Meaning Projection

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This chapter focuses on the phenomenon of MEANING PROJECTION, i.e., the ability of certain implications to remain anchored to the speaker (or some external agent) even when the triggering expression occurs in the syntactic domain of entailment-canceling elements like negation, modals, or question operators. We will begin by distinguishing projection from two closely related concepts: SCOPE (the position where an operator is interpreted, which may differ from its surface position) and PERSPECTIVE (the epistemic state to which an implication is attributed). We will then turn to the behavior of two kinds of projective meanings: PRESUPPOSITION (information that is presented as given) and CONVENTIONAL IMPLICATURE (information that is new yet secondary). The bulk of the chapter is devoted to theories of projection, including approaches based on wide scope, bi-dimensionality, partiality, dynamicity, and at-issueness. Attention will also be paid to the degree to which projective inferences tend to project.

1. Preliminaries: Projection, scope, perspective

The term PROJECTION, coined by Langendoen and Savin (1971), is intended to describe implications that are invariably attributed to the epistemic state of the speaker (or some nonlocal agent). More specifically, if a sentence carries an implication which survives when its triggering expression occurs in the syntactic domain of an entailment-canceling operator (such as negation, a modal, or a question operator), then we say that this implication projects. Intuitively, projected meaning can be regarded as encompassing implications that are robust and more difficult to subdue than the logical entailments of the sentence.

The following examples illustrate the phenomenon of projection and how projected inferences differ from logical entailments. From the positive sentence in (1a) we can infer both (2a) and (2b). However, these two implications are not on a par. This can be seen from the fact that, unlike (1a), its negative counterpart (1b) implies (2b) but not (2a). We may conclude that (2b), unlike the entailment in (2a), projects past negation.

(1) a. The king of France is bald.
b. The king of France isn't bald.

(2) a. Someone is bald.
b. France has a king.

In a similar vein, (3a) implies both (4a) and (4b). However, when (3a) is negated as in (3b), the implication in (4a) melts away whereas the one in (4b) survives. This suggests that the latter implication, unlike the former, exhibits projective behavior.

(3) a. Edna, a fearless leader, started the descent.
b. Edna, a fearless leader, didn't start the descent.

(4) a. Someone started the descent.
b. Edna is a fearless leader.

Projection needs to be distinguished from two other closely related notions: scope and perspective. Starting with the former, SCOPE is a fundamental property of natural language and concerns the problem of how operators find their semantic arguments, i.e., how they find the part of the meaning on which they perform their action. In general, the scope of an operator results from some larger expression that surrounds the operator. Yet often the surface position of an operator does not match the position that would produce the desired interpretation. A classic example of a scopal ambiguity is cited in (5), where which has two readings: the surface scope reading in (5a) and the reverse scope reading in (5b).

(5) Someone loves everyone.
a. $\textbf{someone}(\lambda x.\, \textbf{everyone}(\lambda y.\, love(x, y)))$
'There is at least one person such that this person loves everyone.'
b. $\textbf{everyone}(\lambda y.\, \textbf{someone}(\lambda x.\, love(x, y)))$
'For every person there is a person whom the first person loves.'

To match operators with their scope, several formal mechanisms have been proposed in the literature. These include Quantifying In (predicates are fed free variables as arguments, these variables are abstracted over, and quantifiers are merged with the resulting property in different orders; Montague 1973), Quantifier Raising (quantifiers are merged into their surface position but are covertly raised and attached to their scope; May 1977; Heim & Kratzer 1998), and Flexible Types (quantifiers remain in surface position and type-shifting rules are applied to derive the different scopings; Hendriks 1993; Barker & Shan 2014). Formal details aside, the important point is that projection is, in some sense, the opposite of scope. Scope is a matter of compositional semantics: we structurally match operators with their potential semantic arguments to derive attested interpretations. In contrast, projection is a conventional property of language that arguably does not involve compositional interaction. Projection is baked into the semantics of expressions,[1] so a projective inference will be launched as soon as the sentence

[1] Although, see Section 4 for a brief discussion of 'soft' presuppositions, which are sometimes assumed to be contextually triggered.

contains a word or construction with that property. In fact, projected content is so called precisely because it escapes the domain of operators.

Compared with projection and scope, PERSPECTIVE is the most elusive notion and might not even constitute a uniform phenomenon. In some broad sense, perspective is about the ability of semantic content to be tied to a modal scenario or the mental state of an agent without relying on conventional mechanisms like lexical triggering or semantic composition. It is perhaps easiest to picture perspective as a phenomenon where the semantics of an expression has some degrees of freedom that are to be resolved by subtle contextual factors.

