions of the theories introduced in Section 2, we implemented theory-driven models that simultaneously encoded all predictions of each theory and evaluated their fit to the data. Each model included a combination of binary predictors corresponding to the set of interpretive options licensed by the theory.[5] Each predictor was coded as 1 for conditions predicted to yield acceptance under the corresponding interpretation and 0 otherwise. We fitted generalized linear mixed-effects models (GLMMs) predicting responses to target sentences ('Good' = 1, 'Bad' = 0) from these predictors. Each model included the relevant predictors as fixed effects, with random intercepts and random slopes for all fixed effects by subject; correlations

[4]To further contextualize these results, note that, as expected, M-POS sentences were consistently and robustly accepted by the participants only with TRUE pictures, that is, when the target presupposition was universally satisfied.

[5]In principle, the four basic predictors at hand (∀, ∃, Λ, and LocA) could be combined freely for exploratory purposes. We instead focused on five models closely aligned with the five theories introduced in Section 2, each of which predicts the availability of LocA in combination with (i) ∀-projection only (Heim, 1983; Schlenker, 2009), (ii) ∃-projection only (Geurts, 1998; Beaver, 2001; Van der Sandt, 1992), (iii) Λ-projection only (George, 2008), (iv) both ∀- and ∃-projection (Chierchia, 2009), or (v) both ∀- and Λ-projection (Chemla, 2010; Sudo, 2014).

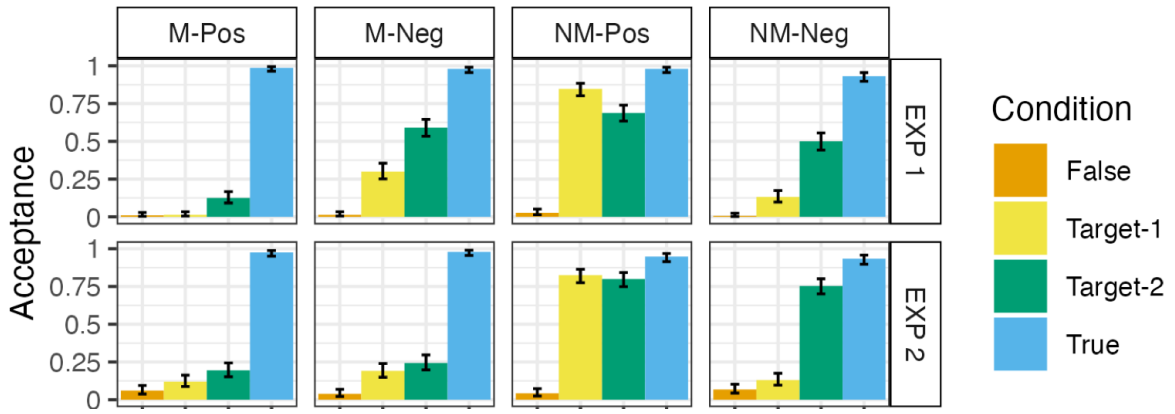


Figure 1: Proportion of 'Good' responses to the M-POS, M-NEG, NM-POS and NM-NEG sentences by picture condition in Exp.1 (existence presupposition) and Exp.2 (gender presupposition). Error bars represent 95% confidence intervals.

between random effects were not estimated. Models were fitted using the `glmer` function from the `lme4` package in R, with a binomial logit link function and optimization via the `bobyqa` algorithm (`glmerControl`). Table 3 reports AIC, BIC, and conditional R^2 values for each model. Across all performance metrics, the $\forall + \Lambda +$ LocA model provided the best fit to the data in both Exp.1 and Exp.2. These results corroborate the qualitative patterns observed in Figure 1, indicating that a theory combining $\forall$-projection, Λ-projection, and LocA most accurately captures participants' judgments across both experiments.

Three discrepancies between Exp.1 and Exp.2 are nevertheless worth noting. Specifically, Exp.1 exhibits three additional contrasts that are absent in Exp.2. First, M-NEG was accepted more frequently with TARGET-2 than with TARGET-1 pictures in Exp.1 (59% vs. 30%), whereas no comparable contrast emerged in Exp.2 (24% vs. 19%). Taken at face value, this pattern is compatible with an $\exists$-proj interpretation of the existence presupposition tested in Exp.1. Second, NM-POS was accepted less frequently with TARGET-2 than with TARGET-1 pictures in Exp.1 (69% vs. 85%), while acceptance rates were comparable across targets in Exp.2 (80% vs. 82%). Finally, in Exp.1, NM-NEG was accepted less frequently than NM-POS with TARGET-2 pictures (50% vs. 69%), both in absolute terms and relative to the TRUE baseline; no comparable contrast was found in Exp.2 (75% vs. 80%). As we discuss below, these contrasts, observed only in Exp.1, are not predicted by any of the theories under consideration.

MODEL	**Exp.1**	npar	AIC	BIC	R^2_{cond}	**Exp.2**	npar	AIC	BIC	R^2_{cond}
$\forall$+LocA		7	3061	3106	0.74		7	3526	3571	0.73
$\exists$+LocA		7	3744	3789	0.62		7	4075	4120	0.56
Λ+LocA		7	3195	3241	0.68		7	2671	2716	0.75
$\forall$+$\exists$+LocA		11	2951	3022	0.75		11	3338	3409	0.73
$\forall$+Λ+LocA		11	2783	2854	0.76		11	2471	2542	0.80

Table 3: Performance indices (AIC, BIC and conditional R2) of the different models for the data in Exp.1 (existence) and Exp.2 (gender). Best scores are highlighted in grey.

