

Presupposition projection from disjunction in online processing¹

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Abstract. Stalnaker (1973, 1974) suggested that presuppositions are evaluated dynamically in a way that crucially takes into account the ‘left-to-right’ unfolding of linguistic expressions. Recently, even more explicit considerations of the timing of online processing have been invoked to account for patterns of presupposition projection (e.g. Schlenker, 2008, 2009; Chemla and Schlenker, 2012; Hirsch and Hackl, 2014). However, relatively little is known about the actual time course of presupposition interpretation, in particular in environments that involve projection. In this paper, we take disjunction as our testing ground, and use visual world eye tracking data to shed light on the unfolding of presupposition projection in real time. Our key generalization is that presuppositions are evaluated immediately when the interpreter encounters the trigger in the left-to-right parse, bearing out a key assumption in the relevant theoretical literature, namely that presupposition projection can be related to incremental processing.

Keywords: presupposition, presupposition projection, disjunction, eye-tracking, visual world paradigm, experimental pragmatics

1. Introduction

A central issue in presupposition theory is the problem of *presupposition projection*: how are the presuppositions of a complex sentence determined from those of its atomic parts? As shown in (1), presuppositions interact with certain embedding expressions differently from entailments:

- (1) a. The bathroom is in a funny place.
- b. The bathroom is not in a funny place.

The entailed contribution of the predicate *is in a funny place* is affirmed in (1a), but denied in (1b). Yet, the inference that there is a bathroom, introduced by the definite description *the bathroom* is conveyed by both sentences: the existence presupposition of the definite description projects from the scope of negation in (1b).

In this paper, we study the interaction between presupposition projection and *online processing*, focusing on *co-ordinate constructions*, which exhibit a complex pattern of projection effects. In the general case, presuppositions project from both the first and second co-ordinate: both of the sentence variants in (2) presuppose that there is a bathroom.

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- (2) a. The rooms have odd shapes, and the bathroom is in a funny place.
 b. The bathroom is in a funny place, and the rooms have odd shapes.

However, it has long been observed that presupposition projection from conjunction can depend on the linear order of the conjuncts, in particular in cases where the conjunct not containing the presupposition trigger entails the presupposition:

- (3) a. There is a bathroom, and the bathroom is in a funny place.
 b. #The bathroom is in a funny place, and there is a bathroom.

The effect of the first conjunct entailing the presupposition of the second conjunct in (3a) is that the sentence as a whole has no presupposition at all. In contrast, the reverse conjunct order in (3b) seems to be infelicitous. Intuitively, this is due to a clash between the requirement introduced by the presupposition in the first conjunct that it be taken for granted that there is a bathroom, and the presentation of that very notion as new information in the second, i.e., the redundancy of the second conjunct seems to induce infelicity here.

The simple example above suggests that linear order interacts with presupposition projection. Most early accounts of projection effectively stipulated this type of effect as a lexical property of sentential connectives (Karttunen, 1973; Heim, 1983). Recent approaches, though, have sought a more explanatory perspective by linking projection to online processing: asymmetric projection in conjunction emerges from the left-to-right nature of processing (Schlenker, 2009; cf. Schlenker 2008; Fox 2008; Chemla and Schlenker 2012; Hirsch and Hackl 2014). While this move towards greater explanatory adequacy is conceptually appealing, these approaches crucially rely on assumptions about online processing that have not been empirically tested, in particular with regards to how projection is evaluated in real time.

Our goal is to directly test one key assumption in this regard, namely (4), which we take to be an implicit or explicit feature of all accounts linking projection behavior to online processing:

(4) **Rapid Incremental Presupposition Evaluation ('RIPE')**

The interpreter decides whether or not a presupposition projects immediately when they encounter the trigger in the left-to-right parse.

Although (4) seems intuitive given general evidence for rapid incremental interpretation, it is not obviously borne out in all cases. An apparent corollary of (4) would seem to be that only material which *precedes* a given presupposition trigger should be able to influence whether or not the presupposition projects. However, there are cases where material *following* the trigger is relevant. Consider the contrast in (5), involving disjunction. (5b) is a well-known example due to Barbara Partee (Partee, 2005), and (5a) is a minimal variant thereof.

- (5) a. Either the bathroom is in a funny place, or Mary is lost.
 b. Either the bathroom is in a funny place, or there is no bathroom.

In both cases, the presupposition trigger (*the bathroom*) is in the first disjunct, while the second disjunct is varied, with an impact on projection: in (5a), the presupposition projects, but it does not in (5b), i.e. only (5a) gives rise to an inference that there is a bathroom. Indeed, the point of (5b) is to communicate agnosticism about whether there is a bathroom.

The pattern in (5) looks inconsistent with RIPE: if projection is evaluated in online processing as soon as the trigger is encountered, then downstream material should not play a role. Given this apparent evidence *against* RIPE, we take disjunction as our empirical object of study. To foreshadow, we argue that, despite initial appearances, disjunction is in fact compatible with RIPE, following Hirsch and Hackl (2014). Our main contribution here is to provide novel empirical evidence from visual world eye-tracking that directly supports RIPE in disjunction.

2. RIPE: motivation and puzzles

We begin by illustrating how asymmetric projection in conjunction can be derived from effects of real time processing (§2.1-2.3). The account we sketch follows Schlenker (2009) — and relies on RIPE. This motivates our choice to pursue RIPE. In the last part of the section, we make explicit the puzzle for RIPE posed by disjunction (§2.4-2.5).

2.1. Background: asymmetric projection in dynamic semantics

Stalnaker (1973) developed a seminal analysis of presupposition, by which presuppositions impose requirements on the discourse context. The context is modeled as the set of possible worlds in which all propositions mutually agreed upon by the conversational participants are true (the ‘context set’, c). A presupposition constrains c such that if a sentence S globally presupposes a proposition p , then S can only be felicitously uttered in contexts where p is true at every world in c . c is assumed to evolve as the discourse unfolds, and the felicity requirement applies to the context set that takes all previous parts of the discourse into account.

