Triggering Presuppositions*

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Abstract. While presuppositions are often thought to be lexically encoded, researchers have repeatedly argued for 'triggering algorithms' that productively classify certain entailments as presuppositions. We provide new evidence for this position and sketch a novel triggering rule. On the empirical side, we show that presuppositions are productively generated from iconic expressions (such as gestures) that one may not have seen before, which suggests that a triggering algorithm is indeed called for. Turning to normal words, we show that sometimes a presupposition *p* is triggered by a simple or complex expression that does not even entail *p*: it is only when contextual information guarantees that the entailment goes through that the presupposition emerges. On standard theories, this presupposition could not be hardwired, because if so it should make itself felt (by way of projection or accommodation) in all cases. Rather, a triggering algorithm seems to take as an input a contextual meaning, and to turn some contextual entailments into presuppositions. On the theoretical side, we propose that an entailment *q* (possibly a contextual one) of an expression *qq'* is treated as a presupposition if *q* is an epistemic precondition of the global meaning, in the following sense: usually, when one learns that *qq'* (e.g. *x stops q-ing)*, one antecedently knows that *q* (e.g. *x q-ed*). Presuppositions thus arise from an attempt to ensure that information that is cognitively inert in general experience is also trivial relative to its linguistic environment. On various analyses, *q* is trivial in its linguistic environment just in case *q* is entailed by its local context; this provides a direct link between presupposition generation and presupposition projection. (An Appendix discusses the relation between this proposal and an alternative one in terms of entailments that are in some sense counterfactually stable.)

Keywords: presuppositions; triggering problem; dynamic semantics; epistemic preconditions; projection problem; local contexts

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1 Introduction

1.1 The Triggering Problem for presuppositions

Most presupposition research of the last 50 years has focused on the Projection Problem: taking as given the presuppositions of elementary expressions, how are those of complex sentences derived from the meanings of their parts?[1] This leaves another question open: why do some expressions trigger presuppositions in the first place? While this is often taken to be an irreducibly lexical fact, several researchers have argued that this view is insufficiently explanatory and possibly incorrect, hence a 'Triggering Problem': given some information that a linguistic expression conveys about the world, can we predict which part is at-issue and which part is presupposed?

To make things concrete, we can start from theories (such as Heim 1983) in which a presupposition failure yields a third truth value # (besides 'true' and 'false'). To state the Triggering Problem in concrete terms, we take as input information about the situations in which an expression is true vs. non-true, and we seek to predict which of the 'non-true' situations yield failure, i.e. the third truth value #, as is illustrated in (1).

(1) Triggering algorithm: input-output relation

An explicit rule that achieves this result is a triggering algorithm. It will be useful in this discussion to call 'bivalent content' of an expression the bipartition between 'true' and 'non-true' that is obtained by lumping together falsity and presupposition failure, as is done on the left side of (1). The Triggering Problem is thus to predict the presupposition of an expression once its bivalent content has been specified. Another way of stating the Triggering Problem is this: find a systematic recipe that takes the bivalent content of an expression and divides it into entailments that are presupposed (when they are not satisfied, the expression has the value #) and entailments that are at-issue (when they are not satisfied, the expression has the value false).

1.2 Goals

This article has two main goals. Our first goal is to summarize recent and new data that highlight the need for a triggering algorithm, for two reasons: presuppositions are productively generated from iconic expressions one may not have encountered before, hence a productive mechanism is called for; in addition, a presupposition *p* is sometimes triggered by a conventional word that does not even entail *p*: it is only when contextual information guarantees that the entailment goes through that the presupposition emerges. Both lines of argumentation are illustrated in (2).

(2) a. This light bulb, are you going to UNSCREW-ceiling_  ? (Schlenker 2019)
=> this light bulb is on the ceiling
b. Will this hunter pull the trigger?
=> this hunter's rifle is loaded

In (2)a, the verb is replaced with a gesture of unscrewing a bulb from the ceiling (transcribed as *UNSCREW-ceiling*). Even if one hasn't seen this gesture before, it conveys information about the position of the bulb. Crucially, this information is treated as a presupposition, and since this couldn't be a lexical fact, a triggering algorithm is needed to explain why this is so.[2] In (2)b, *pull the trigger*

[1] See for instance Beaver and Geurts 2011 for references.

[2] The triggering problem is equally acute if one views the gesture as a simplified iconic animation analyzed within a projection-based semantics (*à la* Greenberg 2013): the information provided is just that we are in a situation with a bulb on a ceiling and someone unscrewing it; the division of information between presupposed and at-issue must be effected on top of the content of the animation.

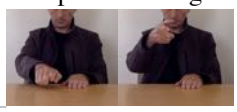
generates the presupposition that the rifle is loaded. But neither *pull*, nor *the*, nor *trigger* can lexically encode such a presupposition. Furthermore, one can perfectly well pull the trigger of a rifle that's not loaded. But common sense knowledge guarantees that *when a hunter pulls the trigger, the rifle is loaded*. The latter inference is presupposed: this is an instance of a presupposition triggered on the basis of contextual information.

Our second goal is to start exploring a new triggering rule, with limitations: we only sketch a 'bare bones' version for some simplified cases, and we do not consider presuppositions triggered by referential expressions (definite descriptions, pronouns), anaphoric triggers such as *too*, focus-sensitive triggers such as *only* and *even*, and cleft constructions. One last (but auxiliary goal) is to explain why alternative accounts, though insightful, encounter difficulties.

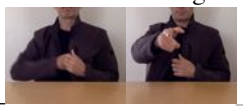
In a nutshell, our proposal is that a contextual entailment *q* of an expression *qq'* is treated as a presupposition if *q* is an epistemic precondition of the global meaning, in the following sense: usually, when one learns that *qq'* (e.g. *x stops q-ing)*, one antecedently knows that *q* (e.g. *x q-ed*). Importantly, the situations in which one learns that *qq'* may be entirely non-linguistic: one may observe by direct perception that it rains at t-1 (= *q*), and then that it doesn't rain at t (= *q'*). In this case, upon learning *qq'* at t, one had an antecedent belief that it rained before.

The proposed rule crucially depends on how one discovers facts about the world; it is thus very different from theories that rely on strategic communication, questions under discussion or implicit focus structure to derive presuppositions.[3] To illustrate the importance of the discovery process, a minimal pair might help. Without negation, both gestural verbs in (3) entail that the agent has a gun with/next to him. But in (3)a, if one witnessed the scene, one would have an antecedent belief about the presence of a gun, which is depicted as being on the table. By contrast, in (3)b, the gun is depicted as being originally hidden in the agent's jacket, and thus one would not typically have an antecedent belief about its existence. This predicts, plausibly in our view, that (3)a presupposes the presence of a gun whereas (3)b doesn't.

(3) The situation will be tense, but the person sitting next to me will not

a. PICK-UP-GUN-SHOOT_  https://youtu.be/-WRpDdgVfOA

=> the person sitting next to me will have a gun in front of him

b. PULL-GUN-SHOOT_  https://youtu.be/yObse1dBMJ4

≠>? the person sitting next to me will have a gun in his jacket

The general intuition that presuppositions are in some sense entailments that count as 'preconditions' is an old one;[4] but the content we give to this concept is new. In our analysis, presuppositions arise from an attempt to ensure that a part *p* of a content *pp'* that is typically cognitively inert (because *p* is antecedently known when *pp'* is discovered) is also trivial relative to its linguistic environment. On various analyses, *p* is trivial in its linguistic environment just in case *p* is entailed by its local context (e.g. Stalnaker 1974, Heim 1983, Schlenker 2009); this provides a direct connection between presupposition generation and presupposition projection.

The rest of this piece is organized as follows. Section 2 summarizes what we take to be defining properties of presuppositions, pertaining to projection and local triviality. In Section 3, we provide arguments in favor of the existence of a triggering algorithm based on the productivity of presupposition generation, notably in iconic signs, gestures or even visual animations that one might not have seen before. In Section 4, we provide further arguments against a lexicalist account based on cases in which what gets presupposed is something that does not follow from an expression *simpliciter*, but from an expression combined with a context (this line of argumentation is independent from the first, and possibly more controversial). Three earlier triggering algorithms are briefly assessed in Section 5 (with

[3] As discussed in Appendix III, however, a variant of the present account can be expected to interact with strategic communication.

[4] See for instance Simons 2001, Thomason et al. 2006, Abusch 2010. As Abusch 2010 notes, an explicit and general definition of what a 'precondition' is has remained elusive.

a more detailed discussion in Appendix I). Our positive proposal is sketched in a simple form in Section 6, with illustrations in Section 7. We discuss the role of context-dependency in Section 8 (including cases in which our account is overly context-sensitive), and offer comparisons and restatements in Section 9, before concluding in Section 10.

2 Presuppositions and local triviality

2.1 Characterizing presuppositions

2.1.1 Projection patterns

What are presuppositions? They are typically characterized by two properties: (i) they have a particular epistemic status, in that they are typically taken for granted by conversation participants; and (ii) they display a characteristic projection behavior, in the sense that they interact in specific ways with logical operators. The epistemic status of presuppositions is a difficult diagnostic to use because there are numerous cases of informative presuppositions (see for instance Stalnaker 2002, von Fintel 2008), as in *I'll pick up my sister at the airport*: nothing tragic happens to my utterance if my interlocutor didn't previously know that I have a sister. By contrast, we take projection behavior to be the standard diagnostic to characterize presuppositions, as illustrated in (4).

(4) a. John knows that he is incompetent.
b. Does John know that he is incompetent?
c. John doesn't know that he is incompetent.
d. If John knows that he is incompetent, he'll get depressed.
e. John might know that he is incompetent.
a,b,c,d,e => John is incompetent
f. None of these ten students knows that he is incompetent.
=> each of these ten students is incompetent

On its own, the inference obtained in (4)a just shows that *knows that he is incompetent* conveys the information that the denotation of *he* is in fact incompetent. What classifies this inference a presupposition is its behavior in embedded environments such as (4)b-f: unlike standard entailments, it is preserved in questions, under negation, *if*, and *might*; and that under *none*-type quantifiers, it gives rise to a universal presupposition that each of the relevant individuals is incompetent.

It is usually thought that the projection data in (4) *taken together* suffice to characterize presuppositions. For instance, universal projection under *none*-type quantifiers can distinguish presuppositions from indirect scalar implicatures, as discussed with French data in Chemla 2009. To illustrate, *x read the class notes and did an exercise* entails *x read the class notes or did an exercise*, but this inference does not project like a presupposition. *No student (both) read the class notes and did an exercise* triggers an implicature that the same statement with *or* replacing *and* is false, hence: *at least one student read the class notes or did an exercise*. This existential inference is crucially different from the universal inference found with presuppositions in (4)f.

Still, there are implicatures besides scalar ones, notably the I-implicatures discussed in Levinson 2000, to the effect that the addressee should "amplify the informational content of the speaker's utterance, by finding the most *specific* interpretation" in view of the speaker's intended point. This is a *very* broad and open-ended class, and in principle presuppositions as analyzed in this piece could constitute a subclass (though we remain neutral on this point): upon hearing a content E with a contextual entailment p that counts as an epistemic precondition of E, the addressee amplifies its informational content by assuming that p holds in the (local) context of E.

2.1.2 Local accommodation vs. cancellation

While projection offers the best characterization of presuppositions, these occasionally fail to do project: a process of 'local accommodation' makes it possible, at some cost, to turn a presupposition into an at-issue contribution (Heim 1983). This is more or less difficult depending on the trigger: 'weak' ones, such as *stop*, may relatively easily allow for local accommodation, so that (5) does not lead to the inference that the interlocutor used to smoke (see also Beaver 2010).

(5) I notice that you keep chewing on your pencil. Have you recently stopped smoking? (Geurts 1994, Simons 2001)

Does that mean that presuppositions can be 'cancelled', just like implicatures? The latter are traditionally treated as being derived from defeasible assumptions about communicative rationality, hence their optionality. With possible lexical exceptions (Zehr and Schwarz 2016), the presupposition of an expression is thought to also be entailed by it, with the result that in unembedded environments it should make its effects felt – e.g. *Ann stopped smoking* invariably yields the inference that Ann smoked before, and no cancellation is possible. *Ann did not stop smoking* may fail to trigger this inference, but not because the presupposition is cancelled: rather, it is turned into the at-issue component in the scope of *not*.

In this piece, we stick to the view that presuppositions are also entailed, since we propose a mechanism to transform entailments into presuppositions. In Section 4, we argue that not just lexical but also contextual entailments can be presupposed (as in the case of *pull the trigger* in (2)b). When the context fails to enforce the entailment (of the form: *x pulls the trigger => x's rifle is loaded),* the triggering algorithm has nothing to operate on. This means that descriptively, contextual triggers do *not* invariably yield the presuppositional inference, even in unembedded environments. This may make our argument from presupposed contextual entailments in Section 4 more controversial than our argument from productivity in Section 3.

2.2 Local triviality

While there are diverse accounts of presupposition projection, one particularly influential idea is that the presupposition of an expression is a component of its meaning that 'wants' to be trivial relative to its local context. A seminal observation was that the conjunction *John is incompetent and he knows that he is* does not carry a presupposition although its second conjunct does. Stalnaker 1974 proposed that this is because the local context of the second conjunct incorporates information contributed by the first conjunct, with the result that the presupposition is automatically satisfied. From this perspective, a theory of presupposition projection is in essence a theory of how local contexts are computed. Stalnaker 1974 sketched a pragmatic mechanism based on belief update, but it proved hard to generalize beyond a couple of connectives. Heim 1983 thus took the very meaning of operators to be instructions to construct local contexts, hence a dynamic semantics for presupposition projection.

In this framework, an elementary clause *pp'* with presupposition *p* (whose presuppositional status is marked by underlining) and at-issue component *p'* is evaluated relative to a context set C as in (6)a, and yields a failure if *p* isn't true throughout C, and otherwise yields the set of *p'*-worlds within C.

(6) a. If *pp'* is an elementary clause with presupposition *p* and at-issue component *p'*, and if C is a context set, C[pp'] = # iff C = # or for some world w in C, *p* is false in w. If C[pp'] ≠ #, C[pp'] = **{w ∈ C: p' is true in w}**.
b. If *F* and *G* are two clauses, and if C is a context set, C[F and G] = (C[F])[G]

To obtain a general theory of presupposition projection, one needs to recursively define the ways in which various connectives affect the context set. For instance, a context set C updated with *F and G* is the successive update of C with *F*, and then with *G*, as illustrated in (6)b. Within dynamic semantics, this approach is very general and can be extended to any connective or operator. Outside of dynamic semantics, Schlenker 2009 showed how local contexts can be reconstructed once the syntax and bivalent meaning of a sentence has been specified; this has the advantage of doing away with lexical stipulations pertaining to the dynamic behavior of connectives (see also Rothschild 2011).

The idea that a presupposition ought to be locally trivial has thus become a cornerstone of several solutions to the Projection Problem. We will suggest that it might also provide a key to the Triggering Problem. In effect, solutions based on local contexts posit that presuppositions should be cognitively inert: once the linguistic environment is taken into account, they should make no contribution whatsoever. This property is exemplified in (6)a, where the presupposition plays no role at all in the output set (boldfaced); rather, the sole function of the presupposition is to trigger cases of semantic failure. But this cognitive inertness could in principle be a much more general phenomenon. With an eye to the behavior of *Sam knows that it's raining,* suppose that at time t one acquires the belief

that *it is raining and Sam believes this*[5]; this means that at time t-1 one didn't hold this belief, and in principle either conjunct (*it is raining, Sam believes it*) could be responsible for this fact. But in many cases, one's knowledge of facts will precede one's knowledge of Sam's beliefs about them, for instance because one has more information about what is going on in the world than in Sam's head. If so, in most cases, one knows that it is raining before learning that Sam correctly believes that it is. This is another way of saying that believing that it is raining is often an epistemic precondition for believing that Sam knows that it is raining. This will form the positive part of our proposal (starting in Section 6). A preliminary statement is provided in (7):

(7) **Presuppositions as epistemic preconditions (informal statement)**
If *E* is a propositional expression uttered relative to a context c', and if *p* is an entailment of *E* relative to c', treat *p* as a presupposition if, when one antecedently believes that c' and one acquires the belief that *E*, one typically antecedently believes that *p*.

To illustrate, upon learning that someone unscrewed a bulb from the ceiling, one would typically antecedently know that the bulb was on the ceiling, hence the presupposition in (2)a. In this case, the triggering rule can be applied to any expression, including new 'words' that one may not have seen before. In addition, our basic rule can be made sensitive to the meaning of an expression relative to a local context, and thus it can turn contextual entailments into presuppositions. In (2)b, *this hunter pulled the trigger* contextually entails that the rifle was loaded. Typically, upon learning that a hunter pulled the trigger (and shot), one would antecedently have known that the rifle was loaded, which explains why this contextual entailment is turned into a presupposition. The contrast in (3) begins to make sense as well: as one sees someone pulling out a gun from their coat, one need not have a pre-existing belief that they had a gun. But as one sees someone picking up a gun from a table, one is more likely to have pre-existing knowledge about the gun's presence.

We turn to a systematic argument for the existence of a triggering algorithm, after which we will summarize existing proposals and sketch a novel triggering rule (with limitations).

3 The need for a triggering algorithm I: productivity

3.1 Traditional arguments

Why should one seek a presupposition triggering algorithm? Two types of arguments often come to mind. First, it is more explanatory to derive presuppositions from a general algorithm than to stipulate them on a word-by-word basis. To put things concretely, if we underline presuppositional contributions, *stop*, *continue* and *start* can be represented as in (8).