4. Discussion

Our results provide clear support for theories predicting intermediate projection (Λ-proj) for non-monotonic quantifiers. This is most clearly evidenced by the contrast between TARGET-1 and TARGET-2 for the NM-NEG sentences. As discussed, this contrast can only be derived under a Λ-proj interpretation, since this reading is true with TARGET-2 but not with TARGET-1 pictures. The other readings we considered are either true in both picture conditions (∃-proj and LocA) or false in both (∀-proj), and therefore fail to distinguish between the two targets.

Beyond intermediate projection for non-monotonic quantifiers, the overall pattern across Experiments 1 and 2 also provides evidence for ∀-proj with negative existential quantifiers, for the availability of local accommodation, and for an additional option of ∀-proj with non-monotonic quantifiers. The theories that most closely match this pattern are those of George (2008), Sudo (2014) and Chemla (2010), with the latter two enjoying a slight advantage insofar as they also predict universal projection for non-monotonic quantifiers in addition to the intermediate option.

Our results further indicate that domain restriction was successfully controlled for. If this were not the case, comprehenders could restrict the domain to the subset of the restrictor that satisfies the presupposition. For example, for the M-POS sentences tested in Experiment 1, such an interpretation would restrict the domain to the boys that have an opened present in front of them, which should lead to acceptance in both FALSE and TARGET-2. However, acceptance rates in these picture conditions were close to floor, suggesting that domain restriction was not a viable strategy for participants in our studies.

At the same time, three aspects of our results remain unaccounted for even by the theories of Sudo (2014) and Chemla (2010). The first concerns the contrast between TARGET-1 and TARGET-2 for the M-NEG sentences in Experiment 1 (i.e., *None of the four children opened the present in from of him*). Almost all theories of projection (with the exception of uniform ∃-proj) predict that presuppositions project universally from the scope of negative existentials. Local accommodation is, of course, independently expected to be available, but it does not by itself predict a contrast between the two targets. In both cases, the interpretation obtained by inserting an $\mathscr{A}$-operator in the scope amounts to 'None of the four children both have a present and opened it'. This interpretation is true with both TARGET-1 (where none of the boys have any presents) and TARGET-2 pictures (where one boy has no present, while the others have closed presents).

A natural way to derive a contrast between TARGET-1 and TARGET-2 for M-NEG sentences is arguably to posit a reading that conveys an existential inference (in addition to its assertion) paraphrasable as *Some boy has a present*. This inference is true with the TARGET-2 pictures but false with the TARGET-1 pictures. There is, in fact, precedent for postulating such an inference: Zehr et al. 2016 argue that it is a presupposition of such sentences, a view that effectively amounts to adopting ∃-proj for negative existentials. Here, however, we tentatively suggest a derivation of this inference that does not require positing ∃-proj.

Our proposal proceeds in two steps. First, we assume that existence and gender presupposition differ in their susceptibility to local accommodation: existence presuppositions are more readily locally accommodated than gender presuppositions. Second, we propose that local accommodation is accompanied by an additional, cancelable inference which, in the M-NEG conditions in Experiment 1, amounts to *Some boy has a present*. This inferences can be derived by assum-

ing that the sentence in (14a) has (14b) as a salient alternative (such alternatives are assumed by implicature-based approaches to presupposition like Romoli 2015 and Chemla 2010). Given local accommodation, conjoining (14a) with the negation of (14b) yields the enriched meaning in (14c), which can be characterized as an implicature. The enriched meaning is true with TARGET-2, but false with TARGET-1 pictures, whereas the literal meaning of (14a) is true with both targets. On this view then, presuppositions continue to project universally from the scope of negative existentials; the existential implicature in (14c) arises only when the presupposition is locally accommodated. This is consistent with the results for gender presupposition in Experiment 2, under the assumption that gender presuppositions cannot be easily locally accommodated.

(14) a. No boy [$\mathscr{A}$ opened the present in front of him].
b. No boy [$\mathscr{A}$ has a present in front of him].
c. (14a) $\wedge$ $\neg$(14b)
$\Rightarrow$ *No boy both has a present in front of him and opened it but at least some boy has a present in front of him.*

Two further aspects of our results are not captured by any of the theories under consideration. Specifically, in Experiment 1, NM-POS sentences were accepted less frequently with TARGET-2 than with TARGET-1 pictures, and they were accepted more frequently than NM-NEG with TARGET-2 pictures. Both of these contrasts were absent in Experiment 2. We leave these effects open for future investigation.

Finally, the present findings parallel and connect with results reported in the domains of homogeneity and free choice, investigated in the very same quantificational environments (Marty et al., 2024, 2025). Results in those domains provided partial support for presupposition-based analyses of free choice and homogeneity, while leaving open questions concerning the respective roles of local accommodation and presupposition projection across different quantifiers. Reconsidering these results in light of the present findings may help refine the empirical support for such presupposition-based theories. We leave this task for future work.

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