Perspective is at stake in various empirical phenomena, such as predicates of personal taste and subjectivity (Lyons 1977; Kölbel 2004; Lasersohn 2005; Stephenson 2007; Sæbø 2009; Pearson 2013; Kennedy & Willer 2016; Coppock 2018; Anand & Korotkova 2022; Koev To appear; a.o.), shiftable indexical pronouns (Rice 1986; Speas 1999; Schlenker 2003; Anand 2006; Sudo 2012; Deal 2020; a.o.), free indirect discourse (Banfield 1982; Doron 1991; Schlenker 2004; Eckardt 2015; Maier 2015; Sharvit 2018; a.o.), and modal subordination (Karttunen 1976; Roberts 1989; Geurts 1999; Asher & McCready 2007; Brasoveanu 2010; a.o.). The theoretical approaches to these phenomena are too diverse to be streamlined into a coherent story. Still, there seems to be a common thread. At some level of generality, all approaches involve some extra parameter that accounts for the availability of an additional perspective, be it a judge parameter (Lasersohn 2005), a secondary speech context (Schlenker 2003), a modal domain (Roberts 1989), or similar. Perspective-sensitive phenomena then involve some form of underdetermination that needs to be resolved by the context. While projection too is a matter of perspective, projected meaning is less flexible in that it is anchored to some external agent (typically, the speaker).

2. Projection empirically

Projection has been studied relative to two major linguistic phenomena: presupposition and conventional implicature. Starting with the former phenomenon, PRESUPPOSITION is meaning that is linguistically marked as old information, i.e., as being taken for granted by interlocuters rather than being part of the main propositional content of the utterance.[2] This kind of meaning was already illustrated in the previous section, showing that both (1a) and (1b) presuppose—i.e., present as given—(2b). Presupposed meaning is encoded by a diverse class of linguistic triggers, including definite noun phrases (like *the selfish ant*), factive predicates (like *regret* or *be glad*), change-of-state aspectual verbs (like *start* or *stop*), cleft constructions (like *it was X who Y*), focus-sensitive particles (like *only, even*, *also*), and others. Examples of sentences with each of these triggers plus the resulting inferences are given in (6)–(10). (Note: >> is short for ‘presupposes’.)

[2] Our focus here will be on discourse-old information which is *linguistically* coded, also called SEMANTIC presupposition. Stalnaker (1974) subsumes this notion under PRAGMATIC presupposition, which encompasses both the linguistic and metalinguistic information that the speaker assumes they share with the listener.

(6) Zoe caught the selfish ant.
>> There is a (unique) selfish ant.

(7) The students are glad that the semester is over.
>> The semester is over.

(8) Jack stopped eating refined sugar.
>> Jack once ate refined sugar.

(9) It was Buddha who set me free.
>> Someone set me free.

(10) Only Finn liked the movie.
>> Finn liked the movie.

In contrast to presupposition, CI (CONVENTIONAL IMPLICATURE) is projective meaning which introduces new information, albeit information that is typically is secondary to the main point conveyed by the utterance.[3] The two sentences in (3), both of which conventionally implicate (4b), are one example of this type of meaning. More generally, CIs are triggered by a subset of parenthetical expressions (including appositives and *as*-parentheticals),[4] expressive adjectives (like *damn*), evidential markers (like *allegedly*), iconic co-speech gestures (like BIG), and others. Some illustrations and the pertaining inferences are provided in (11)–(14) below. (I use +> to mark the relation 'conversationally implicates'.)

(11) Lance, who won seven titles, admitted to doping.
+> Lance won seven titles.

(12) I'll go walk my damn dog.
+> The speaker has a negative attitude toward their dog.

(13) Allegedly, Zoe is pregnant.
+> Given what the speaker heard, Zoe is pregnant.

[3] The label 'conventional implicature' (Grice 1989; Bach 1999; Potts 2005) is somewhat unfortunate since the conventional inferences it describes have precious little to do with implicatures as computed by application of the Gricean maxims. For this reason, I prefer to use the acronym CI, hoping to suppress the wrong connotations.
[4] Koev (2022) divides parenthetical expressions into two large classes: pure and impure. PURE parentheticals (such as the ones mentioned above) may occur anywhere in the sentence and contribute projective inferences. IMPURE parentheticals (including slifting parentheticals, utterance adverbs, biscuit conditional antecedents) typically occur at the root level and modify components of the illocutionary force. Only the former generate CIs, and they will be the focus of interest here.

(14) Cornelia brought [a bottle]_BIG.
+> The bottle that Cornelia brought was big.

Since most of the work has been on parenthetical projection, this chapter will focus on this kind of CI trigger.

Before proceeding, let us summarize how presupposition and CI compare. These meaning types share two main properties: they both are conventionally triggered (i.e., activated by specific linguistic or metalinguistic means), and they both project inferences layered on top of the logical entailments of the sentence. Despite these similarities, presupposition and CI impose different conditions on the context, with presupposition marking discourse-old information (modulo cases of accommodation; Lewis 1979; Heim 1983; van der Sandt 1992; Beaver 2001), while CI marks new information. Furthermore, as we will see later in this section, presupposition and CI exhibit distinct projection patterns: CI robustly projects whereas presupposition can be canceled in compound sentences.[5]

The standard diagnostic for projection is the FAMILY-OF-SENTENCES TEST (e.g., Chierchia & McConnell-Ginet 2000: 1.3). This test has been previously suggested in (1b) and (3b) for the case of negation. More broadly, the family-of-sentences test states that an implication associated with a given clause projects if that clause is placed in the syntactic domain of an entailment-canceling operator, such as negation, possibility epistemic modal, *if*-operator, or a question operator. For instance, the entire family in (15) implies that France has a king, just like the base sentence in (1a). Similarly, all sentences in (16) give rise to the implication that Edna is a fearless leader, just like the unmodified sentence in (2a).