Heim (1983) extended Stalnaker’s approach to a more general model of context update where the context relative to which a presupposition is evaluated is not necessarily c itself. To illustrate, consider conjunction. Heim models the denotation of lexical items not in terms of truth-conditions, but rather in terms of the impact they have on the context set (their ‘context change potential’). Conjunction is defined to sequentially update c with the propositions expressed by the two conjuncts (‘+’ corresponds to intersection applied to the sets of possible worlds that c , ϕ_1 , and ϕ_2 stand for):

- (6) a. ‘ S_1 and S_2 ’ uttered in context c
 b. $(c + \phi_1) + \phi_2$

The key consequence of this sequential update is that S_1 and S_2 are interpreted relative to different contexts: S_1 is directly evaluated relative to c , while S_2 is interpreted relative to a context c' resulting from updating c with the proposition expressed by S_1 ($c' = c + \phi_1$). In turn,

presuppositions triggered in the two conjuncts are evaluated differently: a presupposition of S_1 must be true at all worlds in c , while a presupposition of S_2 must be true at all worlds in c' .

Heim's system is well suited to capture asymmetric projection in conjunction. Concretely, recall (7), where the presupposition trigger *the bathroom* occurs in the first conjunct:

- (7) #The bathroom is in a funny place, and there is a bathroom.

The presupposition is evaluated relative to c and imposes the requirement that the make-up of c conform to (8). By constraining the initial context, the presupposition is felt to project.²

- (8) $c \subseteq \{w : \text{there is a bathroom in } w\}$

The situation is different when the order of the conjuncts is permuted in (9). In this case, the presupposition is evaluated relative to the context c' output by updating c with the first conjunct (*There is a bathroom*), as in (10a). The presupposition of *the bathroom* then places the constraint on c' in (10b).

- (9) There is a bathroom, and the bathroom is in a funny place.

- (10) a. $c' = c \cap \{w : \text{there is a bathroom in } w\}$
 b. $c' \subseteq \{w : \text{there is a bathroom in } w\}$

Because c' only contains those worlds in c at which there is a bathroom, the condition in (10b) is necessarily met, independent of the original make-up of c . Thus, the presupposition does not place any constraint on the initial context and is not felt to project.

2.2. From lexical stipulation to online processing

While Heim's approach offers an elegant analysis for the projection properties of conjunction (and other connectives), it does not achieve full explanatory adequacy. Heim relies on a specific lexical entry for conjunction, which is not formally motivated on independent grounds. In particular, nothing in the framework rules out an alternative entry for conjunction where the conjuncts update the initial context in the reverse order (Rooth p.c. to Heim, Soames 1989, Heim 1990):

- (11) a. ' S_1 and S_2 ' uttered in context c
 b. $(c + \phi_2) + \phi_1$ cf. (6b)

²Note that not only is the presupposition felt to project in (7), but the conjunction as a whole is also felt to be degraded. This is easily explained by the fact that the second conjunct winds up as contextually trivial, as it does not add anything new to c . Stalnaker (1973) already argued this to be a violation of a constraint against redundancy.

With this entry, S_2 is interpreted relative to c , and S_1 is interpreted relative to $c+\phi_2$. Thus, presuppositions would always project from the *second* conjunct, but variably from the *first* conjunct, depending on the content of the second.

It does not seem to be a lexical idiosyncrasy that update proceeds as in (6), and not as in (11). In (6), update proceeds left-to-right, as c is updated with the first conjunct and then the second. In (11), update proceeds right-to-left. The correlation between update order and the left-to-right linear order of the conjuncts can be explained in a principled way if update is directly linked to online processing. This is the direction pursued in recent work, and we outline one illustrative approach here: Schlenker's (2009) theory of local contexts.

Departing from Heim, Schlenker returns to a classical semantic framework, where sentence meanings are modeled as truth-conditions. When interpreting a sentence S in a context c , the interpreter must determine whether the proposition S expresses (ϕ_S) is true or false at each world in c . Worlds at which ϕ_S is true should be kept in c and worlds at which ϕ_S is false should be eliminated. Schlenker proposes that, when the interpreter parses a sub-constituent E of S , they simplify their task as much as possible by disregarding those worlds in c at which they can be sure that the interpretation of E does not affect the overall truth-value of S . The set of worlds under consideration when E is processed is the *local context* for E . Local contexts are computed online, so only information preceding E can be taken into account when determining its local context.

Let us consider how Schlenker's approach applies to conjunction. Two stages of the left-to-right parse for a schematic conjunction are flagged in (12):

(12) [0] S_1 and [1] S_2

At stage [0], the interpreter starts by considering all worlds in c , and c itself is thus the local context for S_1 . After parsing S_1 , the interpreter can identify worlds in c at which ϕ_1 is true and false. Because $\phi_1 \wedge \phi_2$ is necessarily false if ϕ_1 is false, ϕ_2 only affects the truth-value for the conjunction at worlds where ϕ_1 is true; at those worlds, the conjunction is true if ϕ_2 is true and false otherwise. Accordingly, when they parse S_2 , the interpreter only considers worlds at which ϕ_1 is true: the local context for S_2 is $c + \phi_1$. With the local contexts for S_1 and S_2 being c and $c + \phi_1$, the dynamics of context update closely mirror Heim's entry in (6).

Since context update is integrated with online processing, the only way for presupposition projection behavior to be linked to context update is for it too to be integrated with online processing – and, in this way, we arrive at the need for RIPE (which is implicit in Schlenker's discussion). For concreteness, consider the parse of (7) above with the stages shown in (13):

(13) [0] The bathroom [1] is in a funny place and [2] there is a bathroom.