(8) a. x stops q-ing = <u>x q-ed</u>; x doesn't q
b. x continues q-ing = <u>x q-ed</u>; x q's
c. x starts q-ing = <u>x didn't q</u>; x q's

In each case, information pertaining to what happened before the evaluation time is presupposed; information pertaining to the evaluation time is at-issue. The question is why there couldn't be lexical entries, such as those in (9) for *stop*, which provided the same global information (i.e. had the same bivalent content) but divided it differently among the presuppositional and at-issue components, for instance by presupposing nothing, or by presupposing information conveyed about the time of evaluation (Simons 2001).

(9) a. x stops* q = x q-ed; x doesn't q
b. x stops** q = x q-ed; <u>x doesn't q</u>

Abrusán 2011 offers a solution, summarized below and in Appendix I. The triggering rule we will argue for does as well: when one acquires the belief that *x stops q-ing at t,* i.e. that *x q-ed before t and x doesn't q at t*, one usually antecedently believes that *x q-ed before t* (because one is likely to know more about earlier states; this will be in particular the case if information grows by way of direct

[5] It is for simplicity only that we equate *x knows p* with the conjunction *p and x believes p*: all that matters is that *p* can be treated as an epistemic precondition of *x knows p*, and this could be the case for more accurate analyses of knowledge (following in particular Gettier 1963).

perception).

The second traditional argument in favor of a triggering algorithm is that one might be missing generalizations by encoding presuppositions on a word-by-word basis. The data might well allow for a more predictive theory, as researchers often have the impression that there is little cross-linguistic variation across triggers: in terms of the schematic representation in (1), there is a general impression that whenever two words *w* and *w'* have the same bivalent content, they also divide it in similar ways between the at-issue and presuppositional components. In Simons's words (2001), some presuppositions are "nondetachable": "they attach to the content expressed, and not to any lexical item". For instance, English *stop* and *cease* have roughly the same bivalent meaning as French *arrêter* and *cesser*, and all trigger a presupposition about the initial state, as in (8)a. Tonhauser 2017 makes this point more rigorously about Swahili and Guaraní (we come back to potential counterexamples in Section 5).[6]

3.2 Arguments from pro-speech gestures

In order to show that there exists a triggering algorithm, it would be optimal to display cases in which one generates presuppositions *from words that one has never encountered before*: this would guarantee that the presuppositions observed are not due to a pre-existing lexical entry. But if the words have not been encountered, how can we tell what they mean? With standard words, the problem is difficult to solve. But if one uses gestures instead of words, their iconic nature may suffice to make their informational content clear upon first exposure, including in cases in which one has not encountered the gesture before (this is the case because iconic representations are based on productive principles, as outlined in Greenberg 2013 for pictorial semantics).

While most gesture research has focused on *co*-speech gestures, Schlenker 2019, to appear and Tieu et al. 2019 investigate instead *pro*-speech gestures, which fully replace words instead of accompanying them. Strikingly, pro-speech gestures can trigger presuppositions. Tieu et al. 2019 make their point experimentally, with inferential data from three examples: one pertains to an individual turning a wheel, which presupposes that the person is in front of a wheel, as in (10); one involves a person removing their glasses, hence the presupposition that the relevant person had glasses on at the relevant moment; and a third example involves a facial gesture corresponding to a person waking up, hence a presupposition that the person was previously asleep.[7]

(10) Presuppositions triggered by *TURN-WHEEL* (= 'bumper cars' condition)

a. Simple question
Jake and Lily are watching their four children ride bumper cars at the carnival. Each bumper car has two seats. As one of the bumper cars nears a bend in the track, the parents wonder:

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[6] An additional argument is that presuppositions might or might not be generated depending on fine-grained pragmatic considerations (e.g. Stalnaker 1974, Beaver 2010). However pragmatic dependency is an argument that ought to be handled with care. Different triggers are known to generate presuppositions with different strengths, in the sense that they may give rise to local accommodation more or less easily. Once the possibility of local accommodation is granted, it is unsurprising that its availability is constrained by pragmatic factors, and at that point the problem becomes an excessively subtle one: we need to decide whether a presupposition fails to materialize because it is not generated to begin with (possibly because of how the triggering algorithm works), or because it was generated but gave rise to local accommodation.

[7] Our initial example in (2)a is similar to (10) in that positional information about the bulb is presupposed. As noted by a reviewer, the presupposition can be locally accommodated, as in (i)a. But this is part of a broad class of environments that force local accommodation, as is illustrated in (i)b: in (i)a and (i)b alike, contradictory inferences would be obtained if both triggers projected their presuppositions. See Esipova 2016 for a theory of how contrastive focus can force local accommodation in some cases but not in others.

(i) a. This light bulb, are you going to UNSCREW-ceiling or PICK-UP-table?
≠> the bulb is on the ceiling
b. Did Ann stop smoking or start smoking? (modified from Abusch 2002)
≠> Ann smoked

Will Sally TURN-WHEEL_  ?

(i) Target inference: Sally is in the driver's seat.
(ii) Control inference: Sally is in the passenger seat, not the driver's seat.

b. Embedding under *None*
Blake and Diane are watching their group of friends ride bumper cars at the carnival. Each bumper car has two seats. As the various bumper cars near a bend in the track, they worry that:

None of their friends will TURN-WHEEL_  .

(i) Target inference: Each of their friends is in the driver's seat of a bumper car
(ii) Control inference: Not every friend is in the driver's seat of a bumper car
(stimuli from Tieu et al. 2019, with pictures from Schlenker 2019)

Experimental results suggest that both under questions and under *none*, inferences that are characteristic of presuppositions were obtained: the target inferences were significantly more endorsed than the control inferences (see Tieu et al. 2019 for details). Here too, Abrusán's algorithm as well as the one we will argue for can explain why a presupposition is generated: usually, upon acquiring the belief that *there was a wheel and x turned it*, the more stable part of the situation, namely the presence of the wheel, was antecedently believed, and thus it gets presupposed.

3.3 Arguments from pro-speech visual animations

Tieu et al. 2019 replicate their results with composites of written words and word-replacing visual animations ('pro-speech visual animations'). An example is displayed in (11): a visual animation depicting a change of state (from non-meditating, realized as green, to meditating, realized as blue) has the effect of presupposing the initial state; this too was assessed by way of embedding in questions, and under *none*-type quantifiers. Thus for the question in (11), subjects drew an inference that "the union representative is not currently in a meditative state".

(11) Triggering presuppositions with visual animations (Tieu et al. 2019)
(here: a change of state animation pertaining to an alien's antenna turning from green to blue; original video: https://youtu.be/U6dfs-XI2-4)

(green) (green+blue) blue

Since people speak with gestures but not with visual animations, it is clear that this stimulus was new to the subjects, and yet they generated a presupposition 'on the fly', which highlights the need for a triggering algorithm. Since the animation represents a change of state, triggering algorithms that predict that the initial state gets presupposed can account for the observed data.

3.4 Arguments from iconic uses of classifier predicates

In American Sign Language (ASL), 'predicate classifiers' are lexical elements whose position or movement can be modulated in highly iconic ways to provide detailed information about the position or the path of an object. Schlenker, to appear investigates various paradigms involving the horizontal and vertical movement of a helicopter, as represented by a helicopter-denoting classifier predicate moving in signing space. Here we just provide one example and refer the reader to the original paper for several additional paradigms and broader conclusions.

The consultant used a special (and possibly idiosyncratic) 2-handed form of the helicopter classifier, intended to represent a 2-rotored helicopter, as illustrated in (12). This had the advantage of triggering a presupposition that the helicopter had two rotors (Schlenker, to appear further compares

the inferential strength of iconic triggers to that of lexical triggers such as *CONTINUE*).

(12) Horizontal movement of a 2-rotored helicopter classifier, transcribed as: *GO-helicopter-large* (ASL 34, 3530a)

The helicopter path involved a movement from a Boston-denoting locus to a New York-denoting locus, and the entire construction was embedded under *IF* and *MAYBE* to assess presupposition projection. The paradigm with *IF* is illustrated in (13), with quantitative acceptability judgments on a 7-point scale, with 7 = best.[8]

(13) *Horizontal movement, IF*
Context: our company has one helicopter and one airplane.
WITHIN 1-HOUR OUR COMPANY BIG HELICOPTER BOSTON$_a$ NEW-YORK$_b$ **IF** a-_____-b, 2-EMAIL-1.
'If within the next hour our company's big helicopter … from Boston to New York, e-mail me.'
(ASL, 34, 3637a, d, e, f, g; 3 judgments) Video (including conditions b. and c.): http://bit.ly/2CGIYhD

Condition (ASL, 34, 3637; 3 judgments)	**Words** (replacing ____) **and acceptability**	**Translation** (replacing …)
a. neutral path	[7] GO-helicopter-large_	flies
b. orthogonal detour	[6.7] GO-helicopter-large__|__no_acceleration	makes an orthogonal detour on its way
c. at-issue control of orthogonal detour	[5.7] GO-helicopter-large_ WITH __|__no_acceleration	flies with an orthogonal detour on its way
d. pause in the middle	[6.7] GO-helicopter-large__ __	pauses to hover on its way
e. at-issue control of pause in the middle	[6.7] GO-helicopter-large__ WITH PAUSE __ __	flies with a pause to hover on its way

The consultant assessed the strength of several inferences (also on a 7-point scale), including one to the effect that the helicopter had two rotors, and one to the effect that the trip would in fact take place. For our purposes, the main results are the following, illustrated on the case of embedding under *IF*:
(i) All conditions yielded strong endorsement (around 6.5 out of 7) of a presuppositional inference that the helicopter has two rotors.
(ii) The condition in (13)b, which iconically displayed a path with an orthogonal detour, yielded a relatively strong (= 5) endorsement of the presuppositional inference that the movement from Boston to New York would in fact take place (though not necessarily with the detour, which was at-issue). A control expressing the same information with an explicit modifier (roughly, 'with the path shown') didn't trigger this presupposition (endorsement of the same inference was just 3.7).
(iii) The condition in (13)d, which iconically displayed a straight path with a pause in the middle to hover, also yielded a relatively strong (= 5.7) endorsement of the inference that the movement would take place (though not necessarily with a pause, as this was at-issue); here too, a control with an explicit at-issue modifier (roughly, 'with a pause like this') didn't trigger this presupposition (endorsement was just 3.3).

Thus iconic information about the shape of the helicopter triggers a presupposition. Similarly, a pause to hover or an orthogonal detour on the way from Boston to New York trigger a presupposition that the trip will take place. These are rather unusual path modifications and thus it is very unlikely that they are lexical presuppositions (in fact, it is dubious that there is anything lexical about the iconic paths

[8] Our summary of the paradigm does not include a 'curved path' modulation, which didn't trigger a standard presupposition but rather a conditionalized presupposition, called 'cosupposition' in the literature on co-speech gestures; its theoretical significance is discussed in Schlenker, to appear.

themselves). From the present perspective, the intuitive reason for these presuppositions should be as follows (although it should admittedly be assessed on independent grounds): upon learning (especially by direct experience) that a two-rotored helicopter went from Boston to New York, one is likely to have had previous information about the helicopter (which one might have seen before), but not about the trip (which might change from occasion to occasion). On the other hand, upon learning that a helicopter went from Boston to New York with an orthogonal detour or a pause in the middle, chances are that these modifications were unexpected, and thus that one antecedently knew about the overall trip but not about the path modification.

3.5 Further arguments pertaining to temporal asymmetries

The change of state verbs discussed in (8) all presuppose information pertaining to their initial state but not to their final state. As noted, this temporal asymmetry is (slightly indirectly) captured by Abrusán's theory of triggering (reviewed below), and in many cases by our triggering rule as well: since one usually has more information about earlier than about later moments, when one discovers that something changed at t, one is likely to have had an antecedent knowledge of what happened right before t. Can we display this asymmetry 'in action' in productive constructions?

Let us consider the gestural example in (14), where the right hand represents a red panel moving towards a white panel depicted by the left hand. In principle, the question could presuppose nothing, or presuppose the initial state, namely that the red panel is initially on the right, or presuppose the final state, to the effect that the red panel reaches the white panel. We believe the introspective judgments are as in (14)a and not as in (14)b.

(14) *Context:* in a large office, a white panel is positioned behind a red panel.
Will the red panel  _left_hand <---  _right_hand ?
a. Interpreted as: the red panel is to the right of the white panel; will it move towards the white panel?
b. Not interpreted as: the red panel will reach the white panel; will it do so by starting from the right?

The same hypothesis was tested more systematically with (new) data involving highly iconic vehicle classifier predicates in ASL, representing in this case two helicopters at different heights, with one of them going up. There are three positions: low, medium, and high, as shown in (15). The left-hand helicopter is stable at medium height throughout the examples, while the right-hand helicopter goes up or down by one level in each case.

(15) Two vehicle classifiers in ASL, and 3 relative positions (addressee's perspective)

high
↑↓
medium
↑↓
low

medium

signer's right hand

signer's left hand

As in (14), one could in principle imagine that the initial state, or the final state, or neither, gets presupposed; but the initial state is invariably presupposed. This was determined by asking for inferential judgments on a 7-point scale, with 7 = strongest inference. Acceptability was also assessed on a 7-point scale (with 7 = best), but it's irrelevant here because all sentences were maximally acceptable. While the full raw judgments can be found in the Supplementary Materials, what matters for present purposes is that presupposition-like inferences were drawn about the initial position of the right-hand helicopter (from the signer's perspective). For instance, in (16)a the right-hand helicopter moves from a low position to the medium position which is also that of the left-hand helicopter. This gives rise to a fairly strong inference (strength: 5.3) that the right-hand helicopter is initially below the left-hand helicopter.

(16) COMPANY HAVE TWO HELICOPTER. TIME 12:05, WON'T CL_left_medium
'The company has two helicopters. At 12:05, with the left-hand helicopter at an intermediate level,

a. [7] CL_right:low->medium.
the right-hand helicopter won't go from a low to an intermediate level.'
=> right before 12:05, the right-hand helicopter will be below the other helicopter [average strength: 5.3]
b. [7] CL_right:medium->high.
the right-hand helicopter won't go from an intermediate to a high level.'
=> right before 12:05, the right-hand helicopter will be at the same level as the other helicopter [average strength: 6]
c. [7] CL_right:high->medium.
the right-hand helicopter won't go from a high to an intermediate level.'
=> right before 12:05, the right-hand helicopter will be above the other helicopter [average strength: 5.8]
d. [7] CL_right:medium->low.
the right-hand helicopter won't go from an intermediate to a low level.'
=> right before 12:05, the right-hand helicopter will be at the same level as the other helicopter [average strength: 4.8]
(ASL, 35, 0232; 4 judgments; anonymized video: https://youtu.be/eGr4-ly3-X4)

In sum, these new ASL data display a clear asymmetry between initial state (presupposed) and final state (at-issue) in minimal pairs involving iconic classifier constructions.[9]

We conclude that the tendency to presuppose an initial state isn't just exemplified in standard lexical entries (e.g. *stop, start, continue*), but that it is also applied productively to new iconic 'words'. Needless to say, experimental data would be helpful to strengthen this conclusion.

4 The need for a triggering algorithm II: contextual entailments and implicatures

We turn to a different class of arguments supporting the existence of a triggering algorithm: sometimes presuppositions could not be triggered on lexical grounds because the relevant words do not lexically imply the purported presuppositions. Rather, it is only when some contextual assumptions hold that the entailments go through, and that presuppositions can arise (as flagged in Section 2.1.2, these cases might be more controversial than those of the preceding section).

4.1 Arguments from contextual triggers

One such case was briefly mentioned in Schlenker 2010, but it can be strengthened (see also Simons 2001 for discourse-based triggering). The idea was that *x announces that p* entails that *p* in some but not all contexts: one can announce false things, but when *x announces that p* contextually entails that *p*, *p* tends to be presupposed. Schlenker 2010 contrasted *announce* with *inform*, alleging that only the latter lexically entails (and presupposes) the truth of its complement; but when contextual assumptions enforce the veridicality of *announce*, the two verbs trigger presuppositions on a par. However Anand and Hacquard 2014 correctly challenge the claim that *inform* lexically entails the truth of its complement, in part by way of attested examples in which *falsely inform* can be used without contradiction:

(17) a. Family falsely informed that soldier son was killed in Afghanistan (from an online news article).
b. From March 2012, Peart's and King's co-conspirators are alleged to have contacted victims in the U.S. and falsely informed them that they had won more than a million dollars in a lottery.
(Anand and Hacquard 2014).

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[9] It would be interesting to test similar generalizations with nonce words, as schematized in (i). The question is whether the target sentence in (i)d gives rise to the inference that the panel is initially on the right, as is predicted if subjects understand *dax* to mean *move from the right to the center*, with the initial state presupposed.

(i) a. *Context:* a mobile panel can reach its central and fixed position from the left, or from the right.
b. *Learning situation 1:* the panel reaches its position from the right: || <--- ■
Shortly thereafter, the experimenter says: *The red panel just daxed*.
c. *Learning situation 2:* the panel reaches its position from the left: ■ ---> ||
Shortly thereafter, the experimenter says: *The red panel just wugged*.
d. *Target sentence* (uttered at a later point): Now the panel won't dax.

In view of Anand and Hacquard's observation, *announce* and *inform* are *both* examples of contextual triggers.[10] Schlenker 2010 illustrates his claims with the *announce*-related sentences in (18), which are about a group of responsible 30-year-olds. But the facts are clearer if *announce* is replaced with *inform*, and per Anand and Hacquard's observation, they make the same theoretical point.

(18) a. Mary hasn't (i) announced to (ii) informed her parents that she is pregnant / I doubt that Mary has announced to her parents that she is pregnant.
=> Mary is pregnant.
b. Has Mary (i) announced to (ii) informed her parents that she is pregnant?
=> Mary is pregnant.
c. None of these ten women has (i) announced to (ii) informed her parents that she is pregnant.
=> Each of these ten women is pregnant.
(Examples in (i) from Schlenker 2010)

The main suggestion in Schlenker 2010 was that *announce* (and now by extension, *inform*) tends to be presuppositional when, relative to its local context, *x announces to y that p* entails that p is true. The point was made with the example in (19).