(15) a. The king of France isn't bald.
b. Perhaps the king of France is bald.
c. If the king of France is bald, then he wears a wig.
d. Is the king of France bald?

(16) a. Edna, a fearless leader, didn't start the descent.
b. Edna, a fearless leader, might have started the descent.
c. If Edna, a fearless leader, started the descent, then we have nothing to worry about.
d. Did Edna, a fearless leader, start the descent?

We now address the important question of when projective inferences can be canceled, focusing on the behavior of presupposition in complex sentences constructed by logical connectives. First, it has been observed that presuppositions need not project past negation, as illustrated in (17). Since this is at odds with the negative instance of the family-of-sentences test

[5] This is not to say that the boundary between presupposition and CI is always clear cut. Sometimes the same construction, either across languages or within the same language, has been analyzed as belonging to one or the other meaning type. As one example, consider the analysis of grammaticalized evidential markers, as discussed in Izvorski (1997), Faller (2002), Matthewson et al. (2007), Murray (2014), Koev (2017), Bary & Maier (2021), a.o.

for projection (cf. (1b)/(15b)), this behavior is often attributed to a different, 'external' form of negation (Horn 1989: ch.2). Additionally, Karttunen (1973) noted that presuppositions associated with the second clause of a compound sentence are canceled if they are entailed by a first conjunct, negated in a first disjunct, or hypothetically assumed in a conditional antecedent. This phenomenon is exemplified in (18), where none of the sentences as a whole presuppose the existence of a bathroom, despite the presence of the definite noun phrase *the bathroom*.[6]

(17) The king of France isn't bald—there is no king of France!

(18) a. There is a bathroom and/but the bathroom is in a funny place.
b. Either there is no bathroom or the bathroom is in a funny place.
c. If there is a bathroom, then the bathroom is in a funny place.

In contrast to presupposition, CI cannot be canceled in a similar manner. As shown in (19), when placed within the same environments, sentences with CIs are generally infelicitous. This suggests that the projective inferences remain intact and either clash with their negation (19a), or otherwise repeat information leading to redundancy (19b)–(19d).

(19) a. #Edna, a fearless leader, didn't start the descent—she is not a fearless leader.
b. ?Being a fearless leader, Edna, a fearless leader, started the descent.
c. ?Either she is not a fearless leader, or Edna, a fearless leader, started the descent.
d. ?If she is a fearless leader, then Edna, a fearless leader, will start the descent.

3. Approaches to meaning projection

This section critically assesses existing approaches to meaning projection. While several of these approaches were developed to make predictions about either presupposition or CI individually, discussing them together fosters a way to think about meaning projection as a cohesive phenomenon.

3.1. Wide scope approach

One simple solution to the projection puzzle suggests that the puzzle itself is an illusion: certain implications appear to project merely because their triggering expressions systematically occur outside the syntactic domain of higher operators. This approach has been specifically proposed for (a subset of) parentheticals, where their wide scope is derived through preferred attachment to a high syntactic node (Demirdache 1991; Del Gobbo 2003) or as part of the interpretational

[6] Notice that (18a) logically entails, yet does not presuppose, the existence of a bathroom. This becomes evident when the sentence is embedded under a possibility modal, which cancels said entailment (cf. *It is possible that there is a bathroom and/but the bathroom is in a funny place*).

procedure (Nouwen 2014; Venhuizen et al. 2014; Martin 2016; Schlenker 2023), effectively resulting in a wide scope conjunction. This is illustrated in (20).

(20) a. Lance, a cyclist, didn't win.
b. $\neg win(lance) \wedge cyclist(lance)$

While strongly dispreferred, low scope attachment is still available. This is motivated by examples as in (21), where the appositive relative clause appears to contribute to the conditional antecedent.

(21) If tomorrow I called the Chair, who in turn called the Dean, then we would be in big trouble.

One apparent challenge for this approach is explaining why parentheticals should prefer wide scope attachment over low scope attachment. Responding to this challenge, Venhuizen et al. (2014) and Martin (2016) propose that parentheticals 'piggyback' on the scopal properties of their definite anchors, so that parenthetical implications inherit the tendency of their anchors to take wide scope. While theoretically elegant, this idea fails to explain why parentheticals force a specific reading on *indefinite* anchors that otherwise would be ambiguous between a specific and a non-specific reading, as illustrated in (22). Furthermore, it remains unclear in what sense *non-nominal* anchors of parentheticals can be considered definite, in view of examples like (23), where an appositive relative clause is attached to an adjectival phrase.

(22) a. John wants to see a movie (that was directed by Spielberg). (specific or non-specific)
b. John wants to see a movie, which was directed by Spielberg. (specific only)

(23) Mary was intelligent, which John never was.