At stage [0], parsing of the first disjunct begins and the local context is c . With RIPE, the presupposition is evaluated immediately on encounter of *the bathroom* at stage [1]. At this

point, the local context remains c , so the presupposition is evaluated relative to c and projects.³

Permuting the conjunct order results in the presupposition being evaluated in a different local context, exactly as in Heim's system:

(14) [0] There is a bathroom and [1] the bathroom [2] is in a funny place.

At stage [1], the local context for the second conjunct, c' , is determined by updating c with the proposition that there is a bathroom. Then, at stage [2], the presupposition of *the bathroom* is evaluated relative to c' . Just as for Heim, the presupposition is guaranteed to be satisfied in c' regardless of the make-up of c , so fails to project.

In sum, by integrating context update and presupposition evaluation with online processing, Schlenker achieves the same predictions as Heim did, but without lexical stipulation. RIPE plays a key role in the account, as it ensures that a presupposition is evaluated relative to the local context for the conjunct in which that presupposition is triggered.

2.3. Previous evidence for RIPE

Given conceptual rationale for RIPE, we ask: what empirical evidence can be used to directly test RIPE? While psycholinguistic work on the online processing of presupposition is still in a nascent state, early results seem to accord with RIPE.

Several self-paced reading studies have shown fairly immediate effects of contextual manipulations bearing on the status of presuppositions, with increased reading times when the context was inconsistent with the presupposition (Schwarz, 2007; Tiemann et al., 2011). This is in line with presuppositions being evaluated right away when the trigger (and other material in the sentence required to flesh out the content of the presupposition) is encountered. Schwarz and Tiemann (2016) further corroborate this with temporally more fine-grained reading time measures from eye-tracking during reading, and Schwarz (2014, 2015); Romoli et al. (2015) provide parallel evidence from visual world eye tracking.

There is, however, a limitation to the previous results: the bulk of evidence for RIPE comes from studies looking at presupposition triggers in simple, unembedded contexts, so no issues of projection arise.⁴ This is potentially problematic insofar as the predictions of RIPE could be descriptively adequate for unembedded occurrences of presupposition triggers, but not extend to embedded contexts where projection is an issue. By studying co-ordination, our experiments

³As we discussed earlier (cf. (3b)), the presupposition marks its content as information taken for granted in the global context, and continuing the sentence by asserting it results in redundancy. (Note that the presupposition equally affects the local context for the second conjunct, since it is a subset of the global context.)

⁴The key exception to this is Schwarz and Tiemann (2016), who look at the presupposition of *again* under negation and in conditionals, with results that they argue show that evaluating projection presuppositions relative to the global context takes longer than in the case of unembedded ones; we return to the relation between our results and theirs in the general discussion.

directly assess whether RIPE makes adequate predictions when projection is involved. We focus on disjunction which seems to pose a particular challenge for RIPE.

2.4. The disjunction puzzle

Schlenker's incremental system makes a key prediction for disjunction: when a presupposition trigger occurs in the first disjunct, the presupposition should project, just as presuppositions project from a first conjunct. Consider the disjunction data seen earlier:

- (5) a. [0] Either the bathroom [1] is in a funny place, or [2] Mary is lost.
 b. [0] Either the bathroom [1] is in a funny place, or [2] there is no bathroom.

Regardless of the connective, the local context at the outset of the parse is *c*. Given RIPE, the presupposition is evaluated at stage [1], relative to *c*. Thus, the presupposition should constrain *c* and be felt to project.

The prediction is borne out in (5a) – but fails in (5b). Whether or not the presupposition projects, then, depends on the second disjunct. When the second disjunct is independent of the presupposition, it projects, as in (5a). But, at least when the second disjunct expresses the negation of the presupposition, it does not project, as in (5b). This effect of the second disjunct looks at odds with RIPE, since the second disjunct is not encountered until stage [2], after the presupposition is evaluated at stage [1]. Given RIPE, it looks as though the second disjunct comes too late to influence projection.

One reaction to this puzzle may be to abandon RIPE so that the interpreter delays all projection decisions until the end of the sentence. In that case, we would expect that projection could be affected both by information that precedes and follows the presupposition trigger. In fact, this option is explicitly considered by Schlenker, who suggests that the asymmetries that can ultimately be attributed to RIPE merely have the status of a processing preference, and can in principle be overridden by a symmetric evaluation of presuppositions. In doing so, however, we lose a straightforward account of asymmetric projection in conjunction⁵ and must regress to lexical stipulation to account for the contrast in (a)symmetry between the two types of coordination.⁶ Here, we pursue the possibility that the disjunction data can be reconciled with RIPE.

2.5. Reconciling Disjunction with RIPE

Hirsch and Hackl (2014) suggest a way to reconcile the disjunction pattern with RIPE. In their

⁵But note that the empirical picture for conjunction is less clear than it may seem at first. For an attempt at settling this experimentally, see Mandelkern et al. (2017), who do not find any evidence for symmetric projection in conjunction.

⁶In principle, one could also consider a processor that waits to assess projection until the end of the sentence but then bases its computations on linear order, but this would effectively bring us back to stipulating an effect of order, rather than deriving it independently, so we will leave this possibility aside in what follows.

view, the interpreter always makes a decision about whether or not to project a presupposition immediately on encounter of the trigger, but that decision can be revised later in the parse. RIPE is correct, but commitments made at intermediate stages of parsing can be altered.

We start with the first part of the disjunction which is shared by (5a-b), and focus on two stages of the incremental parse, as annotated below.

(5a-b) [0] Either the bathroom [1] is in a funny place, ...

Parsing of the first disjunct begins at stage [0], at which point the local context is the initial context set. At stage [1], *the bathroom* is encountered and, by RIPE, the interpreter evaluates the presupposition. The presupposition places the constraint on c in (8), so projects globally.

$$(8) \quad c \subseteq \{w : \text{there is a bathroom in } w\}$$

This result accords with intuitions for (5a), but not (5b). Hirsch and Hackl's account for (5b) relies on a later stage of parsing, subsequent to stage [1]. Consider the full parse, including the second disjunct:

(5b) [0] Either the bathroom [1] is in a funny place, or there is no bathroom [2].