(19) At a costumed party, we encounter someone with a mask. We do not know whether this is Ann, an 11-year old, or Mary, a 30-year old.
If this is Mary, the person in front of us has / has not (i) announced to (ii) informed her parents that she is pregnant. (Schlenker 2010)

In the global context, *the person in front of us has announced to her parents that she is pregnant* certainly doesn't entail that the person in question is pregnant, since Ann, the 11-year old, couldn't be. But with the addition of the *if*-clause, the local context of the consequent clause ensures that the person in front of us is Mary (because the local context of the consequent of a conditional includes information that follows from the antecedent - see for instance Heim 1983, Schlenker 2009). And relative to that local context, *the person in front of us has / has not announced to her parents that she is pregnant* behaves essentially like *Mary has / hasn't announced to her parents that she is pregnant*. The same facts seem to us to hold if *informed* replaces *announced to*.

In this case too, Abrusán 2011 as well as our own triggering rule can help explain the data. Upon acquiring the belief that *x (correctly) announced y that q*, or *x informs y that q,* in most contexts, one would typically have an antecedent belief about the fact described by *q*.

4.2 Arguments from complex triggers

A different type of argument (discussed in a different context by Simons 2001) can be provided by complex expressions which trigger presuppositions, and yet (i) do not contain lexical triggers that could be responsible for them, and (ii) in some cases, only enforce the relevant inference in the presence of some contextual assumptions.

Two examples are provided in (20). In each case, the version in (i) triggers the same kind of presupposition as the version in (ii); but (ii) plausibly involves a lexical trigger whereas (i) doesn't.

(20) a. Some duels have been organized.
A: What just happened?
B: None of these six guys (i) pulled the trigger (ii) shot.[11]
=> each still has a loaded gun
b. At a euthanasia clinic:
A: What just happened?
B: None of our three patients' executors (i) pressed the 'die' button (ii) started the process.
=> all three patients are alive

[10] Anand and Hacquard's observation need not obliterate the semantic difference between *inform* and *announce*, nor does it imply that the two verbs are equally likely to entail the truth of their complement. For instance, *inform* might come with a presumption that the agent acted in good faith, with the result that *x informed y that p* usually contextually entails that *p* is true. Our argument solely relies on the fact that there are systematic exceptions to veridicality in both cases. (See also the last footnote of Appendix I for remarks on Anand and Hacquard's theory.)

[11] Note that replacing *pulled the trigger* with *had a loaded gun and pulled the trigger* removes the inference, suggesting that the context alone is not responsible for it.

Pull the trigger doesn't contain a word that could generate the presupposition that the gun is loaded. In the general case, this fact isn't even entailed: one can perfectly well pull the trigger of an unloaded gun (hence no contradiction in: *Sam pulled the trigger of an unloaded gun*). But in the present situation, there is plausibly a contextual equivalence between *pull the trigger* and *shoot*, and at this point *pull the trigger* acquires the same presuppositional behavior as *shoot*. The same argument carries over to *press the 'die' button* vs. *start the process*: one can press buttons without consequences, but in the present situation there is a contextual equivalence between the relevant expressions, and the complex expressions acquire a presuppositional behavior.

Each case makes sense in view of the triggering rule we sketched at the outset: upon learning that in a duel situation someone pulled the trigger (and thus shot), one would typically antecedently believe that the gun was loaded; upon learning that someone pressed the 'die' button, one would typically antecedently believe that the button hadn't been pressed yet and that the person was still alive.

One cautionary note should be added. Our discussion might suggest that whenever two expressions have the same bivalent meaning, they trigger the same presupposition. This is arguably correct for lexical expressions, as reviewed (following the literature) in Section 3.1. But this couldn't possibly be right for complex expressions: *Ann smoked and stopped* has the same bivalent meaning as *Ann stopped smoking*, but the conjunction does not trigger a presupposition. This could be taken as an argument to limit the scope of a triggering algorithm to elementary expressions, but if we did so we would miss the triggering of presuppositions by complex expressions such as *pull the trigger*. Thus when we apply a triggering rule to complex expressions, it will have to be limited to avoid overpredicting presuppositions (we will lay out the problem but not give a full solution in this piece).

4.3 Presupposed implicatures

Kadmon 2001 argued that some conversational implicatures are presuppositions as well, and she provides various projection tests for the inferences in (21)-(22) (Kadmon 2001 p. 214).

(21) a. Sue promised John an official invitation.
b. Sue didn't promise John an official invitation.
c. Maybe Sue promised John an official invitation.
d. Did Sue promise John an official invitation?
(a)-(d) => John wanted an official invitation

(22) A: I have to pay my water bill.
a. B: There is a post office around the corner.
b. B: There isn't a post office anywhere around here.
c. B: Is there a post office around here?
d. B: If there is a post office nearby, I'll be going there anyway.
(a)-(d) => water bills can be paid at post offices

In each case, the inference of the a. sentence is defeasible and thus is not a lexical entailment, nor a lexical presupposition.[13] Kadmon takes these inferences to be relevance implicatures, i.e. one's best guess as to why the elementary clause would be a relevant thing to say.[14] What is striking is that these implicatures project like presuppositions. Why should this be? Intuitively, upon learning that Sue promised John an official invitation, one would typically antecedently know that John wanted an official invitation: here the implicature is plausibly an epistemic precondition of the target construction.

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[13] Kadmon also discusses counterfactuality inferences triggered by subjunctive conditionals, but their source is complex enough that we prefer to stay away from this topic in the present discussion. More importantly, she discusses the inferences in (i), which our analysis cannot straightforwardly derive; we revisit this point in fn. 17.

(i) a. It is not true that Sue cried before she finished her thesis.
b. It is quite likely that Sue cried before she finished her thesis.
c. Did Sue cry before she finished her thesis?
a, b, c => Sue finished her thesis

[14] While (21) might conceivably involve a contextual entailment rather than an implicature, (22) genuinely seems to involve a relevance implicature: it is because of the discourse situation (and the assumption of relevance) that B's reply triggers the inference that water bills can be paid at post offices.

4.4 Interim summary

At this point, we have seen two classes of argument in favor of a triggering algorithm. One class has to do with rule-governed behavior: (i) Within or across languages, different words that convey the same information appear to divide it in similar ways among the at-issue and presuppositional components. (ii) Presuppositions can be triggered by new gestures and visual animations, which don't correspond to a pre-existing lexical form. (iii) The same conclusion holds of shape- and path-related inferences of highly iconic predicate classifiers in ASL. (iv) Minimal pairs can also be created with gestures and ASL classifier predicates to confirm the productivity of the rule by which initial states tend to be presupposed. Another class of arguments is based on normal expressions that trigger presuppositions but couldn't do so on lexical grounds because (v) the inference only arises in the presence of some contextual assumptions, and/or (vi) the trigger is complex and does not contain words that could be responsible for the relevant presupposition. In addition, (vii) Kadmon discusses examples in which some relevance implicatures are presupposed.

We conclude that, in some cases at least, a triggering algorithm is called for. While this is consistent with the view that some presuppositions are lexically encoded while others are productively derived, we will seek to develop a relatively uniform triggering rule for a large class of cases.

5 Theories and challenges: a summary

While there have been numerous insightful but informal discussions of how presuppositions are generated (e.g. Grice 1981, Stalnaker 1974, Abbott 2000, Simons 2001), formal proposals have been of three main types (see Abrusán 2011 for an enlightening critical discussion). For brevity, we only summarize the main theoretical directions and challenges, leaving a more detailed discussion for Appendix I.

1. One class of theories takes some presuppositional expressions to evoke some alternatives, just like scalar terms do. Among these theories, some take presuppositions to just be scalar implicatures (Romoli 2014), others take them to deal with alternatives in special ways (Schlenker 2008, Chemla 2010), and still others start from pragmatic constraints on focus alternatives (Abusch 2002, 2010). As can be seen on the example of Abusch's theory, these analyses are interesting but not predictive in the absence of an algorithm to determine which alternatives are considered (a point made very clear in Abusch's own work).

To illustrate, Abusch takes *x stops smoking* to just have a bivalent content, akin to *x smoked and doesn't smoke*. It activates an alternative, namely *x continues to smoke*, which also has a bivalent content: *x smoked and (still) smokes*. Now the crucial assumption is that it is presupposed that at least one alternative is true, hence the disjunction in (23)c, which is equivalent to the desired presupposition: *x smoked*.

(23) a. x stops smoking = x smoked and x doesn't smoke
b. x continues smoking = x smoked and x smokes
c. (x stops smoking or x continues smoking) $\Leftrightarrow$ x smoked

Unfortunately, different choices of alternatives predict different presuppositions, and there is no obvious way to derive the 'right' alternatives on independent grounds. Still, one important minimal pair favors the lexical arbitrariness that is allowed by Abusch's theory: as she notes, *x is right that p* and *x is aware that p* seem to make the same bivalent contribution, but only *is aware* triggers a factive presupposition. Abusch shows that the alternatives in (24) make appropriate predictions: both *be aware* and *be unaware* have a veridical entailment, hence their disjunction does too; but *be wrong* lacks this veridical entailment, which explains why *be right* doesn't trigger a factive presupposition (we sketch an alternative in Appendix I, but not a completely satisfactory one).

(24) a. be right: {be right, be wrong}
b. be aware: {be aware, be unaware}

2. A second line of investigation, developed in Simons et al. 2010 and Tonhauser et al. 2013, starts from the notion of a 'Question Under Discussion' (QUD), and takes certain entailments to 'project' and thus to behave as if they were presupposed when they fail to address the Question Under Discussion. But

this theory encounters two problems. First, as it stands the account is insufficiently predictive and/or makes impossible predictions, as every entailment *p'* of a target expression *p* is predicted to project (a point discussed in Chemla 2006). For instance, as explained in Appendix I, if the QUD is *Does Spain have a king?,* a simple answer *p = Spain has a king* should give rise to the presupposition that its entailment *p' = Spain has a monarch* is presupposed (and in fact the reasoning works if *p'* is just *p* itself). Second, as noted by Abrusán 2011, the account predicts that presuppositions should fail to be generated much more easily than is in fact the case: with a very open-ended QUD *What do you know about John?*, every fact about John should be relevant, and thus *He still didn't quit smoking* should fail to generate a presupposition, contrary to fact.

3. A third line, due to Abrusán 2011, focuses specifically on presuppositions triggered by verbal constructions, and takes those entailments of a sentence that are not about the matrix event time to be presupposed. For instance, *John stopped smoking at* t_1 conveys information about the matrix event time t_1, to the effect that at t_1 John didn't smoke. And it conveys information that is not about t_1, namely that before t_1 John smoked. Abrusán predicts that the latter information should be presupposed (she takes information about times that *follow* t_1 not to be lexically entailed, and thus not to be presupposed either). As developed by Abrusán, this theory captures the temporal asymmetries discussed in Section 3.5.

As we discuss in Appendix I, Abrusán's theory faces an overgeneration dilemma. Expressions such as *demonstrate* seem to entail the truth of their complement. In (25), the embedded clause provides information that is not about the matrix event time, but it is not presupposed, contrary to what is predicted. Similar cases can be found outside the data that Abrusán's theory sought to cover, as in (26).

(25) a. The bloody gloves {demonstrate, imply, prove, show} that Mary committed the murder.
=> Mary committed the murder.
b. Do the bloody gloves {demonstrate, imply, prove, show} that Mary committed the murder?
≠> Mary committed the murder.
(modified from Anand and Hacquard 2014)

(26) a. Mary is pregnant. => Mary was impregnated at least 5 days ago
b. Is Mary pregnant? ≠> Mary was impregnated at least 5 days ago

Abrusán's original theory only applies to lexical, not to pragmatic entailments, and thus it may posit that these entailments are not lexical in nature. But if so it will be unable to explain the cases discussed in Section 4, including those that belong to the same natural class as Abrusán's own examples because they involve change of state constructions (e.g. *pull the trigger* and *press the 'die' button*). From the present perspective, the facts need not be surprising: when one learns that *x demonstrates that p, p* is often hard or non-trivial, and thus one often does *not* antecedently know that *p*. Similarly, upon learning that *x is pregnant*, one typically does not antecedently know that *x was impregnated at least 5 days ago,* hence no presupposition is expected to arise. (See also Appendix I for a case of undergeneration within Abrusán's theory.)

6 Steps towards a proposal: presuppositions as epistemic preconditions

We now summarize the requirements on a triggering algorithm and sketch a new one that meets them.

6.1 Requirements and motivations

The foregoing observations have unearthed conceptual and empirical requirements on a triggering algorithm, stated in (27).

(27) A presupposition triggering algorithm:
a. should productively divide information contributed by new words or iconic representations among an at-issue and a presupposed part (as seen in Section 3);
b. it should do so on the basis of the contextual meaning of these expressions, i.e. the value they have relative to a local context (as seen in Section 4);
c. it should often yield the result that in change of state constructions, the initial state is presupposed (as discussed in Section 3.5, and by Abrusán 2011);
d. but this temporal asymmetry should depend on how information is typically discovered so as to derive the minimal pairs discussed in (3) and in Section 5.

e. In addition, if the triggering algorithm is applied to complex expressions, its scope should be limited for fear of predicting that *(p and pp')* triggers the same presupposition as *pp'* (as discussed in Section 4.2).

The existence of some fine-grained minimal pairs suggests that the triggering rule must be very discriminating, as stated in (27)c. We saw at the outset that the gesture *PICK-UP-GUN-SHOOT* in (3)a has a presuppositional behavior but the gesture *PULL-GUN-SHOOT* in (3)b arguably doesn't: in the former case, the initial state is presupposed, in the latter it isn't; this isn't a unique case, as shown by (26). Such contrasts put new constraints on a triggering algorithm. Our goal will be to develop a proof of concept for one, leaving for future research a full implementation (including the limitations required by (27)e).

It might help to consider again our driving intuition, which is that entailments that are inert in cognitive life should be semantically inert (= trivial) in their linguistic environment. This intuition is theoretically grounded in the projection recipe that requires that a presupposition should be trivial in its local context. But it has empirical consequences that go in the right direction. Take our initial example in (2)a. Suppose you are in a room, and see at time t that x is unscrewing a bulb from the ceiling, corresponding to the content of *UNSCREW-ceiling*. This entails that the bulb is on the ceiling, and that it is being unscrewed. But it's unlikely that you learned everything at once at t; rather, stable properties of the situation, and in particular the fact that the bulb is on the ceiling, are probably things you knew at time t-1. There will be exceptions to this, as when you enter a room and simultaneously see that a bulb is on the ceiling and that someone is unscrewing it. But these exceptions will be comparatively rare.

This justifies having a probabilistic recipe, one that doesn't require that entailments that end up being presupposed should *invariably* be inert in cognitive life, just that they should *generally* be. This recipe will produce the desired contrast between *PICK-UP-GUN-SHOOT* and *PULL-GUN-SHOOT*: upon learning that someone pulled out a gun from a coat, one typically doesn't know that he had a gun; by contrast, upon learning that someone picked up a gun from the table, one typically has prior knowledge of the gun's presence.

The next steps can be divided as follows:

(28) a. definition of a triggering rule that satisfies (27)a-d
b. limitations to the application of the rule to complex expressions in order to satisfy (27)e
c. refinements of the context-dependent aspects of the rule

We will limit our ambitions to a simplified case of the definition of a triggering rule (= (28)a), that in which the triggers are propositional (rather than predicative, for instance). We will discuss but not solve the issue of limiting the application of the rule to complex expressions (= (28)b). And we will see in Section 8 that amount of context-dependency needed for the triggering rule is an open question (= (28)c).

6.2 Sketching a 'bare bones' theory for the propositional case

Let us now make the proposal more concrete. We will consider the meaning of an expression *E* relative to a context c', and we will sometimes write *E* as *pp'* if its meaning is equivalent, relative to the local context c' of *E*, to the conjunction of *p* and *p'* (i.e. c' |= E $\Leftrightarrow$ (p and p')). This will have the advantage that we can graphically identify entailments of interest, for instance in case *p* is the observed presupposition. But this notation is for convenience only, as we will never need to stipulate a division of *E* into *p* and *p'*: which entailments end up treated as presuppositions follows from the triggering rule.

We work with discrete times, and write $acquire_t$ ***pp'*** if the relevant individual or individuals (i) did not have the belief that *p and p'* before t, and (ii) have that belief at t. In other words, their beliefs changed between t-1 and t, but this leaves open whether they already believed that *p*, or that *p*, or neither, at time t-1. We will write $believe_{t-1}$ ***p*** in case the relevant individual(s) already believed that *p* at time t-1.

Now our presupposition triggering rule for the propositional case can be stated as follows:

(29) **Presupposition triggering relative to a context (propositional case)**
For a (contextually) given probability threshold *a*, for a propositional expression *E* in context c', for random time variables t and t', trigger a presupposition *p* if:

(i) c' |= E => p[15], and
(ii) P(believe$_{t-1}$ **p** | believe$_{t-1}$ c' & acquire$_t$ **E**) ≥ a

where P (• | _) is the subjective conditional probability of • given _ and **E** and **p** are the semantic values of *E* and *p* respectively (when no confusion arises, we will forego boldfacing).

In words: trigger a presupposition *p* from an expression *E* in context c' if:
(i) *E* contextually entails *p* relative to c', and
(ii) if one antecedently believed c' and acquires the believe that *E*, there is a high enough chance (above threshold *a*) that one antecedently believed p.