Another challenge for the wide scope approach is its lack of sensitivity to the linear position of parentheticals. It has been observed that parentheticals are interpreted in surface position with respect to order-dependent phenomena like discourse anaphora, presupposition, and VP ellipsis (Potts 2005; AnderBois et al. 2015), where linear dependences can seamlessly traverse from a root clause into a parenthetical and vice versa, provided that antecedents linearly precede their dependents. This phenomenon is illustrated in (24)–(25).

(24) a. Jeremy$_x$ helped out Sarah, who thanked him$_x$.
b. #He$_x$ helped out Sarah, who thanked Jeremy$_x$.

(25) a. Sarah, who was helped out by Jeremy$_x$, thanked him$_x$.
b. ?Sarah, who got help out by him$_x$, thanked Jeremy$_x$.

What such linear contrasts demonstrate is that deriving parenthetical projection should not come at the expense of disrupting the linear dependencies inside the sentence: surface order and projection should be able to coexist. The fact that parentheticals participate in order-dependent phenomena in the usual way strongly suggests that they are interpreted in situ, despite their projective behavior.

Although the wide scope approach is tailored specifically for parentheticals, it is important to point out that it stands no good chance of being extended to presupposition triggers. This is because such triggers target parts of the argument-predicate structure of the sentence, so moving the entire targeted expression outside the scope of operators would not generate the correct meaning.

3.2. Two-dimensional approach

Another approach to meaning projection separates out the asserted content and the projected inferences of the sentence, resulting in a two-dimensional semantic architecture. The legwork is done by the compositional semantics, which shunts projective inferences into a secondary meaning dimension, thus explaining why external operators exert no effect on such inferences. This approach has been applied to both presupposition (Karttunen & Peters 1979) and CI (Potts 2005), as shown in (26) and (27).[7]

(26) a. It's not true that even Bill likes Mary.
b. $\langle\, \neg like(bill, mary), \forall x(x \neq bill \rightarrow \Pr\,(like(bill, mary)) < \Pr\,(like(x, mary)))\,\rangle$

(27) a. Lance, a cyclist, didn't win.
b. $\langle\, \neg win(lance), cyclist(lance)\,\rangle$

The two-dimensional approach improves on the wide scope approach because it does not depend on specific structural assumptions in order to derive projection.[8] Nonetheless, it inherits one of the problems of the wide scope approach by not making the interpretational mechanism order-sensitive. That is, it overlooks the linear order between the triggering expression and the rest of the sentence, which is of key importance for parentheticals as shown in (24)–(25).

Additionally, two-dimensional semantic architectures are known to encounter the BINDING PROBLEM identified by Karttunen & Peters (1979). This problem arises when a single indefinite element in the syntax contributes two existential quantifiers in the logical representation because it needs to bind variables in both meaning dimensions. The difficulty is

[7] For illustration purposes, the analysis in (26) only contains the scalar presupposition of *even* ('Bill is the least probable person to like Mary') and ignores its existential presupposition ('There are other people besides Bill who like Mary').
[8] However, due to this property, this approach has little to say about cases involving semantically embedded CIs, like (21).

illustrated in (28), where the presupposed inference is due to the verb *manage*. According to the formal analysis, it is sufficient for one person to have succeeded George V and for another person to be difficult to do so, while intuitively we are referring to one and the same person, making the predicted meaning too weak.

(28) a. Someone managed to succeed George V on the throne of England.
b. $\langle\, \exists x(succeed(x, george)), \exists x(difficult(x, succeed(x, george)))\, \rangle$

The same problem can be replicated for parentheticals with indefinite anchors, as demonstrated in (29). Once more, the predicted meaning is compatible with a situation where one friend of mine runs the New York City Marathon and another friend of mine is a Yankees fan, whereas the sentence attributes both properties to the same individual.

(29) a. A friend of mine, a fellow Yankees fan, ran the New York City Marathon.
b. $\langle\, \exists x(friend(x) \wedge run(x)), \exists x(friend(x) \wedge fan(x))\, \rangle$

What we really want here is a single quantifier that binds into both dimensions. However, this would bring us back to a single meaning dimension, which runs counter to the central premise of the two-dimensional approach.

Lastly, this approach predicts that the secondary dimension makes a non-standard truth-conditional contribution to the sentence as a whole, either being ignored or resulting in the lack of a classical truth value. For presuppositions, this is as intended by Karttunen & Peters (1979), who formulate rules regarding how the presuppositions of larger constituents are inherited from the presuppositions of smaller constituents. However, false appositives have been shown experimentally to exert a clear truth-conditional effect on the entire sentence, although somewhat moderated by their relevance (Syrett & Koev 2015; Kroll & Rysling 2019).

3.3. Partiality approach

Another approach, specifically designed for presupposition projection, views presuppositions as imposing interpretability conditions on the host sentence. That is, a sentence will lack a classical truth value (T or F) as soon as one of its presuppositions is false (Strawson 1950; Peters 1979; Beaver & Krahmer 2001; George 2008). This idea naturally leads to the CUMULATIVE HYPOTHESIS (Morgan 1969; Langendoen & Savin 1971), which states that the compound sentence inherits all of the presuppositions of its constituent parts, meaning that presuppositions always project to the top. This effect is achieved through the trivalent Weak Kleene semantics for propositional connectives (Kleene 1952: §64) shown in (30), where # stands for 'undefined' (neither T nor F).