The core idea is that (5b) involves a pragmatic garden path, where the interpreter commits to projection immediately on encounter of the trigger at stage [1] – as expected based on RIPE – and then revises that commitment later at stage [2], after the second disjunct is encountered. The downstream revision is motivated by independent principles of discourse interpretation. In particular, Hirsch and Hackl note that a disjunction p or q is subject to the felicity constraint in (15), motivated by general Gricean principles (see also Schlenker 2008):

(15) **Non-opinionatedness (NO)**

To felicitously use a disjunction p or q , the speaker must not believe p , $\neg p$, q , or $\neg q$.

If the condition in (8) holds, then the notion that the building in fact has a bathroom has to become part of the common ground prior to evaluation of the disjunction in (5b). This means that the speaker must believe (or is at least acting as if they believed) that the building has a bathroom, which in turn commits the speaker to believing that the second disjunct in (5b) is false. In other words, because the second disjunct is equivalent to the negation of the presupposition, projecting the presupposition leads to a violation of Non-Opinionatedness. Having committed to projection at stage [1], the interpreter inevitably runs into an NO violation when they parse the second disjunct at stage [2]. This, Hirsch and Hackl propose, leads to the interpreter back-tracking on their earlier commitment so as to respect NO. This can be done by appealing to some version of a local accommodation operator (Heim, 1983), which effectively results in presupposed content being treated on par with regular entailed content (also see the A-operator of Beaver and Krahmer, 2001).

Note that NO is a principle that applies specifically to disjunctions. As a result, the situation in conjunctions is not parallel, and it does not come as a surprise under this view that one does not seem to observe the same right-to-left filtering in the case of conjunctions (also see footnote 5). This proposal therefore offers an explanatory account of the contrast in incrementality between conjunctions and disjunctions, and thus escapes the stipulative aspect of an alternative approach *à la Heim* where the two connectors are lexically defined to meet the projection observations.

2.6. Section summary

We have seen that RIPE is a central assumption of an account linking asymmetric projection in conjunction to online processing – an account achieving significant explanatory depth. Though disjunction seems to provide counter-evidence, Hirsch and Hackl suggest that disjunction could be compatible with RIPE after all. The goal now is to directly test whether RIPE holds in disjunction. We use visual world eye-tracking experiments to assess the time course of presupposition projection, and in particular to test whether commitments to projected presuppositions are reflected in eye movements prior to the second disjunct having fully unfolded.

3. Experiment 1: trigger in first disjunct

Exp. 1 investigated disjunctions with a presupposition trigger in the first disjunct. Consistent with RIPE, our results support Hirsch and Hackl's idea that the interpreter rapidly assumes that the presupposition projects upon encountering the trigger, before the second disjunct unfolds.

3.1. Design & Methods

The experimental stimuli included disjunctions like (16), with the presupposition trigger *stop* in the first disjunct. In (16), *stop* triggers the presupposition that Henry went to the aquarium prior to Wednesday (in shorthand: *Aquarium*<*Wd*). The assertion in the first disjunct is that Henry did not go to the aquarium from Wednesday on (\neg *Aquarium*>*Wd*).

- (16) Either Henry stopped going to the aquarium on Wednesday,
or he waited until Saturday to go to the movies.

Participants heard recordings of sentences like (16) while their gaze was tracked relative to a visual display. The visual display consisted of three pictures, each containing a character and a calendar strip with iconically represented activities (Schwarz, 2014), as in Figure 1. Participants' task was to choose the character they took the sentence to be about.

The crucial picture is the target picture, which came in three variants, corresponding to three experimental conditions, illustrated in Fig. 1A-C. In addition, there was a distractor picture and a 'covered box' (adapted from Huang et al., 2013), where crucial information on what happened on relevant days in the calendar strip is blacked out.