Several points need to be clarified at the outset.
• We take the relevant notion of probability to be a subjective probability that a generic agent could have in view of the information contained in the local context c'.
• In local context theory (e.g. Schlenker 2009), the local context c' of a propositional expression *pp'* is itself propositional, which is crucial to ensure that c' can entail the presupposition (e.g. *p* if *p* is the presupposition of *pp'*). This also means one can believe c', since it is of propositional type.
• At this stage, the belief holder is taken to be a generic agent, and thus the crucial test can be paraphrased as: *upon acquiring the belief that pp' relative to beliefs c', what is the probability that one antecedently believed p?* The concept could be refined by asking: *what is the probability that a random agent who learned that pp' relative to beliefs c' had a prior belief that p?* Since the latter statement would be far more complicated, we stick to the former, taking as primitive the probabilities in (29)(ii).
• When we consider propositions with explicit time dependency, such as *at t' Sam unscrews a bulb from the ceiling*, it will make sense to have in one way or another an over-representation of discovery times that correspond to the event time, consonant with the idea that we learn many things through direct perception, and thus at the event time. Thus when we compute *P(believe$_{t-1}$ at t' there is a bulb on the ceiling | believe$_{t-1}$ c' & acquire$_t$ at t' Sam unscrews a bulb from the ceiling)*, cases t = t' will be overrepresented.

As a 'sanity check', we have provided in Appendix II a formal illustration of the workings of the system, with a model-theoretic implementation in which *x believe$_t$* ***p*** is analyzed (as is standard) in terms of quantification over possible worlds. But we leave for future research several important points: (i) a generalization of the rule to further expressions of a type that 'ends in t', in particular to predicative expressions; (ii) a constraint on the size of the complex expressions to which the rule applies: for the moment, we will pretend that the rule only applies to elementary expressions (= (28)b above); (iii) a refinement of the context-sensitive aspects of the rule (= (28)c above); (iv) a discussion of potentially pathological scenarios discussed in Appendix II.

To see how the triggering rule might be constrained to apply to complex expressions without absurd results, we note that in problematic cases such as (30)a(ii), b(ii), independent principles might defeat the undesirable presupposition.

(30) a. (i) Did Ann stop smoking? (ii) Did Ann **smoke and stop**?
(i) but not (ii) => Ann smoked
b. (ii) Will Sally TURN-WHEEL? (ii) Will Sally **turn a wheel**?
(i) but not (ii) => Sally will be next to a wheel

In (30)a(ii), the first conjunct should be non-trivial in its local context (Stalnaker 1978): *Ann smokes* should make a non-trivial contribution. In (30)b, *a wheel* competes with *the wheel* and by Maximize Presupposition (e.g. Sauerland 2008) yields an inference that it is not presupposed that there is exactly one salient wheel (why *the wheel* triggers the presupposition it does is outside the scope of the present paper). Thus if the triggering rule applied to the boldfaced expressions in (30)a(ii), b(ii) is constrained by the inferences triggered by their constituent parts, the undesirable presuppositions will be avoided. How to do this in a systematic fashion remains to be seen, however.

[15] In simple cases, condition (i) might or might not be redundant: if *p* isn't a contextual entailment of *E* relative to c', one might think it unlikely that *p* is an epistemic precondition of *E*. But as nothing enforces this in the general case, we state explicitly that only contextual entailments are candidates for presuppositions.

6.3 Assessing probabilities and probabilistic thresholds

The simplified model we have introduced takes as given (i) certain subjective conditional probabilities pertaining to how facts are discovered in cognitive life, and (ii) a contextually determined probabilistic threshold that determines which epistemic preconditions are 'strong enough' to be treated as presuppositions. These are currently open parameters, although we will try to argue below that what we need with respect to (i) to derive the key examples is plausible enough. Still, it is important to explain how, in principle, one could evaluate these parameters on independent grounds.

Let us start with the conditional probabilities, starting from a sentence such as (31) (we replace *you* in our earlier examples with *Sam* to avoid complexities due to context-dependency).

(31) This light bulb, is Sam going to UNSCREW-ceiling_  ?

The local context of the target expression is just the global context of the conversation C. We first need to assess the probability in (32).

(32) P(believe$_{t-1}$ **the bulb is on the ceiling** | believe$_{t-1}$ C & acquire$_t$ **Sam is going to unscrew the bulb from the ceiling**) ≥ a

To do so with idealized subjects, we would (i) provide them with information about what is assumed in the context C, and (ii) ask them to assess the subjective probability in (33):

(33) Assume that a random person x knows that C, and comes to learn at time t that the following holds **[description of the proposition acquired]**. What is in your view the chance that x already knew at time t-1 that there was a bulb on the ceiling?

The highlighted expression could be filled with a video or a cartoon of an event (if one wanted a non-linguistic way of providing the information), or a linguistic description of the proposition. In the latter case, one must ensure that no presuppositions bias the judgments. Concretely: one shouldn't describe the situation as: *(at time t) Sam unscrews the bulb from the ceiling*, as this presupposes that at time t there is a bulb on the ceiling, but rather in a more neutral fashion, such as: *(at time t) there is a bulb on the ceiling and Sam unscrews it*. There of course multiple ways in which such conditional probabilities could be assessed. What matters for us is that this can be done without implicating the presupposition triggers whose behavior we seek to derive.

It should be clear that not all entailments will end up being presupposed in this way. To take an example, consider *Ann told us about her holiday*. This entails that *Ann uttered something*. But typically one learns that Ann uttered something by learning what she said. In other words, upon learning at t that Ann told us about her holiday, we won't have a pre-existing knowledge at t-1 that Ann uttered something.[16]

Turning to the threshold *a* that appears in (32), it is plausible that its value can be contextually determined. But in the simplest version of the theory (without context-dependency in this respect), its determination could be effected empirically. Specifically, suppose we start from a large set of lexical items that includes for instance those in (34). In an idealized case, in which we consider the idiolect of a particular subject, we ask this subject to assess the relevant conditional probabilities in (35) for different values of pp' (in this case keeping constant p = Ann is in Paris).

(34) General form: *pp'?*, for p = Ann is in Paris
a. Will Sam know that Ann is in Paris?

[16] If the granularity of times were made extremely fine, we might have a problem, in the following sense: suppose we learn by direct experience that Ann tells us something about her holiday, e.g. because she utters the sentence *I had a wonderful holiday*. One second before the time t at which the sentence was completed, we knew that she was uttering something, but not what she was uttering. So at t-1 we knew that she was uttering something, but not what this was about. This just suggests that the granularity of times used by the present theory shouldn't be too fine-grained, although establishing the correct granularity would require a more sophisticated investigation.

b. Will Sam discover that Ann is in Paris?
c. Will Sam prove that Ann is in Paris?

(35) P(believe$_{t-1}$ **p** | believe$_{t-1}$ C & acquire$_t$ **pp'**)

We then expect that there will be a cut-off at which presuppositions are generated. In particular, the conditional probability for *know* should be above the cut-off (since it triggers a presupposition), while the conditional probability for *prove* should be below the cut-off (because it doesn't trigger a presupposition), and the value for *discover* should be above or below depending on whether it triggers a presupposition.

7 Applications of the proposal

We now briefly recapitulate how the proposed theory can formally capture the generalizations stated in Sections 3 and 4.

(i) Cross-linguistic stability (Section 3.1): We noted at the outset that lexical accounts fail to explain why two words that have the same bivalent meaning (e.g. English *stop* and French *arrêter*) also divide its content in the same way among the at-issue and presuppositional components. This follows from the very form of the triggering rule, since it just takes as input a bivalent meaning (and a context) and returns a presupposition. Two words that have the same bivalent meaning must thus be treated in the same way.

(ii) Pro-speech gestures, visual animations and classifier predicates (Sections 3.2–3.4): Since the triggering rule takes as input any bivalent meaning, it is unsurprising that new bivalent meanings produced by an iconic semantics feed this algorithm just as well. Pro-speech gestures, visual animations and classifier predicates convey information that is thus productively divided among the at-issue and presuppositional components by the rule.

In greater detail, let us consider again the example *Will Sally TURN-WHEEL?* in (10)a. It contains a gestural verb that entails the presence of a wheel next to the agent. We can use the context-insensitive version of the triggering rule to assess the probability that, upon learning that someone turned a wheel, one antecedently knew that there was a wheel next to that person in that situation. For simplicity, we disregard the time argument of *turn* and evaluate the probability in (36), with C being general world knowledge that holds across conversations:

(36) P(believe$_{t-1}$ (Sally is next to a wheel right before t') | believe$_{t-1}$ C & acquire$_t$ Sally turns a wheel at t')

This is plausibly a high probability because, in cognitive life, one typically perceives a wheel being turned after one already knows about the presence of the wheel. More precisely, on the assumption that the discovery process often co-occurs with the event time, situations (tuples) that satisfy acquire$_t$ x turns a wheel at t' will display an overrepresentation of cases with t = t'. The probability in (36) is thus plausibly high, since upon witnessing Sally turn a wheel, one would typically have prior knowledge of the presence of the wheel.

As we hinted at the outset, the same analysis explains the contrast between (3)a (= *PICK-UP-GUN-SHOOT*) and (3)b (= *PULL-GUN-SHOOT*): with t = t', upon learning at t that the person sitting next to me (call this person p) picks up a gun in evidence on a table and shoots, one would typically have antecedent knowledge of the presence of the gun, whereas this wouldn't be the case if the acquired proposition is that p pulls a gun hidden in his jacket and shoots.

(37) a. P(believe$_{t-1}$ (right before t' p has a gun on the table) | believe$_{t-1}$ C & acquire$_t$ at t' p picks up a gun from the table and shoots)
b. P(believe$_{t-1}$ (right before t' p has a gun in his jacket) | believe$_{t-1}$ C & acquire$_t$ at t' p pulls a gun from his jacket and shoots)

Turning to the helicopter paths with an orthogonal detour or a pause in the middle in the ASL examples in (13)b,d, the key is that these seem to be interpreted as unexpected deviations from a normal trajectory, and thus one would typically learn about the deviation after learning about the final destination. These paths represented a movement from Boston to New York, and thus the entailment

that the helicopter goes to New York ends up being presupposed.

(iii) Temporal asymmetries (Section 3.5): We noted that, all other things being equal, in change of state constructions, the initial state tends to get presupposed. This makes sense in the present framework because facts about the past should be antecedently known more than facts about the future, and hence there should be a tendency to presuppose information about antecedent states more than about future states. Consider again the case of (14), with the red panel moving from the right to the center, and consider the kind of underspecified context C relative to which we evaluated the sentence. We need to evaluate the probability in (38):

(38) $P(believe_{t-1}$ (the red panel is initially on the right) | $believe_{t-1}$ C & $acquire_t$ (the red panel moves from the right to the center))

We submit that it is indeed plausible that one would often learn of the panel's movement after knowing about its initial state.

(iv) Presupposed contextual entailments (Sections 4.1-4.2): Since our triggering rule takes as input the meaning of an expression relative to a context, it is unsurprising that contextual entailments can be turned into presuppositions. Let us briefly consider specific examples.

In (19)(i), repeated as (39)a, the content of the conditional is crucial to obtain the entailment that the person is in fact pregnant. In this case, we cannot trigger the presupposition without appealing to the local context c' of the consequent clause. A standard result of dynamic semantics as well as reconstructions of it (Schlenker 2009) is that the local context c' of the consequent is obtained by intersecting the global context C with the content **p** of the antecedent. Ignoring time arguments, we must compute the probability in (39)b. Here **p** ensures that *the person in front of us* denotes Mary, the responsible thirty-year old; and with that assumption, it is reasonably likely that upon learning that Mary announced to her parents that she is pregnant, one antecedently knew that she is pregnant.

(39) a. If this is Mary, the person in front of us has / has not announced to her parents that she is pregnant.
a'. if p, $^{c'}$q
b. $P(believe_{t-1}$ (Mary is pregnant) | $believe_{t-1}$ C ∩ **p** & $acquire_t$(the person in front of us announces that she is pregnant))

The complex trigger *pull the trigger* can be treated in analogous fashion: in local contexts in which *Sam pulled the trigger* entails that *Sam shot,* the fact that Sam's gun is loaded may be turned into a presupposition.

(v) Presupposed implicatures (Section 4.3): There is no particular reason to limit the contribution of an expression to its contextual entailments, and thus taking into account its implicatures when triggering presuppositions is a natural decision. Kadmon's case of *promise* can be treated along these lines: taking into account the implicated content (to the effect that *y wants z*), the probability in (40) is plausibly high, which means that upon learning that x promises z to y and that y wants, there is good chance one antecedently knew that y wants z.

(40) $P(believe_{t-1}$ (John wants an invitation) | $believe_{t-1}$ C & $acquire_t$ (Sue promises an invitation to John & John wants an invitation))

Similarly, upon learning that there is a post office around the corner and water bills can be paid at post offices, there is a good chance that one antecedently knew that water bills can be paid at post offices: the probability in (41) should thus be high, which would account for Kadmon's examples in (22).

(41) $P(believe_{t-1}$ (water bills can be paid at post offices) | $believe_{t-1}$ C & $acquire_t$ (water bills can be paid at post offices)

While we do not derive *all* of Kadmon's cases, we take it to be a good result that the very idea of a presupposed implicature makes immediate sense in view of our triggering rule, and accounts for some non-trivial examples.[17]

[17] Kadmon's example in (ia) (whose presuppositional behavior was discussed in fn. 13) doesn't follow from the present analysis.

One further application could be considered in the future. Recent research has highlighted the gradient character of presuppositions and projective phenomena (e.g. Tonhauser et al. 2018, Tonhauser and Degen 2019). It would thus be natural to explore a more gradient version of the present analysis, on which the higher the probability that an entailment is an epistemic precondition, the stronger a presupposition it should be.

8 The issue of context-dependency

Our theory predicts considerable context-dependency, since the triggering rule is doubly relativized to local contexts: first, because entailments are assessed relative to local contexts, and second, because it is relative to contextual knowledge that conditional probabilities are assessed. In some cases, context-dependency is a good thing, as we show in Section 8.1 In the general case, it is too strong, which will call for more subtle statements of the rule in the future, as we show in Section 8.2.

8.1 The case for context-dependency

We argued above that *inform* doesn't lexically entail the truth of its complement, but often entails due to contextual assumptions. The latter don't just matter to enforce the entailment, but also to determine whether that entailment counts as an epistemic precondition, as illustrated in (42).

(42) a. Smith is 200km away from the South Pole. Will he inform his mother tomorrow that he has reached it?
≠> tomorrow Smith will have reached the South Pole.
b. Smith is 20km away from the South Pole. Will he inform his mother tomorrow that he has reached it?
=> tomorrow Smith will have reached the South Pole

Both sentences leave open whether Smith will have reached the South Pole tomorrow, although this is more likely in (42)b than in (42)a. There seems to be a stronger tendency to generate a presupposition in (42)b than in (42)a. This can be explained if we evaluate probabilities of the full propositions relative to the local context of the target sentence. We must thus ask: upon learning that Smith correctly announces to his mother that that he has reached the South Pole, what is the probability that one antecedently knew he had reached it? It should be greater in the '20km away' than in the '200km away' scenario, hence the result.

The same contextual effects can be found with *know*: depending on whether an entailment counts as an epistemic precondition *in a local context*, it may or may not be treated as a presupposition. Consider the sentence in (43)c in the contexts described in (43)a,b.

(43) Smith is on a difficult expedition to reach the South Pole on skis.
a. Context 1: early 20th century - we have no way of tracking Smith
b. Context 2: 21st century scenario - we have access to Smith's GPS coordinates
c. Target sentence: If Smith knows he has reached the South Pole, he'll send his family a message.

Our impression is that in Context 2, *know* displays its usual behavior and triggers a presupposition that Smith has reached the South Pole. But this inference isn't as strongly present in Context 1. We believe this is because *relative to the context of the conversation* (rather than world knowledge that is shared across conversations), the value of the probability in (44) is lower in Context 1 than in Context 2, because in Context 1 Smith is our only source of information about his position, hence upon learning that Smith correctly thinks he reached the South Pole, one would typically not antecedently know he

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(i) a. Did Sue cry before she finished her thesis? => Sue finished her thesis
b. Did Sue finish her thesis after she cried? ≠> Sue finished her thesis

In general, it is unlikely that upon learning that *p happened before q*, one would antecedently know that *q* but not that *p*, since one tends to know more things about earlier moments. To compound the problem, *Sue finished her thesis after she cried* has roughly the same bivalent content as *Sue cried before she finished her thesis*, but it doesn't trigger the same presupposition, as shown in (i)b. We could posit, however, that some uses of *before* are analyzed in terms of a covert definite description, hence: *before the time at which she finished her thesis*; this would reduce the problem to the triggering of presuppositions by definite descriptions, which we do not discuss in this piece.

has in fact reached it – unlike in Context 2, where tracking devices make it possible to know independently of Smith where he is.[18]

(44) P(believe$_{t-1}$ (Smith has reached the South Pole) | believe$_{t-1}$ c' & acquire$_t$(Smith correctly believes he has reached the South Pole))

Not just the local context but also the nature of the arguments seems to matter. Consider (45) uttered in the various contexts in (46). In Context 1' and Context 2', chances are that upon learning that Ann correctly believes that she made an error in the proof, one would not antecedently know that there is in fact one. The probability that one has this antecedent knowledge is higher in Context 1 and Context 2, where one is more likely to have information that Ann herself doesn't have.

(45) Did Ann realize she made an error in her proof?

(46) a. Context 1: Uttered by Ann's genius advisor
=> Ann made an error in the proof
a'. Context 1': Uttered Ann's 13-year old brother.
Why is my sister so distraught? …
≠> Ann made an error in the proof
b. Context 2: Ann is a good professional mathematician.
≠> Ann made an error in the proof
b'. Context 2': Ann is a beginning student.
=> Ann made an error in the proof

The nature of the complement seems to matter as well, as illustrated in (47).