(30) WEAK KLEENE

ϕ	$\neg\phi$	$\phi \wedge \psi$	T	F	#	$\phi \vee \psi$	T	F	#	$\phi \rightarrow \psi$	T	F	#
T	F	T	T	F	#	T	T	T	#	T	T	F	#
F	T	F	F	F	#	F	T	F	#	F	T	T	#
#	#	#	#	#	#	#	#	#	#	#	#	#	#

Recalling the family-of-sentences test from Section 2, Weak Kleene correctly predicts that presuppositions project past (regular) negation. However, its predictions about sentences with binary propositional connectives are inaccurate: presuppositions do not always percolate up in such sentences, as was demonstrated in (18). In other words, even if a presupposition turns out to be false, the sentence may still end up having a classical truth value rather than being undefined.

Things notably improve if we apply the Strong Kleene semantics for propositional connectives. This semantics posits that a compound sentence is undefined only if the classical truth values assigned to its parts are insufficient to produce a classical truth value, as shown in (31).[9]

(31) STRONG KLEENE

ϕ	$\neg\phi$	$\phi \wedge \psi$	T	F	#	$\phi \vee \psi$	T	F	#	$\phi \rightarrow \psi$	T	F	#
T	F	T	T	F	#	T	T	T	T	T	T	F	#
F	T	F	F	F	F	F	T	F	#	F	T	T	T
#	#	#	#	F	#	#	T	#	#	#	T	#	#

It is straightforward to confirm that Strong Kleene yields correct predictions about the generalizations in (18), where presupposition failure results in truth or falsity rather than undefinedness. For conjunction, if a false presupposition associated with a second conjunct is entailed by the first conjunct, the latter must be false as well, so the sentence as a whole will be false (as indicated in the second row of the truth table for conjunction). For disjunction, if a false presupposition associated with a second disjunct is entailed by the negation of the first disjunct, the latter must be true and so the sentence as a whole will be true (see the first row of the truth table for disjunction). Finally, if a false presupposition of a consequent is entailed by the conditional antecedent, then the antecedent must be false as well, resulting in a true sentence (as shown in the second row of the truth table for conditionals).

Notice that, according to (31), the truth tables for conjunction and disjunction are symmetric along the main diagonal, and also that presuppositions are not expected to project

[9] Specifically, a negative sentence is classically-valued when as soon as the non-negated sentence is classically-valued (similar to Weak Kleene), a conjunction is false as soon as one of the conjuncts are false (even if the other conjunct is undefined), a disjunction is true as soon as one of the conjuncts are false (even if the other disjunct is undefined), and an conditional is true if the antecedent is false or the consequent is true (regardless of the value of the other part).

from conditional antecedents. These characteristics lead to incorrect predictions about projection in conjunctions and conditionals (there is little consensus on whether projection from disjunctions is symmetric). For example, while *There is a bathroom and the bathroom is in a funny place* is fine, reversing the order of conjuncts leads to redundancy; similar observations hold about conditionals. In light of this, Peters (1979) walks Strong Kleene half a step back, restoring Weak Kleene regarding the case when the first clause suffers from presupposition failure. This is shown in (32).

(32) PETERS CONNECTIVES

ϕ	$\neg\phi$	$\phi \wedge \psi$	T	F	#	$\phi \vee \psi$	T	F	#	$\phi \rightarrow \psi$	T	F	#
T	F	T	T	F	#	T	T	T	T	T	T	F	#
F	T	F	F	F	F	F	T	F	#	F	T	T	T
#	#	#	#	#	#	#	#	#	#	#	#	#	#

I end this subsection with the cautionary note that the basic idea behind the partiality approach—i.e., that presupposition failure leads to semantic deficiency—has been qualified even for simple sentences. For example, while *The king of France is bald* would typically present semantic difficulty, *Last week my friend went for a drive with the king of France* rings just plain false. Such contrasts have been linked to notions like topicality or relevance (Strawson 1964; von Fintel 2004).

3.4. Dynamic approach for presupposition

The asymmetric projection pattern of presuppositions in complex sentences has prompted a dynamic perspective wherein language is interpreted incrementally in a left-to-right fashion. Instead of asking whether a presupposition is SATISFIED (i.e., entailed) by the context before the sentence is uttered, presupposition is now viewed as imposing a restriction on the LOCAL CONTEXT, which includes the initial context plus any information added to it by parts of the sentence that have already been processed (Karttunen 1974; Heim 1983; 1992; Beaver 2001; cf. Schlenker 2009; Barker 2022). This shift in perspective allows the interpretation rules to kill two birds with one stone, capturing both the truth and the projection pattern of sentences with presuppositions. A dynamic semantics that achieves this is presented in (33)–(34). (Below, S_p is a simple sentence carrying presupposition p,[10] A and B are sentences of any complexity, and $c + A$ stands for the update of context c (a set of possible worlds) with sentence A.)

(33) $c + S_p = c \cap [\![S]\!]$, defined only if $c \subseteq p$

[10] It is assumed that only simple sentences carry presuppositions and also that presuppositions themselves are simple (i.e., they do not embed other presuppositions).