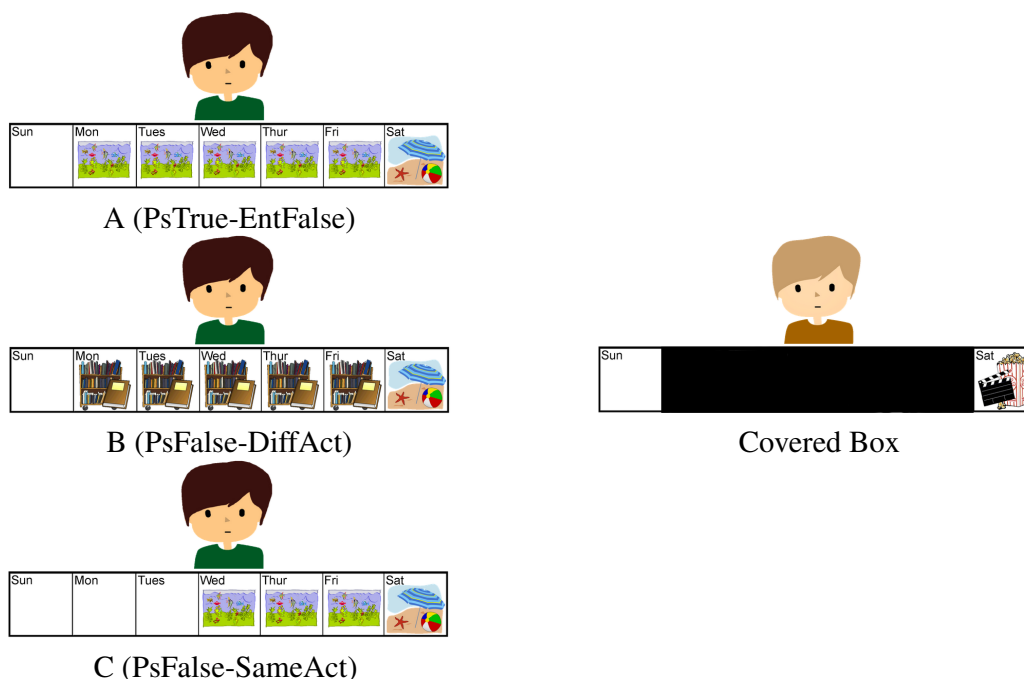


Figure 1: Illustration of Target variants and Covered Box for Exp. 1

The logic of the design was to manipulate whether or not the presupposition of *stop* was met in the target picture, and assess whether the presupposition being met increased the likelihood of participants fixating on the target as the sentence unfolded. In Condition A, the presupposition is met: for the sample item above, Henry went to the aquarium before Wednesday in A. In Conditions B-C, the presupposition fails, since other activities took place prior to Wednesday (Condition B), or no activities did (Condition C). In the item above, the character went to the library prior to Wednesday in Condition B. We refer to B as the DiffActivity (PsFalse) condition and C as the SameActivity (PsFalse) condition. While B constitutes a minimal control condition for A in that they share the same day structure, C was included to control for any independent effect of the presence of slots featuring the mentioned stopped activity.

While the target varies in whether or not the presupposition is satisfied, the distractor picture (not shown) is incompatible with the presupposition in all cases. In the covered box, activities prior to Wednesday are obscured, so the presupposition *could* be satisfied, but is not necessarily so: in the sample item, the character may or may not have gone to the aquarium on Monday and Tuesday. In this way, the covered box is always *compatible* with the presupposition.

Factoring in the assertion now, neither target variant ultimately verifies both the presupposition and the assertion. In Condition A, where the presupposition is verified, the assertion fails, since the character continued to go to aquarium after Wednesday, and went to the beach, not the movies, on Saturday. In Conditions B and C, the presupposition fails, as discussed, and the assertion fails as well. The covered box is ultimately, then, the only picture participants can select: in the covered box, the character does go to the movies on Saturday, verifying the non-presupposing disjunct.

Since we are interested in the online looking pattern, however, more important for our purposes is the status of the assertion *prior to the end of the sentence*. We focus on the critical region underlined in (16). Prior to encounter of *movies* at the end of the sentence, all pictures are still potentially compatible with the assertion, since all have an activity on Saturday. In this way, we can isolate effects of presupposition at this point.

Predictions The critical measure is the relative proportion of fixations on the target relative to the covered box in the online data. If participants rapidly compute the presupposition of *stop* and assume projection, per RIPE, an effect of condition should emerge in the critical region: participants should be more likely to fixate on the target image in Condition A (PsTrue) than in either Conditions B or C (PsFalse). In those conditions, their gaze should be drawn to the covered box comparatively more strongly, since the covered box is the only potential presupposition match. On the other hand, if presuppositions are not rapidly evaluated on account of the trigger, but rather are deferred until the full disjunction is fully processed, no effect of condition is predicted. For the behavioral measure, participants are expected to select the covered box as the best overall picture match in all cases, as discussed.

While RIPE predicts an effect of condition during the critical region, an alternative lexicalist approach which stipulates that disjunctions project a conditional presupposition *symmetrically* for triggers in either disjunct does not. If the semantics of disjunctions is such that the second disjunct can affect whether or not a presupposition introduced in the first disjunct has to be met globally (cf. (11b)), then the evaluation of this presupposition most plausibly would be deferred until the second disjunct is processed. In that case, no effect of condition should emerge in the critical region.

Participants and Procedure 24 items were created with the properties described above, with 4 versions each (a fourth control condition, not discussed here for reasons of space, had a target where both the presupposition and the entailed content of the first disjunct were true). In addition, there were 30 fillers, all of which involved disjunctions, with varying properties (such as truth of 1st vs. 2nd disjunct, presence of presupposition trigger, etc.) to counterbalance a number of different factors across the experiment. 35 students at the University of Pennsylvania participated for course credit. The experiment was implemented in the Experiment Builder software by SR Research, and data was collected on an EyeLink 1000 eye tracker.

3.2. Results

Data Analysis Eye movement data were analyzed beginning at the onset of the disjunction marker *or*, in order to measure proportions of looks to the target after the first disjunct had been fully heard but before the second disjunct had been completed. Since the key alternative candidate for matching the disjunction was the covered box (which was compatible with a global interpretation of the presupposition), we computed a target advantage score where looks to the covered box were subtracted from looks to the target. For purposes of analysis, proportions were transformed to Elogits, and the analysis for individual time-windows used mixed effect models with subjects and items as random effects, as well as a slope for condition to the extent

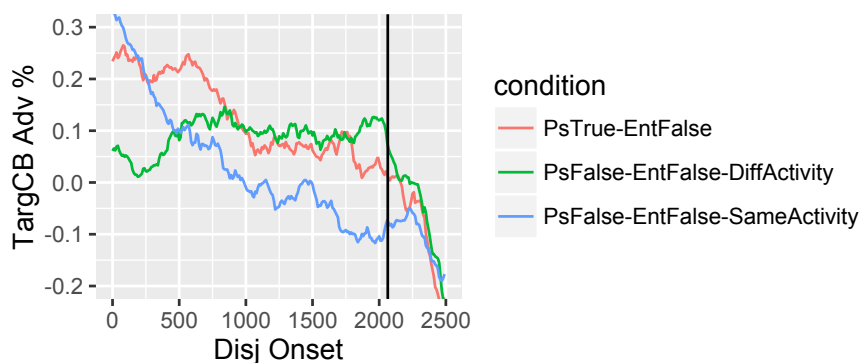


Figure 2: Looks to Target-Looks to Covered Box by Condition relative to onset of ‘or’

that these models converged. Significance of individual effects was assessed through model comparisons with minimally varied models where the condition-factor had been removed.