(47) From a non-mathematician, to a mathematician:
a. Did you realize you made an error in your proof?
≠> the addressee made an error in the proof
b. Did you realize you mistreated your students?
=> the addressee mistreated students

Because one typically has greater access to a mathematician's behavior than to the correctness of their proofs, the difference makes sense: upon learning that the mathematician realized that they mistreated their students, one would typically antecedently believe that they did so; but upon learning that they realized that they made an error in their proof, one might not antecedently know there was an error.

More generally, recent corpus and experimental work has highlighted the context- and content-dependency of projection phenomena, including for presuppositions (e.g. Beaver 2010, Tonhauser and Degen 2019)[19], and from this perspective the context-dependency of our proposed rule might go in the right direction.

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[18] The same analysis might capture the observation, made by Geurts 1994 and Simons 2001, that *stop* fails to trigger a presupposition in (ii): in the context of the conversation, upon learning that the nervous stranger smoked but no longer does, one would typically not antecedently believe that the stranger smoked before.

(i) [To a stranger:] Why are you so nervous? Have you recently stopped smoking? (Geurts 1994, Simons 2001)

[19] Tonhauser and Degen's (2019) find that "higher-probability content is more projective than lower-probability content". For instance, *Does Sandra know that Julian dances salsa?* projects a factive presupposition more strongly if the context specifies that Julian is from Cuba than if it specifies that he is from Germany. This fact may be interpreted in a deflationary fashion: in the second case, it is less likely that the presupposition is satisfied, which should facilitate local accommodation. Alternatively, one may want to derive this result from the triggering rule. The context-sensitive rule discussed in the present section might help. The key is that, all other things being equal, the rule is sensitive to the probability that certain entailments are antecedently believed. Specifically, applying Bayes's rule, the propositional triggering rule in (29) can be reformulated as in (i). The boxed term is the probability that one antecedently believed the purported presupposition.

(i) P(believe$_{t-1}$ **p** | believe$_{t-1}$ c' & acquire$_t$ **E**) = [P(believe$_{t-1}$ c' & acquire$_t$ **E** | believe$_{t-1}$ **p**) / P(believe$_{t-1}$ c' & acquire$_t$ **E**)] * $\boxed{\text{P(believe}_{t-1}\ \mathbf{p})}$

8.2 Excessive context-dependency

Despite these arguments, the present theory is excessively context-dependent.[20] Take *regret*. We assume that *x regrets that p* entails that *x believes that p*, but the challenge is to explain why this is a presupposition. Now it makes good sense to assume that, in general, if one learns that *(x believes that p and) x regrets that p*, one antecedently knew that *x believes that p*. But in special cases this won't be so. Suppose I am in the complaint department of an electronics store. I can ask my colleague working in the same department: *Does your customer regret that she bought an iPhone?* Here the context ensures that upon learning that the customer regrets buying an iPhone, one couldn't have antecedently known that my interlocutor's customer had bought an iPhone. Rather, it is by processing the complaint that one can learn that she bought an iPhone. This predicts that no presupposition should be generated, but this doesn't seem correct.

One solution, suggested by a reviewer, is to radically weaken the scope of our theory by taking our generalization about antecedent knowledge to be a lexicalization tendency, not a productive rule. This would be in the spirit of the tendency-based account of inchoative/causative alternation of Haspelmath 1993 and Wechsler 2015: *wash* is unlikely while *melt* is likely to correspond to an event that occurs spontaneously, and correspondingly an inchoative/causative alternation is lexically more common for *melt* than *wash*. In this spirit, one could seek to correlate the chance that a word trigger a lexical presupposition that *p*' with the chance that, upon learning that *pp*', one antecedently knew that *p*. An advantage of this weaker theory is to allow for some cases of lexical arbitrariness, as in the case of *be aware* vs. *be right*, which the reviewer takes to be in the middle of the hierarchy: upon learning that *x correctly believes that p*, one might have an antecedent knowledge that *x believes p*, or an antecedent knowledge that *p is true*. While we propose an alternative analysis of this contrast in Appendix I, it is fair to say that it is not fully satisfactory, hence the tendency-based proposal could be a useful alternative. But from the present perspective, it comes at a huge price: it makes it impossible to account for the cases of contextual triggering discussed in Section 4.[21]

A more desirable solution to avoid excessive context-dependency could be to apply the triggering rule to expressions of the appropriate type (technically, expressions whose type 'ends in t') without regard to the nature of their arguments and to their local context. Concretely, let us consider *regret*. We can determine that, for variables *x* and *p*, *x regrets that p* entails (relative to the general knowledge C which is shared across conversations) that *x believes that p* holds. Now we ask what is the chance that, for variables *x* and *p*, if one learns that *(x believes that p and) x regrets that p*, one antecedently knew that *x believes that p*. Here *x* and *p* will range over all sorts of individuals and propositions, and the contextual knowledge used (C, shared across conversations) will be unspecific, and thus the details of the linguistic and discourse context will not make themselves felt.

To develop this solution, we would need to evaluate the probability of open sentences, i.e. of sentences with variables. Thus to analyze the presupposition of *TURN-WHEEL* as in (10)a, we must compute the probability in (48), where *x* doesn't refer to a specific individual but ranges over a variety of individuals; and similarly for *t* and *t*', which range over a variety of times.

(48) $P(believe_{t\text{-}1}$ (x is next to a wheel right before t') | $believe_{t\text{-}1}$ C & $acquire_t$ x turns a wheel at t')

The assignment of probabilities to open sentences has been systematically analyzed by Leblanc 1962, and it is also discussed in Lassiter 2011, so in principle we can limit the excessive context-dependency of the present theory; but doing so technically is beyond the scope of this article.

However if we stopped here, this measure would be too radical, as it would obliterate cases of presupposition triggering that rely on a local context (be it due to the discourse context or to the linguistic environment of an expression); we would thereby lose an account of the triggers discussed in Section 4.1. We thus conjecture that the triggering rule applies to the most general context that allows the relevant entailment to go through, as stated in (49). For expressions such as *TURN-WHEEL*, which entail the relevant proposition (here: the presence of a wheel next to the agent) relative to the general knowledge C, the triggering rule is applied relative to C. In these cases, we compute the

[20] Thanks to Harvey Lederman, Una Stojnić, Yasu Sudo and some reviewers (p.c.) for raising related points.

[21] Cases discussed in Section 3 could in principle be handled by taking new words to be classified (as presuppositional or not) using the tendency-based hierarchy.

presupposition of an expression once and for all, thus emulating the effects of lexical accounts. When an entailment only arises relative to a local context, as for contextual triggers c', the triggering rule is assessed relative to c'.

(49) **Conjecture: choice of the context with respect to which the triggering rule is applied**
a. If *E* entails *p* relative to the general knowledge C which is assumed to hold across conversations, then the triggering rule is applied to *E* and *p* relative to C, and determines whether *p* is presupposed or at-issue.
b. Otherwise, if *E* entails *p* relative to the local context c' of *E*, the triggering rule is applied to *E* and *p* relative to c'.

We leave for future research an exploration of the analysis applied to open sentences and of the conjecture stated in (49).

9 Alternatives and restatements

As announced at the outset, the present analysis takes presupposition to be first and foremost a cognitive, not a communicative phenomenon: the theory takes as primitive an assessment of how facts are discovered in cognitive life. We now sketch two alternatives, one in terms of counterfactual reasoning, and the other in communicative terms.

9.1 A restatement in terms of counterfactual reasoning?

Schlenker, to appear, sketches a different triggering rule, based on the idea that entailments get presupposed if they are 'stable' in terms of counterfactual reasoning. Specifically, if we write as *pp'* the conjunction of the at-issue and of the presuppositional components we can apply the test in (50). It asks that one assume, relative to the assumptions of the context, that *pp'* holds true. Then it assesses the counterfactual stability of the entailment *p* by asking whether, on the counterfactual assumption that *pp'* had not been the case, *p* would still have held. The test is crucially applied with a non-monotonic analysis of counterfactuals.

(50) Stability of entailments (counterfactual test)
Assume that *pp'* holds (relative to the Context Set C), and that C |= pp' => p (i.e. *p* is a contextual entailment of *pp'*). If (counterfactually) *pp'* had not been the case, would *p* still have been the case?
If $\rightarrow$ represents the counterfactual conditional, this can be represented as:
C, pp' |= (not pp') $\rightarrow$ p[22]
Yes: treat *p* as a presupposition.
No: do not treat *p* as a presupposition.

Consider for instance the pre-existence of an object, as in *x TURN-WHEEL at* t_1 (discussed in Section 3.2). The intuition is that, on the assumption that x turned a wheel, if this had not been the case, the wheel would still have been in front of x. Here it is of course crucial that the counterfactual should not mean that if *pp'* had not been the case, it would *necessarily* have been the case that *p*, as this requirement would be far too strong. But the non-monotonic semantics for counterfactuals explored by Stalnaker (1967) and others is far weaker: it only asks that we consider the *closest* world(s) in which *pp'* fails to be the case, and determine whether in those worlds *p* still holds. The desirable answer – that the wheel would still have been in front of the agent – is intuitively plausible in this case.

We show in Appendix IV that, in very special cases, this analysis makes the same predictions as a version of our official proposal. Specifically, if our probabilistic parameter is set to 1, and if belief revision for the counterfactual *if F, G* is effected by going back to the most recent belief state that didn't entail *F*, we get a very close match between the two theories. In other words, there is a common core to the triggering rule based on counterfactual reasoning and the triggering rule developed in this piece, although in the general case they are rather different.

9.2 A communicative reinterpretation?

We based our discussions on discovery processes in cognitive life, but we could reinterpret the analysis

[22] This should be read as follows: in each world w that is in C and satisfies the (classical, non-presuppositional) meaning of *pp'*, w makes true the counterfactual conditional *(not pp')* $\rightarrow$ *p*.

in purely communicative terms. In a nutshell, we could replace the triggering rule in (51)a with that (51)b, where the notion *one believes that F* is replaced with *one assumes that F*, pertaining to the assumptions of a conversation, and *one acquires the belief that F* is replaced with *one asserts that F*.

(51) a. $P(\text{believe}_{t-1}\ \mathbf{p} \mid \text{believe}_{t-1}\ C\ \&\ \text{acquire}_{t}\ \mathbf{pp}') \geq a$
b. $P(\text{assume}_{t-1}\ \mathbf{p} \mid \text{assume}_{t-1}\ C\ \&\ \text{assert}_{t}\ \mathbf{pp}') \geq a$

This analytical direction faces two challenges. First, there is a serious risk of circularity if we reduce triggering to the expected behavior of expressions which themselves trigger presuppositions: it could be that the triggering rule in (51)b is correct for the uninteresting reason that *pp'* is typically conveyed with an expression that presupposes *p* (one could imagine that this bivalent content can be expressed as *(p and pp')*, which doesn't trigger a presupposition, but this could be rare for a variety of reasons). Second, for the crucial cases in which we need a triggering rule for expressions that could not have a lexical presupposition (such as those discussed in Sections 3.2, 3.3, 3.4 and 4), this analysis can hardly rely on actual communicative experience to compute the relevant probabilities (since these are nonce words), and it needs to assess what *would* be taken for granted in counterfactual communicative interactions. This wouldn't require a theory of how facts are discovered (as in our 'official' theory), but rather of how conversations develop. We do not know whether this line of analysis can be made plausible.

10 Conclusion

We have reached two main conclusions. First, a lexical approach to presupposition generation isn't just insufficiently explanatory. It also fails to account for presuppositions triggered by a variety of non-lexical triggers: iconic expressions (pro-speech gestures and classifier predicates), contextual triggers, and complex triggers. Second, a simple triggering rule can be motivated on the basis accepted presupposition projection mechanisms. Within different versions of dynamic semantics, a presupposition must be trivial relative to a local context. We proposed that this rule derives from an attempt to guarantee that entailments that are typically inert in cognitive life are also semantically inert relative to their local context. This led us to posit a rule whereby if upon learning that *pp'*, one typically antecedently knew that *p*, p should be treated as presupposed.

We only sketched how such a solution could go, and there are multiple open issues on the empirical and on the theoretical side. Three bear mentioning at this early point. First and most obviously, the conditional probabilities that enter in the triggering rule ought to be assessed on independent grounds (by way of psychological experiments); the value of the threshold should be determined as well. Second, our positive proposal has only been stated for the propositional case, but it should be extended to presupposition triggers of predicate type. Third, the excessive context-dependency of the present triggering rule (as discussed in Section 8.2) should be corrected.

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Appendix I
Three Theories

In this appendix, we summarize three important earlier proposals (briefly mentioned in Section 5) and discuss challenges that they (and we) encounter.[23]

♦ Abusch 2002, 2010

One can take Abusch's (2002, 2010) starting point to be the observation that focus can yield presupposition-like phenomena.[24] For instance, (52) may evoke the set of alternatives {You will vote for Biden in November, you will vote for Trump in November}. With the assumption that at least one of these alternatives is true, we obtain the inference that you will in fact vote in November.

(52) Will you vote for $[\text{Biden}]_F$ in November?
=> you will vote in November

By assuming that the items in (53) lexically activate appropriately-defined scales, Abusch can derive their presuppositional behavior.

(53) a. stop: {stop, continue}
b. win: {win, lose}
c. be right: {be right, be wrong}
d. be aware: {be aware, be unaware}

Here all expressions are taken to have a bivalent meaning, but it is presupposed that one of the alternatives is true, hence the desired presuppositional effect. This is particularly easy to see with the semantic decomposition offered in (54)a,b for *x stops smoking* and *x continues smoking*: it is immediate that their disjunction that is equivalent to *x smoked*, i.e. their joint presupposition.

(54) a. x stops smoking = x smoked and x doesn't smoke
b. x continues smoking = x smoked and x smokes
c. (x stops smoking or x continues smoking) $\Leftrightarrow$ x smoked

The immediate difficulty is that with different alternatives, different results are obtained. In (55), *continue* is given the set of alternatives {continue, start}, and as a result *x continues smoking* presupposes their disjunction, namely that *x smokes*. While this reading may be accessed in special contexts, one needs to explain why in general it is presupposed that *x smoked*, while it is *asserted* that *x still smokes*.[25]

(55) Deviant alternative set: continue: {continue, start}
a. x starts smoking = x didn't smoke and x smokes
b. x continues smoking = x smoked and x smokes
c. (x starts smoking or x continues smoking) $\Leftrightarrow$ x smokes

In Abusch's defense, there seems to be genuine arbitrariness in some cases. She mentions the exquisite contrast between *x is aware that p* and *x is right that p:* both have a believing/saying component, and a veridical component, but *x is aware that p* presupposes that *p* is true and asserts that *x believes p*, whereas *x is right that p* presupposes that *x said/believes that p* and asserts that *p* is true. The contrast naturally follows from Abusch's alternatives in (53)c,d: *aware* and *unaware* both have a veridical component, hence their disjunction does too; *be right* and *be wrong* both have a 'believing/saying' component, hence it too is preserved by their disjunction. But the lexical nature of the account seems to be essential to derive this fine-grained contrast, since there is no obvious difference between the global meaning of *be aware* and *be right*.

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[23] See Schlenker, to appear for a detailed discussion of how these theories can or cannot account for presuppositional data pertaining to iconic pro-speech gestures and ASL classifier predicates.

[24] See for instance Büring 2012 for a far more detailed discussion of the inferential effects of focus and givenness, which we do not discuss in the present paper.

[25] Special contexts involve contrastive focus, as in *Did Robin start smoking or did Robin continue to smoke?* The fact that alternative can change presuppositions when manipulated is of course consonant with Abusch's theory, but it also highlights the need for certain lexical stipulations – as Abusch herself makes transparently clear.

As a result, this contrast is a direct challenge to our theory (and to any theory that triggers presuppositions on the basis of bivalent meanings). Still, there might be a useful difference between the implications of these two verbs: *x was right that p* usually conveys that *p* was controversial at the relevant time, whereas *x was aware that p* doesn't. Thus (56)b suggests, a bit oddly, that it was controversial that Obama should abide by the Constitution (by contrast, *Obama is right that Trump has to abide by the Constitution* might be more natural if one thinks that the embedded clause is now a matter of controversy); this controversiality inference is absent from (56)a,c,d.[26]

(56) a. Obama was aware that he had to abide by the Constitution.
b. ?Obama was right that he had to abide by the Constitution.
c. Obama correctly believed that he had to abide by the Constitution.
d. Obama went by his correct belief that he had to abide by the Constitution.

No matter what the precise source of this controversiality inference (and we grant that this point requires further investigation), it may affect the triggering rule. In (57), we have made explicit the controversiality component of *x is right that p* and its absence in *x is aware that p*. *F* stands for *p* (to evaluate the factive presupposition) or *x believes that p* (to evaluate the presupposition that the agent believes the complement).

(57) a. Be aware: $P(believe_{t-1}\ (F) \mid believe_{t-1}\ C\ \&\ acquire_t\ (p \text{ and } x \text{ believes that } p))$
b. Be right: $P(believe_{t-1}\ (F) \mid believe_{t-1}\ C\ \&\ acquire_t\ (p$ **and p is controversial** and x believes that p)

The boldfaced conjunct in (57)b will make it less likely that, upon learning that *x is right that p*, one antecedently knows that *p* is true, with the effect that for *F = p* we should get a lower probability than in the case of (57)a. The latter is similar to the case of *x knows that p*: chances are that upon learning that both *p* and the belief that *p* hold, one had an antecedent knowledge of the state of the world. For *F = x believes that p*, there is no reason to assume a high value in (57)a. Can a high value be justified in (57)b? In case *be right* is interpreted as a speech act, such a high value makes sense: upon learning that x is right in a disagreement about p, one will often have a pre-existing belief about the disagreement and thus about x's beliefs. It's less clear that this extends to silent disagreements. But the contrast between *be aware* and *be right* as analyzed here seems to go in the right direction, although a full analysis has yet to be developed.