(34) a. $c + \neg A = c - (c + A)$
b. $c + A \wedge B = (c + A) + B$
c. $c + A \vee B = (c + A) \cup ((c + \neg A) + B)$
d. $c + A \rightarrow B = (c + \neg A) \cup ((c + A) + B)$

In essence, these update rules replicate the standard truth conditions of propositional logic.[11] More remarkably, they also predict how presuppositions project in complex sentences. To see this, just pay attention to where the + sign occurs on the right-hand side of each rule. Starting with (34a), updating with a negative sentence is defined just when updating with the positive counterpart is defined, meaning that presuppositions project past negation. According to (34b), updating with a conjunction is defined only if the initial context can be updated with the left conjunct and the resulting context can be updated with the right conjunct. Thus, we get projection from first conjuncts and no projection from second conjuncts if its presupposition is entailed by the first conjunct. Similarly, (34d) predicts that in conditional sentences the presuppositions of the antecedent project while the presuppositions of the consequent are canceled if they are entailed by the antecedent. Finally, (34c) predicts projection from both disjuncts, unless a presupposition in the second disjunct is entailed by the negation of the first disjunct. In summary, a presupposition projects if it must be satisfied by the initial context; if it must be satisfied by a local context, projection may be canceled.

The satisfaction model makes the general prediction that presuppositions associated with the second part of a sentence project in a conditionalized form. For example, if a presupposition of the consequent is entailed by the antecedent, as in (35), the predicted inference will be trivially true, explaining why we get the sense of presupposition cancelation. However, if a presupposition of the second part of the sentence is logically independent of the first part of the sentence, as in (36), a stronger unconditional inference is projected. This issue is known as the PROVISO PROBLEM (Geurts 1999; Beaver 2001; Lassiter 2012).

(35) If Mary has a husband, then her husband is happy.
a. If Mary has a husband, then she has a husband. (predicted)
b. (none) (attested)

(36) If Mary is rich, then her husband is happy.
a. If Mary is rich, then she has a husband. (predicted)
b. Mary has a husband. (attested)

[11] That is, negative sentences remove from the context those worlds in which the positive sentence is true; conjunction preserve only those worlds in which both conjuncts are true; disjuncts preserve those worlds in which either the first disjunct is true, or the first disjunct is false and the second disjunct is true; and finally, conditionals preserve those worlds in which the antecedent is false, or both the antecedent and the consequent are true.

The proviso problem is taken up by another dynamic account, which views presupposition as a form of anaphora (van der Sandt 1992; Geurts 1999). The close parallels between presupposition and anaphora are suggested by data as shown below, where (38) mimics the behavior of (37).

(37) a. There was a storm. It was fierce. (cross-sentential anaphora)
b. If a farmer owns a donkey, then he beats it. (donkey anaphora)

(38) a. Fred left. Mary knows that Fred left.
b. If Fred left, then Mary knows that Fred left.

The key claim of this account is that presupposition projection and anaphora resolution are handled by the same general mechanism. That is, a presupposition must be resolved either by binding it to a suitable antecedent (the preferred option) or by accommodating it, where 'global' accommodation to the top level of the discourse is the default option (Heim 1983). Presupposition projection then results from global accommodation, while presupposition cancelation results from binding (or local accommodation). As an illustration, the projection contrast in (35)–(36) is derived in (39)–(40) within Discourse Representation Theory (Kamp 1981; Kamp & Reyle 1993), where a semantic representation $[\ D \mid C]$ consists of a set D of discourse referents and a set C of conditions on such referents, and ∂ is Beaver's (2001) presupposition operator. Importantly, in (39) the presupposition triggered by *her husband* is bound to the conditional antecedent and generates no inference, while in (40) it is globally accommodated and generates the unconditional inference 'Mary has a husband'.

(39) If Mary has a husband, then her husband is happy.

a. $[\ x \mid\ x = mary,\ [\ y \mid husband.of(y,x)] \Rightarrow [\ \mid\ \partial[\ v \mid \partial[\ z \mid\ ],\ husband.of(v,z)],\ happy(v)]]$

↓ (binding z to x)

b. $[\ x \mid x = mary,\ [\ y \mid husband.of(y,x)] \Rightarrow [\ \mid \partial[\ v \mid husband.of(v,x)],\ happy(v)]]$

↓ (binding v to y)

c. $[\ x \mid x = mary,\ [\ y \mid husband.of(y,x)] \Rightarrow [\ \mid happy(y)]]$

(40) If Mary is rich, then her husband is happy.

a. $[\ x \mid x = mary,\ [\ \mid rich(x)] \Rightarrow [\ \mid\ \partial[\ y \mid \partial[\ z \mid\ ],\ husband.of(y,z)],\ happy(y)]]$

↓ (binding z to x)

b. $[\, x \mid x = mary,\ [\ \mid rich(x)] \Rightarrow [\ \mid \partial[\, y \mid husband.of(y,x)], happy(y)]]$