The graph in Fig. 2 illustrates Target Advantage scores over time for the second disjunct (the black line indicates the mean disambiguation point, corresponding to the onset of *movies* in (16)). There is a clear effect of presupposition: during the second disjunct, participants are significantly more likely to fixate on the target in Condition A (PsTrue) than in Conditions B-C. The contrast with condition B (DiffActivity) is present early on (0-500ms; $\beta = 2.14$, $SE = 0.61$, $t = 3.52$, $\chi^2 = 10.06$, $p < 0.01$), but does not last throughout. The contrast with condition C (SameActivity) emerges first in the 500-1000ms time window ($\beta = 1.48$, $SE = 0.60$, $t = 2.47$, $\chi^2 = 6.08$, $p < 0.5$), and lasts through the remainder of the ambiguous period.

Discussion The contrast in the proportion of looks in the second disjunct indicates that the manipulation of whether or not the presupposition is met in the target picture has an effect. This is consistent with the idea that the interpreter assumes projection online, i.e. when the trigger is in the first disjunct, they immediately compute the presupposition and assume projection. This is in line with the prediction of RIPE, but not with an alternative possibility where the potential relevance of the second disjunct for projection is taken into consideration before any consideration of the presupposition is undertaken.

4. Experiment 2: trigger in second disjunct

In Experiment 2, we extend the data set by testing whether RIPE is supported when the presupposition is triggered in the *second* disjunct, rather than the *first*. Again, our results support the idea that the presupposition is rapidly computed and assumed to project online.

4.1. Extending to trigger-second order

As a first step, let us consider what the incremental system we sketched based on Schlenker (2009) predicts for a disjunction with a presupposition trigger in the second disjunct. The disjunction in (17) offers an illustration:

(17) Either [0] Mary's lost, or [1] the bathroom [2] is in a funny place.

As with any parse, the local context at stage [0] is simply the entire context set, c . At stage [1], the local context for the second disjunct, c' , is determined. A disjunction S_1 or S_2 is true at any world where one or both of ϕ_{S_1} and ϕ_{S_2} is true. The content of S_2 , therefore, affects the truth-value of $\phi_{S_1} \vee \phi_{S_2}$ only at worlds which ϕ_{S_1} is false. As such, c' in (17) is that subset of c containing only worlds at which Mary is not lost:

(18) $c' = c \cap \{w : \text{Mary is not lost at } w\}$

At stage [2], *the bathroom* is encountered and the presupposition is evaluated relative to c' . For it to be satisfied, the building must have a bathroom at every world in c' , as in (19a). The predicted overall presupposition, then, can be paraphrased as the conditional in (19b).

(19) a. $c' \subseteq \{w : \text{the building has a bathroom at } w\}$
 b. If Mary isn't lost, the building has a bathroom.

In predicting a conditional presupposition, Schlenker's approach converges with proposals in dynamic semantics which stipulate an entry for *or* by which a presupposition triggered in the second disjunct projects as conditional (Beaver, 2001: contra Geurts 1999). Yet, this prediction is problematic. Intuitively, (17) does not presuppose (19b), but rather something stronger: the presupposition is simply that the building has a bathroom, independent of whether or not Mary is lost. Observing a non-conditional presupposition where a conditional is predicted is known as *the proviso problem*. Though the proviso problem may seem to argue against an account like Schlenker's altogether, the situation is more complex, as there are examples where a conditional presupposition is observed. A well-known case is (20) (adapted from Geurts, 1996: p. 271), where the intuited presupposition is that if John is a diver, he has a wetsuit.

(20) Either John isn't a diver, or he brought his wetsuit on the trip.

To explain the non-conditional presupposition of (17), many authors accept the prediction of a conditional presupposition, but augment the account with a pragmatic mechanism which strengthens the conditional to a non-conditional. In (17), (19b) is strengthened to (21):

(19b) If Mary isn't lost, the building has a bathroom.

(21) The building has a bathroom.

Different accounts of strengthening have been advanced (van der Sandt, 1992; Geurts, 1999; Beaver, 2001; Singh, 2007; Schlenker, 2011; Lassiter, 2012). While we cannot go into great detail for reasons of space, the last two in particular lend themselves to an integration with the present discussion. Briefly, they assume that conditional presuppositions get strengthened if the material featuring in the antecedent is taken to be irrelevant for whether or not the presupposition holds. For Schlenker (2011), in particular, this is introduced as a process that makes reference to left-to-right order in processing, parallel to the motivation for RIPE above: preceding material can be considered for presupposition evaluation, but also can be deemed irrelevant

in this regard if it contextually fails to bear on whether or not the presupposition holds. For our purposes, this suggests that resolving the proviso problem is a process that takes place equally rapidly as presupposition projection in general, so that strengthened presuppositions should be detectable in online processing measures. Experiment 2, then, directly extends the approach from Experiment 1 by looking at the effect of presupposition triggers in the second disjunct.

4.2. The paradigm

The test sentences in Experiment 2 consisted of disjunctions such as (22), where the aspectual verb *continue* occurs in the second disjunct and triggers the presupposition that Henry went to the movies prior to Wednesday (movies < Wd).

(22) On Wednesday, Henry either went to the aquarium, or he continued going to the movies.

As in Experiment 1, each test sentence was paired with a visual display made up of three pictures: a target, a distractor, and a covered box. The target picture was varied between two experimental conditions, as in Fig. 3.⁷ In both, the first disjunct (that Henry went to the aquarium) is true. In Condition A, the presupposition of *continue* is met as well, as Henry went to the movies on Sunday, Monday, and Tuesday. In Condition B, Henry did not go to the movies before Wednesday (but only after Wednesday), so the presupposition is false. Thus, the target image in both conditions is compatible with the asserted content of the disjunction as a whole (given that it matches the first disjunct), but differs minimally between conditions in whether the presupposition is verified (version A; hence, PsTrue) or not (version B; PsFalse). In the covered box, Henry's activities on Monday, Tuesday, and Wednesday were obscured, as in (3), leaving it open whether or not the presupposition (or the disjunction as a whole) is matched in this picture. The distractor (not show here) was neither compatible with the presupposition nor the assertion, as it had a different activity prior to Wednesday.