♦ **Simons et al. 2010**

Simon et al. 2010 start from the (very convincing) observation that 'Questions under Discussion' (QUDs) may affect whether a presupposition arises or not. For instance, in (58) the QUD is whether France has a king, and as a result the definite description fails to presuppose that there is king, as it would be bad conversational practice to presuppose what's under discussion.

(58) –Does France have a king?
–Well, the king of France didn't attend the opening of Parliament.

This fact alone can be derived by every theory that allows for local accommodation. Simons et

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[26] Two remarks should be added.
1. (56)b might improve if replaced with: *Obama said that he had to abide by the Constitution, and he was right*. But the underlined conjunct yields an inference that the point was non-obvious at the time, which might satisfy the controversiality inference of *be right*.
2. A natural question is whether the deviance of (56)b is just due to the at-issue nature of the veridical implication, whence it should be non-trivial *at the time of speech* that Obama had to abide by the Constitution (when he was President). Our impression is that (56)b implies that it was controversial *at the time* that Obama had to abide by the Constitution. This implication seems to us to be absent from (i), where the non-triviality requirement holds at most of the time of speech.

(i) Obama had to abide by the Constitution and he was aware of it.

The control in (56)d is intended to show that the presupposition of *x is right that p*, to the effect that *x believes or says that p*, is not responsible for the deviance of (56)b (note also that the presupposition may just be about a belief, as in: *Obama believed that he had to abide by the Constitution, and he was of course right (that he had to))*.

al. go much further in suggesting that entailments may 'project' beyond operators, and may thus behave like presuppositions, in case they are not relevant to the QUD, thanks to the definitions in (59):

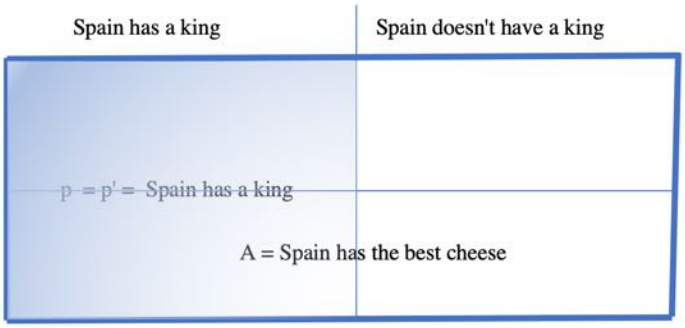
(59) Definition of relevance and at-issueness in Simons et al. 2010
a. An assertion is relevant to a QUD iff it contextually entails a partial or complete answer to the QUD.
b. A question is relevant to a QUD iff it has an answer that contextually entails a partial/ complete answer to the QUD.
c. A proposition p is at-issue relative to a question Q iff the question ?p is relevant to Q.

To illustrate, in (60) we initially treat *know* as bivalent and veridical (it entails the truth of its complement) and note that the entailment *you can eat raw vegetables* is not relevant to the QUD, and thus it is not at-issue and projects; things are different with the entailment that France has a king in (58).

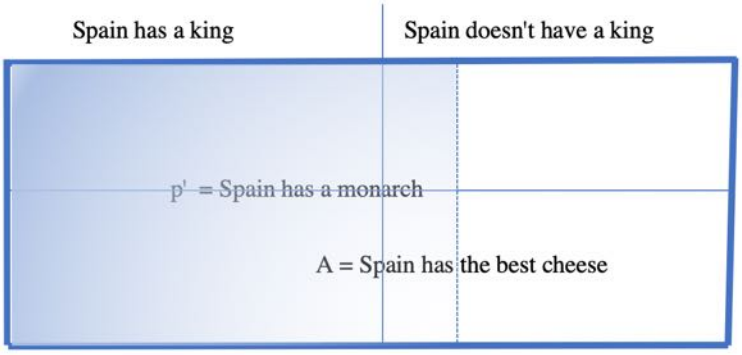
(60) Background scenario: a nutritionist has been visiting first grade classrooms to talk to the children about healthy eating
Q: What most surprised you about the first graders?
A: They didn't know that you can eat raw vegetables.

The difficulty, noted in Chemla 2006, is that this account is insufficiently predictive and/or makes impossible predictions. Suppose *p* provides an answer to Q, and take *p'* to be an entailment of *p* (*p'* could be identical to *p*, as in the case illustrated in (61)). Find a proposition *A* that partly overlaps with every cell of Q (so that *not A* also overlaps with every cell of Q). For instance, take a 2-cell QUD similar to (58), *Does Spain have a king?*, with a simple answer, *p = Spain has a king* (which does not trigger a presupposition). Take *A* to be: *Spain has the best cheese in the world*. This certainly overlaps with each of the two cells. Take an entailment *p'* of *p*, either *p* itself, or something weaker, for instance *Spain has a monarch*. Now *p'* has *(p' or A)* as an entailment, and it is not relevant to Q, so *(p' or A)* can project. Similarly, *(p' or not A)* can project. If both do, then we get a presupposition that *p'*: it now becomes presupposed that Spain has a monarch. The reasoning that leads to the prediction that *p* should project is illustrated in (61). (62) is similar but pertains to a mere entailment *p'* of *p*. Since the reasoning is general, every entailment *p'* of *p* is predicted to project – which couldn't be correct, and calls, at a minimum, for some constraints.

(61) QUD corresponding to *Does Spain have a king?* The answer is p = *Spain has a king*.
With A = *Spain has the best cheese*, *(p or A)* as well as *(p or not A)* are entailments that fail to address the QUD and should thus project, hence *p* should project as well.



(62) QUD corresponding to *Does Spain have a king?* The answer is now p = *Spain has a king*. We consider an entailment *p'* = *Spain has a monarch*. With A = *Spain has the best cheese*, *(p' or A)* as well as *(p' or not A)* are entailments that fail to address the QUD and should thus project, hence *p'* should project as well.



On the assumption that this account can be constrained, it still encounters another problem, discussed by Abrusán 2011 (and noted by the authors themselves). Abrusán notes that the account incorrectly predicts that presuppositions should fail to be generated in (63) and (64), since the fact that the first graders failed the exam, or that John used to smoke, are relevant to the QUD; but intuitively the presuppositions are generated in this case.

(63) Q: What most surprised you about the first graders?
A: They didn't know that they have failed the exam.

(64) Q: What do you know about John?
B: He still didn't quit smoking.

♦ **Abrusán 2011**

❑ *Insights*

After criticizing Abusch's and Simons et al.'s accounts, Abrusán 2011 proposes a triggering algorithm for the verbal case. For her, entailments that are not 'about' the event time of the verb get presupposed (this is motivated by considerations on attention, as only entailments that are about the event time are taken to be the main point of such constructions). We won't be concerned with how 'aboutness' is defined.[27] In the case of change of state verbs, which will be of some importance below, Abrusán's theory works as in (65).

(65) a. John stopped smoking at t_1.
b. Entailment 1: John does not smoke at t_1
c. Entailment 2: John smoked at t_2 (where t_2 is some contextually given interval before t_1)

The simplified representation in (65)a, with event time t_1, comes with several entailments, two of which are stated in (65)b,c. Entailment 1 is about event time t_1 and thus it does not get presupposed. By contrast, Entailment 2 is not about event time t_1 and thus it gets presupposed.

Our analysis agrees with Abrusán's in some but not in all cases. Take for instance change of state verbs. For Abrusán, *John stopped smoking at* t_1 triggers a presupposition that John smoked before t_1 because this entailment is not about the matrix event time. For us, the intuition is a bit different: upon learning that John doesn't smoke at t_1 but did before, one would typically antecedently know the part about the past, namely that John smoked before t_1. We discuss two types of counterexamples to Abrusán's theory. The main problem is that her analysis overgenerates because it treats as presupposed some entailments which are not. From our perspective, this happens when an entailment *p* of an expression *pp'* is not about the matrix event time (hence Abrusán predicts a presupposition), and yet

[27] In a nutshell, a sentence S is *not* about an individual [named by] c just in case for every interpretation M, S is true in M iff for every interpretation M' which is just like M for atomic sentences, except possibly ones that contain c, S is true in M'. Abrusán 2011 discusses various necessary refinements to obtain a theory of presupposition generation. In particular, she needs to treat the matrix and the embedded time arguments in *John knows (at* t_1*) that it is raining (at* t_1*)* as counting as different so as to differentiate between entailments that should vs. shouldn't become presupposed).

when one learns that *pp'*, one doesn't typically antecedently know that *p* (so the present analysis predicts no presupposition). In other cases, Abrusán's theory undergenerates, because an entailment *p* of an expression *pp'* is about the matrix event time (hence it is at-issue for Abrusán), and yet when one learns that *pp'*, one typically antecedently knows that *p*.

❑ *An overgeneration dilemma*

As mentioned by N. Klinedinst (p.c.), a class of verbs discussed in Anand and Hacquard 2014 presents systematic exceptions to Abrusán's analysis, as illustrated in (66) (*establish* could be added to the class, as noted by N. Klinedinst):

(66) a. The bloody gloves {demonstrate, imply, prove, show} that Mary committed the murder.
=> Mary committed the murder.
b. Do the bloody gloves {demonstrate, imply, prove, show} that Mary committed the murder?
≠> Mary committed the murder.
(modified from Anand and Hacquard 2014)

It is clear that the entailment about the past murder is not about the matrix event time of the construction and is thus predicted by Abrusán to be presupposed, contrary to fact.

Abrusán's theory can posit that these constructions do not entail their propositional arguments to begin with, as shown by examples such as (67), where the embedded clause is not presented as true (Abrusán, p.c.). Since Abrusán's theory only intends to turn *lexical* entailments into presuppositions, it does not predict presuppositions in this case.

(67) That article {demonstrates, implies, proves, shows} that Obama was born in Africa.
≠> Obama was born in Africa

But in view of the cases of contextual triggering discussed in Section 4, these data present a dilemma for Abrusán's theory: if it sticks to the view that presuppositions are triggered from lexical rather than contextual entailments, it fails to account for the diverse examples we discussed where contextual information is crucial. If it allows itself to take as input contextual entailments, it will overgenerate in the case of (66).[28]

From the present perspective, when one learns that *x demonstrates* (or: *implies, proves, shows, establishes*) *that p, p* is often hard/non-trivial, and one often does *not* antecedently know that *p*; one might learn *p by* learning that x demonstrates it. In other words, it makes sense to assume that the probability in (68) is relatively low, and if so we do not expect *p* to count as an epistemic precondition

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[28] In addition, an algorithm that works on top of lexical entailments alone might encounter difficulties in other cases, since it is possible to use *know* without a factive entailment, with the meaning of *be absolutely certain that*, as in the real life examples in (i); or Abrusán's (ii) (*Very Serious People* is a mocking title used to refer to pundits who are certain of facts that are false); the challenge will thus be to draw a principled distinction between *know* and the examples in (35).

(i) a. Warsh is a Very Serious Person, and all Very Serious People know that deficits are bad. (Tim Duy)
(retrieved on December 24, 2019 at https://economistsview.typepad.com/timduy/2017/10/kevin-warsh-very-serious-person.html)
b. But the belief that America suffers from a severe "skills gap" is one of those things that everyone important knows must be true, because everyone they know says it's true. (Paul Krugman)
(retrieved online on December 24, 2019 at https://www.nytimes.com/2014/03/31/opinion/krugman-jobs-and-skills-and-zombies.html?ref=opinion)

(ii) The keys were not in the drawer but she knew that they were there, so she foolishly kept on searching. (Abrusán 2011).

A proponent of Abrusán's theory might argue that these examples involve a variety of context shift, be it Free Indirect Discourse or 'protagonist projection', investigated in Abrusán, to appear. But in both varieties, shifting is blocked by unshifted readings of *yesterday* (i.e. readings from the speaker's rather than from the agent's perspective). Still, it seems to us that sentences like (iii) are compatible with a non-factive reading of *know*, which casts doubt on this explanation.

(iii) Yesterday evening, Trump just knew that yesterday morning/the day before yesterday Biden had plotted to overthrow him.

of *x demonstrates that p*.

(68) P(believe$_{t-1}$ p | believe$_{t-1}$ C & acquire$_t$ (p and x demonstrates that p))

The same analysis extends to (3)b in the main text (= *PULL-GUN-SHOOT*), which is another case of overgeneration: here the initial state (= the gun's presence under the jacket) is predicted to be presupposed but isn't, because upon learning that someone pulls a gun from his jacket and shoots, one typically doesn't antecedently know that the person has a gun.

Further problems arise when we consider presuppositions that are clearly triggered from contextual entailments. Take *x is pregnant* and *x is a doctor*: in both cases, common sense knowledge yields an entailment that something relevant happened before the matrix event time: *x was impregnated at least 5 days ago, x went to medical school*. If we adopted a context-sensitive version of Abrusán's algorithm, these entailments would be predicted to be presupposed, but in fact neither is.[29] From our perspective, this is because neither is an epistemic precondition of the target proposition: upon learning that *x is pregnant*, one typically does not antecedently know that *x was impregnated at least 5 days ago;* similarly, when one learns that *x is a doctor,* one typically does not antecedently know that *x went to medical school;* rather, it is *by* learning that *x is a doctor* that one acquires the belief that *x went to medical school*.

(69) a. Mary is pregnant. => Mary was impregnated at least 5 days ago
b. Is Mary pregnant? ≠> Mary was impregnated at least 5 days ago

(70) a. Mary is a doctor. => Mary went to medical school
b. Is Mary a doctor? ≠> Mary went to medical school

The case of *be pregnant* is straightforward: it is clear that in general upon learning that someone is pregnant, one does not have antecedent knowledge that this person was impregnated at least 5 days before: the probability in (71) is plausibly low.

(71) P(believe$_{t-1}$ (x was impregnated at least 5 days ago) | believe$_{t-1}$ C & acquire$_t$ (x is pregnant))

Abrusán's theory correctly predicts that in change of state constructions, the initial state gets presupposed, as we illustrated at the outset in (8). But what about the final state? She argues that such inferences are in fact pragmatic rather than lexical.[30] But once the possibility of contextually triggered presuppositions is taken into account, it becomes harder to explain why entailments about the final state are not presupposed.

Take the sentence *Will the police blow up this suspicious package?* Certainly, *x blows up y* contextually entails that, at a later point, y is destroyed. Furthermore, such a presupposition wouldn't make the question idle – it would in effect be asking about the manner of destruction. But this is not how the question is understood: the final state just isn't presupposed.[31] From the present perspective, the asymmetry between initial and final states is relatively expected: upon learning that x blows up y, one typically has greater antecedent knowledge of the past than of the future.

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[29] Abrusán 2011 did not claim to have a general triggering algorithm, and thus we are considering here potential extensions of her proposal.

[30] Abrusán argues that the contrast between (ia) and (ib) suggests that *smoked before* is entailed but *didn't smoke after* isn't. But (ib) leaves open the possibility that there was a small interval between the stop and the new start. (ii) is thus a better test: Abrusán expects (maybe correctly) that (ii)b should be more acceptable than (ii)a.

(i) a. #John stopped smoking, but he has never smoked before.
b. John stopped smoking, but then he started again.

(ii) a. #(At 12:05pm sharp,) the temperature stopped being negative, but was never negative before.
b. (At 12:05pm sharp,) the temperature stopped being negative, but was never non-negative after.

[31] The same point could be made with the verbal gesture *TAKE-OFF-ROTATING*, used in Schlenker, to appear to represent a helicopter take-off. There is certainly a contextual entailment that the helicopter will end up in the air, but it is not presupposed: *At 12:05, will the company's helicopter TAKE-OFF-ROTATING?* definitely doesn't presuppose that shortly after 12:05 the helicopter will be in the air.

❑ *Undergeneration*

There are also cases in which Abrusán's theory arguably undergenerates, and treats as at-issue some entailments that are in fact presupposed. One such case is discussed by Abrusán 2011: it pertains to *regret*. (72)a triggers the inference that John believes that he worked as a linguist (this might come in addition to a factive presupposition to the effect that John in fact worked as a linguist[32]). But this inference pertains to the matrix event time, so without a refinement, Abrusán's theory predicts that it should not be presupposed, contrary to fact.

(72) a. Does John regret that he worked as a linguist?
b. => John believes that he worked as a linguist

Abrusán 2011 proposes two potential solutions. One is that *regret* is a normal factive verb (presupposing the truth of its complement), but that it allows for Free Indirect Discourse uses in which "it reports an attitude of a subject towards facts as perceived by him". However the mere *possibility* of a Free Indirect Discourse reading does not explain the 'belief' entailment that is in fact obtained.[33] More relevantly, Abrusán considers the possibility that there is indeed a belief entailment, but that it is not about the matrix event time. Rather, it is about a time right before the matrix event time, so that this entailment can be presupposed; pragmatic reasoning then leads to the inference that the entailment still held at the matrix event time. This raises the same problem as before about the contextual entailments: why does the output of pragmatic reasoning not feed the triggering mechanism in this case although it does in other cases?

In addition, an analysis based on pragmatic enrichment does not seem right: in a situation in which a person's beliefs keep changing because of memory problems, *x regrets that p* still comes with the presupposition that *x believes that p*, not with the (contextually plausible) presupposition that *x believed that p:*

(73) John has Alzheimer's and spends his time forgetting about his past career in linguistics.
Does John regret that he worked as a semanticist?
=> John believes that he worked as a semanticist

In (73), the lexical part of Abrusán's analysis of *regret* predicts that right before the time of utterance John believed that he had been a semanticist. There is no pragmatic reason to strengthen this inference to encompass the time of utterance, since John keeps forgetting. But the inference still goes through, which suggests that it is lexically triggered by *regret*.