↓ (global accommodation of y)

c. $[\, x\, y \mid x = mary, husband.of(y,x),\ [\ \mid rich(x)] \Rightarrow [\ \mid\ happy(y)]]$

3.5. Dynamic approach for CI

The two-dimensional approach to projection (presented in Section 3.2) is appealing because it separates out the asserted and the projected content of the sentence. However, this separation also disrupts the anaphoric dependencies between the two meaning dimensions (recall (24)–(25) and (28)–(29)). A way out of this predicament is to replace the 2D semantics with a 1.5D semantics, where the descriptive content is kept separate while the anaphoric links are preserved. This is precisely what Murray (2014) and AnderBois et al. (2015) propose for CIs within a dynamic framework. Specifically, they argue that asserted content constitutes an update proposal that is negotiable (Stalnaker 1978), whereas CIs impose a direct, non-negotiable update on the context. To illustrate, consider the sentence with an appositive in (41), following closely AnderBois et al.'s (2015) formalism.

(41) a. Fluffy, a Siamese, curled in the corner.
b. $\exists p \wedge p \subseteq c \wedge \exists x \wedge x = fluffy \wedge siamese_c(x) \wedge curl_p(x) \wedge \exists c \wedge c = p$

The semantic representation above is interpreted as follow. The first two conjuncts introduce the proposal p (representing the root clause proposition) as a subset of the context set c. The next two conjuncts introduce a discourse referent for the subject of the sentence. The following two conjuncts are crucial: the appositive content updates the context whereas the root clause content updates the proposal. Finally, through the last two conjuncts and assuming that the proposal has not been challenged, the context is reintroduced to include the new proposal. Zooming out, the key point is that appositives and root clauses contribute to two different bodies of information: the former restrict the context directly while the latter restrict the proposal.

This account derives projection due to the specific way in which propositional operators are interpreted (Stone 1997, 1999; Stone & Hardt 1999). That is, they bind selectively into components of their syntactic domain, thereby excluding material that is directly anchored to the context. This is illustrated in (42) for negation, where $\mathbf{not}_p^{p'}(\ldots)$ expresses the condition that p' is the complement of p.

(42) a. Fluffy, a Siamese, didn't curl in the corner.
b. $\exists p \wedge p \subseteq c \wedge \exists x \wedge x = fluffy \wedge \mathbf{not}_p^{p'}(siamese_c(x) \wedge curl_{p'}(x)) \wedge \exists c \wedge c = p'$

Although the appositive occurs in the syntactic domain of negation, its contribution is coindexed with the context c, whereas negation binds predicates coindexed with p' (the worlds in which Fluffy did not curl in the corner). This means that the speaker is committed to the appositive content despite the presence of negation, i.e., the appositive content projects. Moreover, since the appositive is interpreted in situ, any existing anaphoric links are preserved.

The direct update account views CIs as enforcing an update on the context without input from the addressee. The main empirical motivation for this claim is the observation that such content cannot be challenged by direct responses like *That's not true*, as shown (43). However, the problem with such responses seems to be that propositional anaphors (like *that*) generally have difficulty picking out such content (Snider 2017: ch.5). Other, non-anaphoric responses are quite capable of serving this role, as seen in (44), which would be unexpected if CI were indeed non-negotiable meaning.

(43) A: Fluffy, a Siamese, curled in the corner.
B: That's not true. (Fluffy didn't curl in the corner. / #Fluffy is not a Siamese.)

(44) A: Fluffy, a Siamese, curled in the corner.
B: Fluffy is not a Siamese.

Focusing on parenthetical triggers for CIs, Koev (2022: ch.3) abandons the direct update story and instead proposes to derive parenthetical projection in a more principled way. The key idea is that parenthetical expressions are illocutionarily independent: parentheticals are headed by (covert) force operators that are anchored to the context and cannot be bound by external propositional operators, resulting in projective behavior. The idea of illocutionary independence is motivated by the existence of 'hybrid' sentences, as in (45), where the root clause and the parenthetical differ in illocutionary force (Levinson 1983: 5.4).

(45) a. Does John, who could never learn elementary calculus, really intend to do a PhD in mathematics?
b. Wittgenstein was an Oxford philosopher, wasn't he?

Under the illocutionary independence account, a negative sentence with an appositive is analyzed as outlined in (46).

(46) a. Jill, who is a linguist, isn't rich.
b. $\mathbf{decl}_c^p(\mathbf{not}_p^q(\exists x \wedge x = jill \wedge \mathbf{decl}_c^r(linguist_r(x)) \wedge rich_q(x)))$

The semantic representation above contains two declarative operators, one heading the root clause and another heading the parenthetical expression, both anchored to the context. While the

root clause operator introduces a propositional referent which binds the negation (which in turn binds into the lexical predicate *rich*), the parenthetical operator introduces a propositional referent which binds into the lexical predicate *linguist*, thereby shielding the parenthetical content from the effects of negation. As a result, the speaker is committed to two propositions: the complement of the proposition that Jill is rich, and (crucially) the proposition that Jill is a linguist. Thus, the parenthetical content is predicted to project without the need to be forced upon the context.