Predictions The crucial data are again provided by the online eye-tracking measure. In this case, we define the critical region as extending from the onset of *continue* to the onset of the last word of the sentence, as in (22). Note that, unlike in Experiment 1, the presupposition trigger itself is part of this critical region. While the full second disjunct is needed to flesh out the content of the presupposition (that Henry went to *movies* before Wednesday), the encounter of *continue* alone already suffices to draw the inference that the character in question had *some* sequence of activities preceding Wednesday. As a result, already at the beginning of the critical region, we may see an effect of condition. A greater proportion of looks to the target is expected in Condition A (some activity on Monday-Wednesday) than in Condition B (no activity on these days). As the noun *movies* is encountered, this asymmetry should remain since the target in A satisfies the full presupposition (that Henry went to the *movies* prior to Wednesday). But, crucially, an effect prior to *movies* can give clear evidence that the presupposition is considered rapidly, prior to the end of the clause (even before the full content of the presupposition has been provided).

⁷In addition, there were two further conditions where the first disjunct was false in the target picture for counterbalancing purposes; we do not discuss these here in detail for reasons of space.

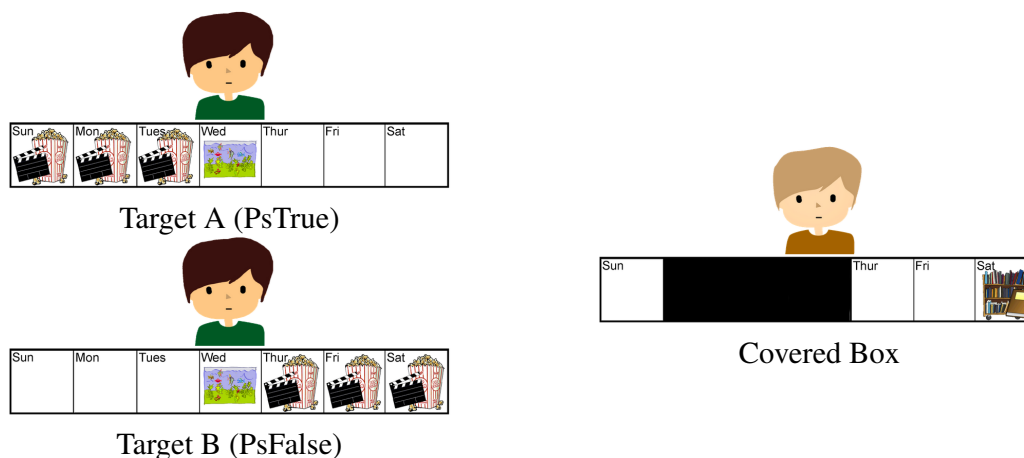


Figure 3: Illustration of Target variants and Covered Box for Exp. 2

To re-iterate, any effect of condition in Experiment 2 would implicate *two* rapid online processes relating to presupposition interpretation. First, the presupposition of *continue* has to be considered rapidly for any effect to arise. Secondly, the relationship of this presupposition to the preceding linguistic context has to be determined immediately as well, to determine that having gone to the aquarium on Wednesday (the content of the first disjunct) is not likely to bear on the question of going to the movies prior to Wednesday, leading to strengthening of the presupposition to a non-conditional one (assuming, as before, a conditional presupposition, in line with a RIPE-based account of projection, to begin with).

The secondary measure of picture selection is also informative in Experiment 2, as it allows us to assess whether participants adopt a strengthened non-conditional presupposition in the final interpretation. In Condition A, the target matches the strengthened presupposition and assertion, so is the expected response regardless. In Condition B, however, the strengthened presupposition is not met, so participants must select the covered box if they adopt that interpretation. Otherwise, if they compute a conditional presupposition or locally accommodate a strengthened presupposition, they can select the overt picture. In addition to the selection itself, we collected reaction time data from the offset of the sentence to the time of picture selection.

Participants & Procedure The experimental stimuli consisted of 24 items structured as in the sample item above. In addition, there were 30 filler items, again varying crucial properties, such as presence of a trigger and truth or falsity of the disjunction as a whole, for purposes of counterbalancing to avoid potential experiment-level strategic effect and to mask the experimental manipulations. 48 undergraduate students at the University of Pennsylvania participated in the experiment for course credit. As in Exp. 1, the experiment was implemented in Experiment Builder, and data was collected on an EyeLink1000 eye tracker.

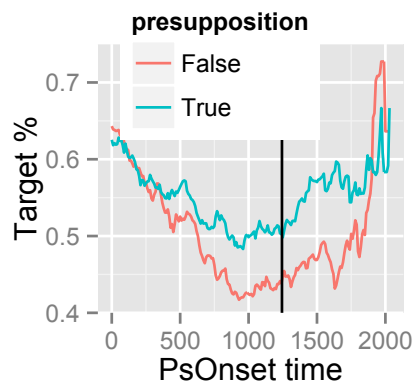


Figure 4: Proportion of looks to Target by condition in Exp. 2, relative to the onset of *continue*. Black line marks mean disambiguation point (corresponding to *movies* in (22))

4.3. Results

Eye movement data The graph in Fig. 4 shows the proportion of looks to the target by condition relative to the onset of the presupposition trigger *continue*, with the black line again indicating the mean onset of the disambiguating word (*movies* in illustrations above).

A difference between the conditions with A (PsTrue) and B (PsFalse) versions of the Target emerges already before 1000ms after the onset of *continue*. This is reflected in a significant effect during the time-window starting with the onset of *continue* and ending with the onset of the disambiguating noun (the correlate of *movies*) as confirmed by mixed-effect model analyses on Elogit-transformed proportions of looks to target and subsequent model comparison ($\beta = 0.77$, $SE = 0.35$, $t = 2.18$, $\chi^2 = 4.61$, $p < 0.5$), suggesting that the presupposition of *continue*, that some activity must have been going on prior to Wednesday, is already having an effect on the interpretation prior to the full second disjunct unfolding. This is consistent with the prediction of RIPE. Right after participants encountered *continue*, they are more likely to fixate on the target if the presupposition is verified than if the presupposition fails.