From the present perspective, can we explain why *x regrets that p* doesn't just entail but in fact presupposes that *x believes that p*? The question is as follows: on the assumption that one has learned that *x believes that p and x regrets that p,* is it usually the case that one antecedently knows that *x believes that p*? This seems plausible on the assumption that one usually knows more about a person's beliefs than about their desires. This makes sense in view of the fact that a person's beliefs can be inferred from the information they have access to, in particular the state of the world, whereas their desires are more complex to infer. This would need to be explored in greater detail, but in any event there is nothing in the present theory to block presupposition generation in this case, unlike in Abrusán's

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[32] We write that the factive presupposition *might* come in addition to the belief presupposition because an alternative possibility is that it derives from it. In a nutshell, many modalized presuppositions become factive when their modal character is not explicitly justified (this is known as the 'Proviso Problem', discussed for instance in Lassiter 2012). This arises for instance with *want*: out of the blue, *Ann doesn't want me to stop smoking* triggers the inference that I smoked before; but when the target sentence is preceded by *Ann wrongly believes that I am a smoker, and __* , the factive inference disappears.

[33] Abrusán, to appear adds a further possibility, namely what she calls 'protagonist projection', which has slightly different properties from Free Indirect Discourse. This doesn't seem to change the dialectical situation: the mere *possibility* of protagonist projection doesn't explain why the inference in (72)b is nearly obligatory. In addition, our impression is that the existence of the 'belief' inference isn't affected by the addition of expressions that block protagonist projection/Free Indirect Discourse, such as an unshifted uses of *yesterday* or of an expressive, as in (i).

(i) Up to this point, Sam hasn't regretted praising his idiotic assistant during yesterday morning's meeting.

theory.

We believe that there are further cases of undergeneration in Abrusán's theory. *At t, x deters y from q-ing* presupposes that at t there is a risk that y harms x through q (the details don't matter as long as there is a non-trivial inference *about t*). For instance, *In 2016, did the Obama administration deter Russia from influencing the election?* presupposes that in 2016 Russia tried, or at least had a possible desire, to influence the election; it isn't clear how the strategies deployed by Abrusán for *regret* will work in this case.[34]

Within our theory, the analysis of *deter* requires that we assess the probability in (74). Now it is plausible that one usually knows about threats before learning about actions take to deter them, which might explain why this probability is high and the entailment gets presupposed.

(74) $P(believe_{t-1}$ (there is a risk that y harms x through q) | $believe_{t-1}$ C & $acquire_t$ (x deters y from q-ing)

In sum, there are systematic cases in which Abrusán's system overgenerates, and these can in principle be avoided by the present theory; there also seem to be cases of undergeneration, which seem easier to avoid within the present framework.[35]

[34] See Schlenker, to appear for further potential problems pertaining to ASL classifier predicates.

[35] Two remarks should be added about earlier accounts.

1. Anand and Hacquard 2014 seek to explain why verbs of the *inform* class often presuppose the truth of their complement. They note that these verbs refer to "discourse moves which lead to the acceptance of the complement *p* into the common ground of the reported discourse", and they propose that "this acceptance of *p* can easily bleed into the actual common ground (...): an illusion of factivity arises whenever a reported context is taken to faithfully represent the conversational community in the world of evaluation." This line of analysis raises two questions. First, why do verbs of this class yield a presupposition that that the complement is true relative to the original conversation? Second, why does that presupposition get 'imported' into the reporting conversation? No general account is offered yet. In addition, this line of explanation won't extend to presuppositions that are triggered outside of speech reports, unlike the one we develop in this piece.

2. There might be a connection between the analysis developed in this piece and the theory of presupposition as abduction sketched in Thomason et al. 2006 (see also Hobbs et al. 1993). As an anonymous reviewer notes, their idea is to find "the most probable explanation for what was said". "Typically if the utterance contains an expression that does not make sense unless p is true, there is a good case for adding p to the speaker's beliefs". Thomason et al. 2006 frame their proposal within a dynamic theory and thus (we believe) they too can relativize triggering to a local context. Furthermore, theirs is clearly a communicative theory. The challenge, of course, is to find a non-circular way to define what it means for an expression to "not make sense" as opposed to "be false". Concretely, in (3)a (*PICK-UP-GUN-SHOOT*) and (3)b (*PULL-GUN-SHOOT*) alike, the presence of a gun can be inferred, but only in the former case does it seem to be clearly presupposed. In (2), the gesture *UNSCREW-ceiling* provides iconic information about an action of unscrewing a bulb from the ceiling, but only one component (the presence of the bulb on the ceiling) is presupposed. Thomason et al. explicitly state that "utterances, like other actions, may depend for their effects on preconditions about the situation in which they are performed"; as we understand things, the challenge is to define in a general fashion what these preconditions are.

Appendix II
Formal Illustration

In this appendix, we illustrate the presupposition triggering rule developed in Section 6.2 (copied in (75)) by providing a possible worlds interpretation in which an individual x believes a proposition p just in case each of the worlds compatible with what x believes satisfies p; in other words: x's epistemic base entails p (a standard assumption in possible world semantics).[36]

(75) **Presupposition triggering relative to a context (propositional case)**
For a (contextually) given probability threshold *a*, for a propositional expression *E* in context c', for random time variables t and t', trigger a presupposition *p* if:
(i) c' |= E => p, and
(ii) P(believe$_{t\text{-}1}$ **p** | believe$_{t\text{-}1}$ c' & acquire$_t$ **E**) ≥ a

where P (• | _) is the subjective conditional probability of • given _ and **E** and **p** are the semantic values of *E* and *p* respectively (when no confusion arises, we will forego boldfacing).[37]

In words: trigger a presupposition *p* from an expression *E* in context c' if:
(i) *E* contextually entails *p* relative to c', and
(ii) if one antecedently believed c' and acquires the believe that *E*, there is a high enough chance (above threshold *a*) that one antecedently believed p.

We must thus reason probabilistically about certain complex events, cases in which one antecedently believed at t-1 a proposition c' (corresponding to the local context of the target expression), and one acquired at t a belief that **E**, the proposition corresponding to the target construction. Take the sentence *Will Sally TURN-WHEEL?*, which presupposes that Sally is in front of a wheel (in a car situation, she is in the driver's seat). For simplicity, we focus on just one epistemic agent x, and on the times t and t-1. We need to consider all possible events in which (i) x initially believed c' and then (ii) x acquired the belief that Sally turned a wheel in front of her. Within our possible worlds interpretation of belief, (i) means that the agent's epistemic base at t-1 was included in the set of worlds corresponding to c', represented in all our illustrations below by the outermost rectangle. (ii) means that the agent's epistemic base at t-1 is not included in **E**, but that it becomes included in **E** at t. **E** will be represented as a colored rectangle in the upper left corner of c'. We assume that information grows monotonically, and thus beliefs at t are more specific than beliefs at t-1. Thus we consider all cases in which the agent's epistemic base was initially within c' but was not included in **E** at t-1, and then became included in **E** at t. For simplicity, we will assume throughout that at t the agent's epistemic base is identical to (rather than just included in) **E**, and hence everything will hinge on the agent's initial epistemic base at t-1.

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[36] A reviewer asks whether our analysis leads to the prediction that truths of arithmetic are presupposed. If one adopts a possible worlds framework in the analysis of *believe$_{t\text{-}1}$ **p***, as is done for concreteness, the answer is 'yes', at least if truths of arithmetic are true in every possible world. But this problem is entirely due to the lack of fine-grainedness of possible world semantics, and the problem already arises in all standard treatments of presuppositions. For instance, in the analysis of Heim 1983, the context set is a set of possible worlds, and whatever follows from the context set is presupposed. As a result, all truths of arithmetic are presupposed.

[37] As hinted by a reviewer, we could also state that a presupposition is triggered if the probability that one antecedently believed p is 'much greater' than the probability that this wasn't the case, as stated in (i), where *b* is the parameter giving the difference between the two probabilities (the crucial parts are boxed)

(i*) Alternative version of (75)(ii): P(believe$_{t\text{-}1}$ **p** | believe$_{t\text{-}1}$ c' & acquire$_t$ **E**) ≥ P(not believe$_{t\text{-}1}$ **p** | believe$_{t\text{-}1}$ c' & acquire$_t$ **E**) + b

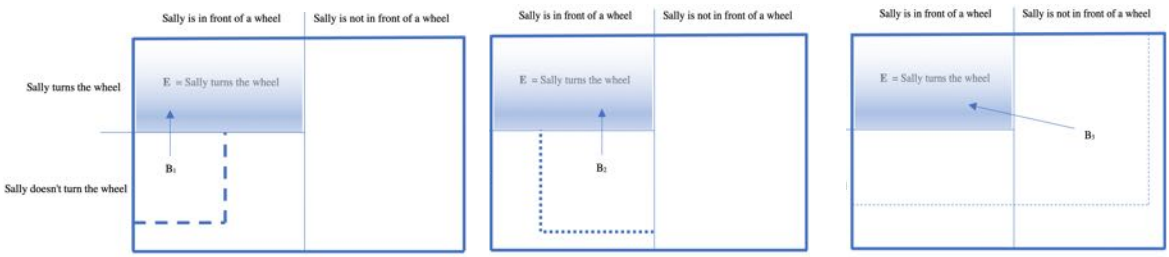
Since P(believe$_{t\text{-}1}$ **p** | believe$_{t\text{-}1}$ c' & acquire$_t$ **E**) + P(not believe$_{t\text{-}1}$ **p** | believe$_{t\text{-}1}$ c' & acquire$_t$ **E**) = 1, this alternative version can be rewritten as (ii*) below:

(ii*) P(believe$_{t\text{-}1}$ **p** | believe$_{t\text{-}1}$ c' & acquire$_t$ **E**) ≥ (1 - P(believe$_{t\text{-}1}$ **p** | believe$_{t\text{-}1}$ c' & acquire$_t$ **E**)) + b
i.e. P(believe$_{t\text{-}1}$ **p** | believe$_{t\text{-}1}$ c' & acquire$_t$ **E**) ≥ (1+b)/2

In other words, setting a = (1+b)/2, (i*) above is equivalent to (75)(ii).

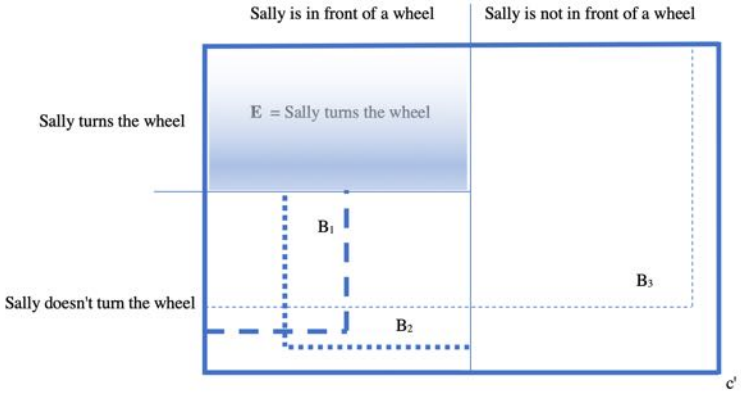
To take a concrete case, three (disjoint) events of belief change are depicted in (76). **E** corresponds to the set of possible worlds of c' in which Sally turns a wheel in front of her. The left-most part of c' corresponds to worlds in which Sally is in front of a wheel (**E** is a strict subset of that area), while the right-most part of c' corresponds to worlds in which Sally isn't in front of a wheel. The initial belief states are $\mathbf{E}\cup B_1$ (in event e_1), $\mathbf{E}\cup B_2$ (in event e_2), and $\mathbf{E}\cup B_3$ (in event e_3).

(76) 3 events in which one (i) initially believes c', and (ii) acquires the belief that Sally turned a wheel in front of her: in e_1, the agent's epistemic base contracts from $\mathbf{E}\cup B_1$ to **E**; in e_2, from $\mathbf{E}\cup B_2$ to **E**; in e_3, from $\mathbf{E}\cup B_3$ to **E**



The three initial belief states $\mathbf{E}\cup B_1$, $\mathbf{E}\cup B_2$ and $\mathbf{E}\cup B_3$ are represented in one and the same figure in (77).

(77) 3 events in which one (i) initially believes c', and (ii) acquires the belief that Sally turned a wheel in front of her



Our three events of belief change thus differ only with respect to the initial epistemic state (the posterior epistemic state always ends up being **E**): for $i\in\{1, 2, 3\}$, in event e_i, the agent initially had belief $\mathbf{E}\cup B_i$ (at t-1), and then acquired belief **E** (at t).

The key in (77) is that two of the initial belief states, namely $\mathbf{E}\cup B_1$ and $\mathbf{E}\cup B_2$, are included in the set of worlds in which Sally is in front of a wheel (on the left-hand side of the rectangle): these are cases in which the agent initially knew that Sally was in front of a wheel. But there is also one initial belief state, namely $\mathbf{E}\cup B_3$, where this is not the case: the corresponding area is not entirely within the left-hand side of the rectangle.

To apply our analysis, we must establish a probability threshold for *a* in (75), and assign probability weights to the three events e_1, e_2 and e_3. We will initially take the threshold *a* to be at 80%, and we will discuss two assignments of probabilities, one (= Scenario 1) in which the desirable result is obtained (*Will Sally TURN-WHEEL?* presupposes that Sally was initially in front of a wheel), and one (= Scenario 2) in which it is not.

All that matters when computing the conditional probability in (75)(ii) is the relative probability weight of e_1, e_2, e_3 relative to the disjunction of these events. For instance, $P(e_1 \mid e_1 \text{ or } e_2 \text{ or } e_3)$ is just $P(e_1) / (P(e_1 \text{ or } e_2 \text{ or } e_3)$, and since e_1, e_2, e_3 are mutually exclusive, this is just $P(e_1) / (P(e_1) + P(e_2) + P(e_3))$. We simplify the discussion by taking $P(e_1) + P(e_2) + P(e_3) = 1$, i.e. by taking e_1, e_2 and e_3 to be exhaustive (nothing hinges on this as long as the proportions $P(e_i)/((P(e_1) + P(e_2) + P(e_3))$ for $i = 1, 2, 3$ are as we specify). In Scenario 1, the probabilities of our three events of belief change are specified as in (78).

(78) Scenario 1: it is presupposed that Sally was in front a wheel (probability threshold: $a = 80\%$)
e_1 (= the agent initially had belief $\mathbf{E}\cup B_1$ and acquired belief $\mathbf{E}$) has probability 40%
e_2 (= the agent initially had belief $\mathbf{E}\cup B_2$ and acquired belief $\mathbf{E}$) has probability 40%
e_3 (= the agent initially had belief $\mathbf{E}\cup B_2$ and acquired belief $\mathbf{E}$) has probability 20%

In this scenario, upon acquiring the belief that **E**, there is a 40% chance that one antecedently believed $\mathbf{E}\cup B_1$, but this doesn't rise above the 80% threshold that would trigger a presupposition, and similarly for $\mathbf{E}\cup B_2$. However, there is an 80% chance that one antecedently believed $\mathbf{E}\cup B_1\cup B_2$, since both antecedent belief states $\mathbf{E}\cup B_1$ and $\mathbf{E}\cup B_2$ are included within $\mathbf{E}\cup B_1\cup B_2$. As a result, $\mathbf{E}\cup B_1\cup B_2$ ought to be presupposed, and since $\mathbf{E}\cup B_1\cup B_2$ is included in the set of possible worlds in which Sally is in front of a wheel, this should be presupposed.

There are of course weaker propositions that are marked to be presupposed as well: c' itself, and also $\mathbf{E}\cup B_1\cup B_2\cup B_3$, since (upon acquiring the belief that **E**) there is a 100% chance that one antecedently believed that proposition. But since $\mathbf{E}\cup B_1\cup B_2$ is strictly stronger than $\mathbf{E}\cup B_1\cup B_2\cup B_3$ (or c', for that matter) only the stronger presupposition makes itself felt.

It can be noticed that $\mathbf{E}\cup B_1\cup B_2$ is a bit stronger than just *Sally is in front of a wheel*. This need not be a problem since typically further information is presupposed as well in this case, e.g. pertaining to the size and position of the wheel.

In Scenario 2, defined as in (79), it should not be presupposed that Sally is in front of a wheel.

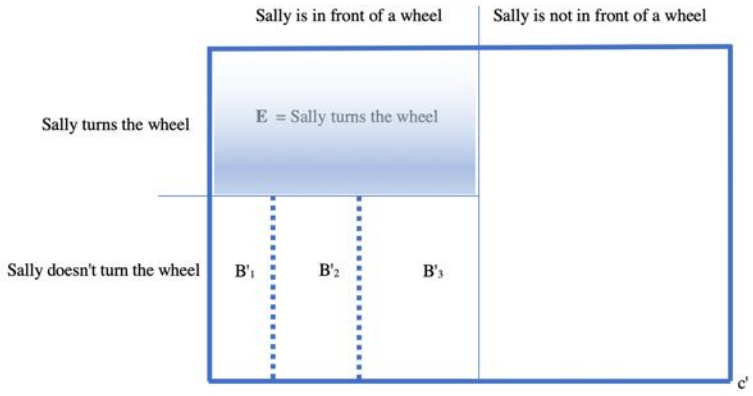
(79) Scenario 2: it is not presupposed that Sally was in front a wheel (probability threshold: $a = 80\%$)
e_1 (= the agent initially had belief $\mathbf{E}\cup B_1$ and acquired belief $\mathbf{E}$) has probability 30%
e_2 (= the agent initially had belief $\mathbf{E}\cup B_2$ and acquired belief $\mathbf{E}$) has probability 30%
e_3 (= the agent initially had belief $\mathbf{E}\cup B_3$ and acquired belief $\mathbf{E}$) has probability 40%

Crucially, the chance that (upon acquiring the belief that **E**) one antecedently believed $\mathbf{E}\cup B_1\cup B_2$ is only of 30%+30% = 60%, which does not rise above the 80% threshold. Similarly, the probability that one antecedently believed $\mathbf{E}\cup B_1\cup B_3$ is only of 70%, and similarly for $\mathbf{E}\cup B_2\cup B_3$. There is a 100% chance that one antecedently believed $\mathbf{E}\cup B_1\cup B_2\cup B_3$, but this area contains worlds in which Sally isn't next to a wheel, so it is not presupposed that Sally is in front of a wheel.