Note also that the two illocutionary operators in (46) need not have identical meanings. While both are declarative in force, we can boil into these two operators different discourse requirements, e.g., regarding the relevance of the content they embed. This allows us to capture the discourse effects that are at the heart of the QUD approach presented in the following subsection.

3.5. QUD approach

The approaches discussed so far have been syntactic or semantic, and—with the exception of the two-dimensional approach—only apply to presupposition or to CI. A general *pragmatic* approach is based on the discourse status of projective content (Simons et al. 2010; Beaver et al. 2017; Tonhauser et al. 2018). Specifically, this approach seeks to derive projection from the fact that projective meaning is usually not at-issue, i.e., not relevant to the QUESTION UNDER DISCUSSION (QUD; Roberts 2012).

The cornerstone of this approach is the hypothesis that there is a systematic overlap between projection and lack of at-issueness, as stated in (47).

(47) PROJECTION PRINCIPLE (cf. Simons et al. 2010: 309)
An implication projects iff it is not at-issue relative to the current QUD.

This principle is motivated by the observation that projected meaning cannot naturally answer explicit questions even when containing the necessary information. Examples (48) and (49) illustrate this for the cases of presupposition and CI, respectively.

(48) Q: Does France have a king?
A: #The king of France is bald.

(49) Q: Is Edna a fearless leader?
A: #Edna, a fearless leader, started the descent.

Moreover, given the close connection between (presentational) focus and the current QUD (Rooth 1992; Schwarzschild 1999; Beaver & Clark 2008: ch.2), projection may flip depending on prosodic prominence, as seen in (50) (Beaver 2010).

(50) a. {Will the T.A. discover that your work is plagiarized?}
If the T.A. disCOVers that your work is plagiarized, I will be forced to notify the Dean.
>> Your work is plagiarized.

b. {Is your work plagiarized?}
If the T.A. discovers that your work is PLAgiarized, I will be forced to notify the Dean.
>/> Your work is plagiarized.

Due to its generality, the QUD approach has the potential to unite the diverse class of projective meanings under a single property, i.e., at-issueness. However, there are both empirical and theoretical concerns about the Projection Principle. Empirically, the main concern is the bi-conditional form of this principle, which predicts a perfect correlation between projection and not-at-issueness. Specifically, looking at the right-to-left direction, notice that embedded complements under non-factive predicates do not project even when not at-issue. One example is cited in (51), where the complement is not relevant to the QUD (it describes a state while the question is about an event), and yet this complement fails to project.

(51) Q: What happened after the satellite started sending bogus data?
A: The space agency claimed that there was water on Jupiter.

Perhaps because of data like these, Beaver et al. (2017) and Tonhauser et al. (2018) restrict the application of the Projection Principle to 'projective' content, i.e., to content that has the *potential* to project in the sense that it does not obligatorily take scope under embedding operators. However, this move begs the question of what makes such content projective in the first place. The most plausible answer would be that this is due to some form of conventional marking, yet this answer would rub against the pragmatic grain of the QUD approach.[12]

A second concern is that the QUD approach proposes no theoretical mechanism that explains why projectivity and at-issueness are so tightly linked. Such a mechanism would presumably integrate compositional semantics and discourse structure. However, without a concrete proposal, it is difficult to evaluate the empirical predictions with the necessary level of precision.

4. Gradient projection

Projection has traditionally been regarded as an all-or-nothing property, meaning that an expression either always triggers a projective inference or it never does. However, this obscures

[12] As for the left-to-right direction of the Projection Principle, there are examples where content seems to be at-issue but still projects (Koev 2022: ch.4). Nonetheless, there is still a strong tendency for projective content to maintain its non-at-issue status.

the fact that the projective inferences triggered by certain expressions are easier to defeat than those triggered by other expressions. The literature has thus distinguished between SOFT and HARD presupposition triggers, where the former are triggered by contextual alternatives (Abusch 2010; Romoli 2015) or by information that is cognitively inert (Abrusán 2011; Schlenker 2021). The relevant empirical contrast is illustrated in (52), where the inference from *win* to *participate* melts away when it clashes with contextual information, whereas the existential inference triggered by a cleft constriction does not.

(52) a. I have no idea whether John ended up participating in the Road Race yesterday. But if he won it, then he has more victories than anyone else in history.

b. I have no idea whether anyone read that letter. ??But if it is John who read it, let's ask him to be discreet about the content.

Relatedly, recent work has compared the strength of projection across different triggers, discovering fine-grained differences. Tonhauser et al. (2018) experimentally show that different projective meanings project to different degrees, with CI and hard presupposition triggers being more projective than soft presupposition triggers. Moreover, the degree to which content projects turns out to be positively correlated with the degree to which said content is not at-issue, arguing for a gradient version of the Projection Principle in (47).

5. Conclusion

Meaning projection is the ability of certain implications to survive embedding under entailment-canceling operators without their lexical triggers being subjected to some form of syntactic manipulation. The range of projective triggers is very diverse, and the engendered inferences chiefly fall into the categories of presupposition or conventional implicature. Various approaches have been developed to explain projection. While some of these approaches aim at capturing projection as a cohesive phenomenon, a comprehensive theory remains elusive.

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