Behavioral data Beginning with response pattern by condition, participants were more likely to select the target picture in Condition A (96%), where the presupposition was met, than in Condition B (75%), where it was not, but where the covered box offered a viable alternative choice where the presupposition could be met. A logistic mixed-effect model analysis revealed this difference to be statistically significant ($\beta = 3.45$, $SE = 0.52$, $z = 6.59$, $p < 0.001$).

While Condition A and Condition B differ, it is notable that participants still do select the target with high frequency in Condition B (75%). This suggests that participants often do *not* have a strengthened presupposition projected in the final interpretation. This looks initially at odds with the online data which provide evidence for an effect of presupposition in the critical region. We suggest that those target choices obtained after participants strengthened the conditional presupposition, but then revised this strengthening.

This explanation is further consistent with the reaction time data.

Reaction times by condition and response choice also reveal a telling pattern. Fairly unsurprisingly, covered box choices when the presupposition was not met in the target picture (Condition B) were slower than target choices (8061 vs. 6874 ms respectively). However, target choices were furthermore significantly faster when the presupposition was met (6297ms, version A), as confirmed by mixed effect model analyses and model comparison ($\beta = -653$, $SE = 281$, $t = -2.33$, $\chi^2 = 4.97$, $p < 0.5$). This suggests that even though the target picture was the majority choice overall in the B version, this choice was not as straightforward as in the A version, presumably due to the difference in the presupposition being met. Importantly, such a delay would not be expected if target choices in Condition A and B equally obtained with a satisfied conditional presupposition.

5. Discussion

Our starting point in this paper was the observation of an asymmetry in presupposition projection in conjunctions. We argued that recent explanatory accounts for this asymmetry based on left-to-right processing share an implicit assumption, which we made explicit in the form of RIPE. We then reviewed cases that are not as clearly asymmetric, in particular disjunction. Facing this contrast between conjunctions and disjunctions, we were left with two alternatives: either give up the general asymmetric model based on RIPE and stipulate an asymmetric lexical entry for conjunctions and a symmetric entry for disjunctions, or maintain RIPE and explain apparent symmetry in disjunctions as resulting from a more complex process involving an initial commitment to projection, which is then rescinded in cases where this conflicts with independent pragmatic principles, in particular NO.

The goal of our experiments was to show that empirical evidence on processing is indeed consistent with RIPE, in that it reflects early commitments to projected presuppositions. We focused on disjunctions, where RIPE makes a crucial prediction: while RIPE predicts early commitment to presupposition projection, approaches that posit a symmetric entry for disjunctions would naturally account for speakers not committing to projection before encountering the entire second disjunct. We saw that the results are consistent with RIPE, in that our eye-tracking data from Experiment 1 suggest early commitment to presupposition projection, contrary to what is expected according to lexicalist approaches. We furthermore saw that a strengthening mechanism endorsed by most recent authors takes place rapidly when the presupposition trigger appears in the second member of a disjunction, which is again in line with a rapid processing and integration of presuppositions.

Taking the results at face value, especially those from Experiment 2, one might consider a third possibility, namely that presuppositions are initially taken to project unconditionally from the first and second disjuncts as well. That is, one might interpret the results of the second experiment not as showing that there is rapid strengthening of an underlying conditional presupposition (as we concluded), but rather as showing that processing presuppositions does not take preceding information into consideration at first. Such an interpretation would be reminiscent of some early accounts of presupposition projection, endorsing what is known as the cumulative hypothesis (Langendoen and Savin, 1971). The presupposition-suspension mechanism (e.g. local accommodation) involved in Hirsch and Hackl's back-tracking mechanism,

which is used to account for the optionality of projection from the first member of a disjunction, could then be held responsible for the optionality of projection from the second member despite the posited initial commitment in projection. While this view would be compatible with our results taken in isolation, we argue that it is not tenable in the more general landscape of presupposition projection. First, as illustrated with the sentence in (20), presuppositions sometimes project *conditionally* out of disjunctions. This observation is at odds with a parser that would *unconditionally* project presuppositions as soon as it encounters a trigger. Moreover, while a process such as local accommodation possibly taking place both in the first and second member of a disjunction is well in line with the apparent symmetry of disjunctions, it is hard to see how the mere availability of local accommodation could account for the asymmetry of conjunctions. By contrast, note that RIPE does not suffer the same criticism, since resorting to local accommodation in disjunctions is motivated by an independent pragmatic principle, Non-Opinionatedness, which does not apply to conjunctions: the lack of presupposition projection in conjunctions where a trigger appears in the second conjunct results from the conditional nature of the presupposition induced by incremental-processing, and not from local accommodation.

More generally, our results provide new insights into the online processing of presuppositions and therefore further constrain theories of presupposition projection. Insofar as decisions about presupposition projection are made right away, the range of options for lexically encoded projection properties, should there be the need for any, is substantially reduced. An important task to carry out in more detail in future work is to relate the present results to previous findings, such as those by Schwarz and Tiemann (2016), who conclude based on evidence from eye-tracking during reading that projection takes time. While that conclusion may at first sight seem at odds with the interpretation of our data offered here – that projection decisions are made rapidly –, this need not be the case, as the steps the processor engages in to determine whether a presupposition project could well start out right away when the trigger is encountered, and yet take time to complete. Furthermore, it is worth noting that the time-windows of our effects are only immediate in the broader sense that they show up prior to relevant further information having been introduced, which is again perfectly consistent with the notion that the overall process of presupposition projection does take a certain amount of time to complete. Finally, yet another important direction for future work is to extend the present methodology to other connectives, and in particular to settle the question of whether or not conjunctions display any genuinely symmetric projection effects.

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