The claim that *Sally* TURN-WHEEL presupposes that Sally is next to a wheel should thus be translated into a claim that, in view of general knowledge, standard discourse situations are like Scenario 1 and not like Scenario 2.

Many more cases would need to be discussed in future research. Some cause problems for the present theory, such as Scenario 3, illustrated in (80)-(81):

(80) A problematic case with three antecedent belief states



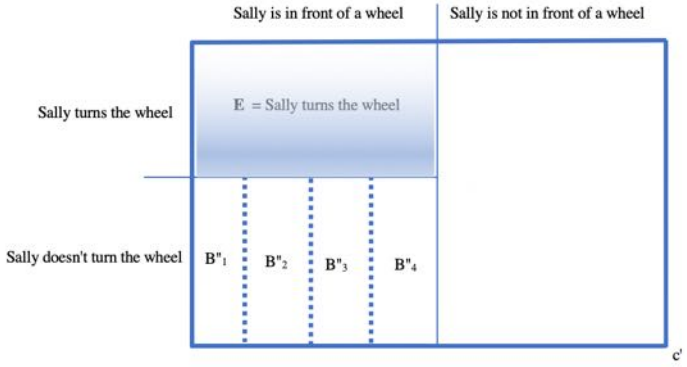
(81) Scenario 3, with B'_1, B'_2 and B'_3 as in (80), and probability threshold $a = 60\%$
e'_1 (= the agent initially had belief $\mathbf{E}\cup B'_1$ and then acquired belief $\mathbf{E}$) has probability 30%
e'_2 (= the agent initially had belief $\mathbf{E}\cup B'_2$ and then acquired belief $\mathbf{E}$) has probability 30%
e'_3 (= the agent initially had belief $\mathbf{E}\cup B'_3$ and then acquired belief $\mathbf{E}$) has probability 40%

Since we are assuming a threshold of $a = 60\%$, we have that $\mathbf{E}\cup B'_1\cup B'_2$, $\mathbf{E}\cup B'_1\cup B'_3$, and

$\mathbf{E}\cup B'_2\cup B'_3$ are all selected to be presupposed. The reason is this: there is a 60% chance that one antecedently believed $\mathbf{E}\cup B'_1\cup B'_2$, since this is the case both in event e'_1 and e'_2, whose probability weights add up to 60%. Similarly, there is a 70% chance that one antecedently believed $\mathbf{E}\cup B'_1\cup B'_3$, and also a 70% chance that one antecedently believed $\mathbf{E}\cup B'_2\cup B'_3$. As a result, the following propositions are all selected to be presupposed: $\mathbf{E}\cup B'_1\cup B'_2$, $\mathbf{E}\cup B'_1\cup B'_3$, and $\mathbf{E}\cup B'_2\cup B'_3$. Therefore their intersection must be presupposed as well. But their intersection is nothing other than **E**.[38] This cannot be, as this would go against a pragmatic principle that mandates that every expression is non-trivial in its local context. But then we are caught in a dilemma: either no presupposition is predicted at all, despite the fact that it is in this case certain that upon acquiring the belief that **E** one antecedently believed that Sally is in front of a wheel. Or we predict a presupposition which is overly strong, making the target expression itself trivially true.

We can easily generalize the problem for cases in which the threshold is higher, e.g. $a = 75\%$, as in (82)-(83).

(82) Another problematic case with four antecedent belief states



(83) Scenario 4, with $B"_1$, $B"_2$ and $B"_3$ and $B"_4$ as in (82), and probability threshold $a = 75\%$
$e"_1$ (= the agent initially had belief $\mathbf{E}\cup B"_1$ and acquired belief **E**) has probability 25%
$e"_2$ (= the agent initially had belief $\mathbf{E}\cup B"_2$ and acquired belief **E**) has probability 25%
$e"_3$ (= the agent initially had belief $\mathbf{E}\cup B"_2$ and acquired belief **E**) has probability 25%
$e"_4$ (= the agent initially had belief $\mathbf{E}\cup B"_2$ and acquired belief **E**) has probability 25%

In Scenario 4, there is a 75% that (if one believed c' and acquired the belief that **E**), one antecedently believed $\mathbf{E}\cup B"_2\cup B"_3\cup B"_4$, and similarly for $\mathbf{E}\cup B"_1\cup B"_3\cup B"_4$, $\mathbf{E}\cup B"_1\cup B"_2\cup B"_4$, and $\mathbf{E}\cup B"_1\cup B"_2\cup B"_3$, so each of those is selected to be presupposed, hence their intersection should be presupposed as well. But their intersection is none other than **E**.

We do not know of any principled way to block this state of affairs, or to argue that it cannot arise.[39]

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[38] Note that $((\mathbf{E}\cup B'_1\cup B'_2)\cap(\mathbf{E}\cup B'_1\cup B'_3))\cap(\mathbf{E}\cup B'_2\cup B'_3) = \mathbf{E}\cup B'_1\cap(\mathbf{E}\cup B'_2\cup B'_3) = \mathbf{E}$.

[39] E. Chemla] (p.c.) suggests that in situations in which **E** is (absurdly) predicted to be presupposed, the threshold *a* must be raised. We leave this possibility for future research.

One separate issue that could be discussed in the future pertains to the relation between the triggering rule in (75) and presupposition accommodation. The reason is this: when we apply the rule in Scenario 1 (= (78)), we trigger a further constraint on c', namely that it should be strengthened (i.e. set-theoretically reduced) to a context c'^{+} so as to entail the presupposition **p**, i.e. that Sally is in front a wheel. This result could be achieved by global accommodation, i.e. by strengthening the global context C, or possibly by local accommodation, i.e. by replacing c' with c'^{+} without modifying C. In either case, one could stop here, or one could further require that the triggering rule still yield an appropriate result when applied in c'^{+}. But this further requirement would be automatically satisfied: since by construction c'^{+} entails **p**, it will be the case that: $P(\text{believe}_{t-1}\ \mathbf{p} \mid \text{believe}_{t-1}\ c'^{+}\ \&\ \text{acquire}_t\ \mathbf{E}) = 1 \geq a$.

Appendix III
Exploitation

In the main text (in (29)), we posited in essence that **p** must be treated as presupposed relative to its local context c' as soon as $P(believe_{t-1}\ \mathbf{p} \mid believe_{t-1}\ c'\ \&\ acquire_t\ \mathbf{pp'}) \geq a$. But one could start instead from an analysis in which $P(believe_{t-1}\ \mathbf{p} \mid believe_{t-1}\ c'\ \&\ acquire_t\ \mathbf{pp'}) \geq a$ only yields a requirement that, relative to its local context, *p* has a probability ≥ a of being entailed by that context. Still, following the general spirit (but not the letter) of "rational speech act" approaches to communication (e.g. Goodman and Frank 2016), this rule might in some cases be exploited to give rise to a near-certainty that *p* is entailed by its local context. In other words, if *stops smoking* comes with a requirement that there is probability ≥ a that *used to smoke* is locally entailed, strategic reasoning could lead to a near-certainty that *used to smoke* is in fact locally entailed.

We assume that there can be uncertainty about what is taken for granted in the conversation. At the initial state of the reasoning, then, the requirement is that listener L_0 should have probability ≥ a = (1-ε) of treating *used to smoke* as being presupposed, by way of the mechanisms we outlined above. But there is also a probability ε that L_0 treats *used to smoke* as being at-issue. The speaker S_1, for her part, is in the following situation. She could utter *pp'*, with a small risk of *p* being treated as at-issue. But if this is her goal, she could be explicit about it, for instance by saying *Robin used to smoke and stopped,* i.e. *p and pp'*.[40] So there are two cases to consider depending on whether S_1 means for *p* to be treated as presupposed, or as being at-issue. We will write as U_1(pp' | p at-issue) the expected utility for S_1 of an utterance of *pp'* on the assumption that she wants to treat *p* as being at-issue, and more generally U_1(utterance | intended meaning) will be the utility obtained by a certain utterance given a certain intended meaning. We will take utility to be 1 if the meaning is conveyed, 0 if it's not, and the cost of an expression E will be written as c(E). We consider each case in turn.

Case 1: S_1 wants *p* to be treated as at-issue

U_1(pp' | p at-issue)	= (probability of communicative success * 1) - cost
	= ε - c(pp')
U_1(p and pp' | p at-issue)	= (probability of communicative success * 1) - cost
	= 1 - c(p and pp')

S_1 being rational, S_1 will produce *p and pp'* just in case

U_1(p and pp' | p at-issue) > U_1(pp' | p at-issue)

or in other words just in case

1 - c(p and pp') > ε - c(pp'), i.e. 1 - ε > c(p and pp') - c(pp')

If we write δ for the cost difference between the expression *(p and pp')* and the expression *pp'* (i.e. δ = c(p and pp') - c(pp')), this condition will be satisfied whenever ε + δ < 1.

Case 2: S_1 wants *p* to be treated as presupposed

The equations are different when *p* is intended to be presupposed.

U_1(pp' | p presupposed)	= (probability of communicative success * 1) - cost
	= (1- ε) - c(pp')
U_1(p and pp' | p presupposed)	= (probability of communicative success * 1) - cost
	= 0 - c(pp')
	= -c(pp')

[40] See Schlenker 2008 for a theory of presupposition projection that is based on the competition between … *pp'*… and … *(p and pp')*… .

If these are the only alternatives, S_1 can only produce *pp'* if she intends for *p* to be presupposed, since uttering *(p and pp')* would yield a certainty of miscommunication and (because of the cost) a negative utility. So to summarize:

(84) Behavior of S_1
In all cases, if S_1 intends *p* to be presupposed, S_1 utters *pp'*; in other words: P(pp' | p presupposed) = 1 (and thus P(p and pp' | p presupposed) = 0).
Whenever $\varepsilon + \delta < 1$: if S_1 intends *p* to be at-issue, S_1 utters *(p and pp'):* P(p and pp' | p at-issue) = 1 (and thus P(pp' | p at-issue) = 0).

Now the strategic listener, L_1, reasons on the basis of S_1's utility maximization behavior, as summarized in (84). On the assumption that L_1 wants to recover the meaning intended by S_1, it is clear that this leads to the conclusions in (85).[41]

(85) Behavior of L_1
In call cases, if S_1 utters *(p and pp')*, always treat *p* as at-issue.
Whenever $\varepsilon + \delta < 1$: if S_1 utters *pp'*, always treat *p* as presupposed

In other words, despite the presence of a small chance ε that *p* was not treated as presupposed by the naive listener, strategic reasoning may lead to the conclusion that a more sophisticated listener will treat *p* as presupposed with probability 1.

[41] In greater detail: L_1 needs to determine the probability that S_1 intended *p* to be treated as at-issue or as presupposed. Using Bayes's rule,
P(p at-issue | pp') = [P(pp' | p at-issue)/P(pp')] * P(p at-issue) = 0 since P(pp' | p at-issue) = 0. Therefore P(p presupposed | pp') = 1. And in all cases, P(p at-issue | p and pp') = 1.

Appendix IV
Epistemic Preconditions vs. Counterfactual Stability

Schlenker, to appear, sketches a triggering rule according to which *counterfactually stable local entailments are presupposed*. As stated in (50), the test asks that one consider a contextual entailment *p* of *E*, and that one assume, relative to the assumptions of the context, that *E* holds true. Then it assesses the counterfactual stability of the entailment *p* by asking whether, on the counterfactual assumption that *E* had not been the case, *p* would still have held, as stated in (86)a.

(86) Assume C |= E => p (i.e. *p* is a contextual entailment of *E*). If $\rightarrow$ represents the counterfactual conditional, the test is whether:
C, E |= (not E) $\rightarrow$ p
Yes: treat *p* as a presupposition.
No: do not treat *p* as a presupposition.

We will prove a very limited equivalence between a version of the 'counterfactual stability' idea and the present analysis based on epistemic preconditions. The key is to provide the non-standard semantics for conditionals in (87). It is a 'variably strict' conditional in the domain of worlds considered by a strict conditional is given by a belief state Bel_t, but is expanded to an earlier and weaker belief state if the antecedent of the conditional is inconsistent with Bel_t.

(87) **Semantics of $\rightarrow$**
We assume that information growth is monotonic, and thus that one believes at t+1 everything one believed at t, but not conversely, and that beliefs can be arbitrarily weakened if one is willing to go far enough in the past. We write as => the material implication.
If w belongs to a belief state Bel_t, then for non-modal expressions *F* and *G*, Bel_t, w |= F $\rightarrow$ G has the following truth conditions:[42]
(i) indicative case: if Bel_t |≠ not F, Bel_t, w |= if F, G iff Bel_t |= F => G;
(ii) counterfactual case: if Bel_t |= not F, and if Bel_{t-1} = the most recent belief state $Bel_{t'}$ such that $\mathbf{Bel_{t'}}$ **|≠ not F**, then
Bel_t, w |= if F, G iff Bel_{t-1} |= F => G.

It can now be observed that a version of the analysis with counterfactual stability is equivalent to a version of the analysis with epistemic preconditions.

(88) We write Bel_t |= F for: for each w in Bel_t, Bel_t, w |= F.
Using the notations of the main text, and on the assumption that C |= E => p, the following two conditions are equivalent.

a. Modified Counterfactual Stability
if $believe_{t-1}$ C and $acquire_t$ **E**, Bel_t |= (not E) $\rightarrow$ p

b. Modified Epistemic Precondition
P($believe_{t-1}$ **p** | $believe_{t-1}$ C & $acquire_t$ **E**) = 1

Note that the conditions in (88)a imply $believe_{t-1}$ C & **E**, which connects the condition Bel_t |= (not E) $\rightarrow$ p to the condition C, E |= (not E) $\rightarrow$ p in (86).

The proof is straightforward.

(i) To prove (a) => (b), assume Modified Counterfactual Stability, and assume $believe_{t-1}$ C and $acquire_t$ **E**. By (a), Bel_t |= (not E) $\rightarrow$ p. Since $believe_t$ **E**, Bel_t |= E and the conditional is counterfactual, so using (87)(ii) we get $\underline{Bel_{t-1} |= (not\ E) => p}$. Since $believe_{t-1}$ C and (by assumption) C |= E => p, we also have that $\underline{Bel_{t-1} |= E => p}$. Taken together, the two underlined condition imply that $believe_{t-1}$ **p**. In other words, if $believe_{t-1}$ C and $acquire_t$ **E**, $believe_{t-1}$ **p**, and hence: P($believe_{t-1}$ **p** | $believe_{t-1}$ C & $acquire_t$ **E**) = 1.

[42] Note that both cases can be unified under clause (ii) if 'closest earlier belief state' is replaced with: 'closest earlier or identical belief state'.

(ii) To prove (b) => (a), assume P(believe$_{t-1}$ **p** | believe$_{t-1}$ C & acquire$_t$ **E**) = 1 and believe$_{t-1}$ C and acquire$_t$ **E**; it immediately follows that believe$_{t-1}$ **p**. Since Bel$_t$ |= E, to evaluate Bel$_t$ |= (not E) $\rightarrow$ p we must apply the counterfactual rule in (87)(ii). Since acquire$_t$ **E**, Bel$_{t-1}$ is the most recent belief state that doesn't entail *E*, the condition is that Bel$_{t-1}$ |= (not E) => p. It is fulfilled because believe$_{t-1}$ **p**, ie. Bel$_{t-1}$ |= p.[43]

[43] Without fully comparing the two frameworks, we note that the analysis based on counterfactual stability has one potential advantage over the one advocated in this piece, and one empirical drawback. The potential advantage is that judgments about the value of counterfactual statements might be easier to elicit than ones about the intuitive probability of certain conditions. For instance, for an example involving the verb *take off*, we could state the counterfactual stability test as follows:

(i) Suppose at 12:05 the company's helicopter was on the ground and took off. If this entire thing hadn't happened, would it still be the case that right before 12:05 the company's helicopter was on the ground?

A drawback of an approach based on counterfactual stability is that it probably makes incorrect predictions for the *prove* class. *Did Smith prove that Jones was the murderer?* does not presuppose that Jones was the murderer. But the test based on counterfactual stability might well make the wrong prediction in this case: on the assumption that Jones was the murderer and Smith proved it, if this entire thing hadn't happened, it is likely that Jones would still have been the murderer.

Supplementary Materials:
Raw ASL data

Raw ASL data can be downloaded at the following URL:[44]

https://drive.google.com/file/d/1Xl-u_FizMm5S2G7CQAQYh9HpiQLtOylB/view?usp=sharing

[44] As can be seen there, the consultant explicitly noticed that in the first judgment task he adopted the *viewer's* rather than the *signer's* perspective when interpreting the question, contrary to what the question asked; this is easily corrected for, and when this is done the first judgment task gives rise to the same pattern as the other three judgment tasks. Taking this correction into account, the raw inferential scores for the questions in (16) were as follows: a: 5 5 5 6; b: 6 6 6 6; c: 6 5 6 6; d: 4 5 5 5.