Experimental Work in Presupposition and Presupposition Projection

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Abstract

Recent years have seen a surge of experimental approaches to the study of natural language meaning, both to get solid data on subtle phenomena hard to assess through introspection, and to understand how abstract characterizations of linguistic knowledge relate to real-time cognitive processes in language comprehension. The present paper reviews work in one of the most recent areas to see extensive experimental investigations, namely presupposition and presupposition projection. Presuppositions are at the very nexus of linguistically encoded content and contextual information, as they relate directly to the discourse context but also interact in intricate ways with their intra-sentential linguistic environment. They are thus extremely suitable for investigating the interplay of linguistic and more domain general processes in language comprehension, as well as for experimental investigations of subtle theoretical phenomena.

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1 INTRODUCTION

Given its origins in philosophy and logic, the study of linguistic meaning has traditionally focused on developing formal accounts of basic empirical phenomena easily accessible through intuitions. However, recent years have seen a surge of more systematic empirical approaches to the overall enterprise, both to get solid data on subtle phenomena hard to assess through introspection, and to understand how abstract characterizations of linguistic knowledge relate to real-time cognitive processes in language comprehension. The present paper reviews work in one of the most recent areas to see extensive experimental investigations, namely presupposition and presupposition projection. Presuppositions are at the very nexus of linguistically encoded content and contextual information, as they relate directly to the discourse context but also interact in intricate ways with their intra-sentential linguistic environment. More specifically, presuppositions convey information that is typically assumed to already be taken for granted by the discourse participants. Furthermore, they are characteristically unaffected by a variety of linguistic embedding environments, such as negation, conditionals, and questions. They are thus extremely suitable for investigating the interplay of linguistic and domain general processes in language comprehension.

The following discussion is structured as follows: the present section briefly reviews the basic theoretical background (for a detailed recent review, see Beaver & Geurts, 2012). Section 2 surveys methodological approaches, from basic response measures to more fine-grained online processing measures, and their application to the experimental study of presuppositions. Section 3 turns to theoretical issues concerning presupposition projection and discusses experimental investigations of cases where presupposed content does not project, of the nature of the projected content, as well as of the cognitive processes involved in resolving presuppositions in context.

1.1 The Status of Presuppositions

The notion of presupposition first reared its head in connection with definite descriptions. Frege (1892) argued that the existence of an entity satisfying the descriptive content is a ‘Voraussetzung’ (i.e., a pre-condition or presupposition)
for the containing sentence to have any meaning. In a similar vein, (Strawson, 1950, arguing against Russell (1905)), claimed that definite descriptions that failed to refer led to sentences that are neither true nor false (rather than plain false, as Russell would have it). Definites have continued to receive ample attention (see, e.g., Reimer & Bezuidenhout, 2004), but a key insight of early work on presupposition (Karttunen, 1973, 1974; Stalnaker, 1973, 1974) was that the key properties of definites are shared by a fairly wide variety of linguistic expressions, including factive verbs (e.g., know), aspectual verbs (e.g., stop and continue), iteratives (e.g. again and too), and clefts. Subsequent decades saw a wide variety of work trying to account for so-called ‘presupposition triggers’ and their properties in unified theoretical frameworks. More recently, a need for differentiating different classes of triggers has been recognized.

One central feature of presuppositions is that their status contrasts with that of the truth-conditional at-issue content (Roberts’s (1996) ‘proffered’ content). Presuppositions are backgrounded (not at-issue) and (typically) taken for granted, as illustrated below. A false presupposition commonly yields a sentence that is neither true nor false.

(1) a. John climbed Mt. Everest again this year.
   b. Professor Jones stopped failing all of his students.
   c. It was Sue who broke the window.

Intuitively speaking, 1a asserts this year’s climbing achievement, but presupposes a previous one. 1b asserts that from the relevant point on forward, Professor Jones has not been failing his students, but presupposes that he did so previously. Finally, 1c asserts that Sue is the culprit, but takes it for granted that someone broke the window. Another indication that the relevant content is not at-issue is that denying these sentences will generally not involve denying the presupposed content; furthermore, even ‘no’ answers to their yes/no-question counterparts will involve a commitment to the presupposition (barring further elaborations).

1.2 Presupposition Theory: Semantics vs. Pragmatics

One way of capturing that sentences with unmet presuppositions are neither clearly true nor false is to abandon the bivalent nature of classical logic and to assume a third truth value, commonly represented by ‘#’. When a presupposition is false, an atomic sentence containing its trigger will have just that truth value. Trivalent logics based on Kleene (1952) were used early on to capture the nature of truth-value judgments for presuppositional sentences, and recent years have seen a revival of trivalent semantic theories (Beaver & Krahmer, 2001; Fox, 2008; George, 2008), as well as of supervaluationist versions thereof (van Fraassen, 1968).

Another family of approaches, following Stalnaker (1973, 1974), advances a pragmatic approach to presuppositions. In the broadest sense, this view sees the term ‘presupposition’ as encompassing everything mutually taken for granted
in a given discourse. This is Stalnaker’s Common Ground, represented by a
set of possible worlds consistent with what is mutually assumed. Generally
speaking, the assertion of a sentence updates the Common Ground, but if this
is associated with a presupposition, it can only happen if the Common Ground
entails what is presupposed. Thus, what is seen as lack of a truth value on
trivalent approaches is now seen as an inability to update a Common Ground.
On a purely pragmatic approach, there is a question of how a given utterance of
a sentence becomes associated with a presupposition, if presuppositions are not
encoded in the semantics of any lexical entries. Stalnaker remains somewhat
non-committal in this regard. However, as he already points out, it’s perfectly
compatible to assume that (at least some) pragmatic presuppositions are due
to semantically encoded presuppositions (cf. the notion of ‘Stalnaker’s bridge’
introduced by von Fintel, 2004). For present purposes, we will maintain the
common assumption that specific expressions are standardly associated with
presuppositions, without prejudging just how this association is brought about.

Within linguistics, dynamic theories (starting with Kamp, 1981; Heim, 1983)
adopt Stalnaker’s perspective of presuppositions as constraints on context up-
dates, but incorporate it directly into a revised semantic framework. Heim’s
File Change semantics proposes to see sentence meanings themselves in terms of
their context change potential. The resulting system combines aspects of triva-
lent and pragmatic approaches by providing a partial semantics where failure
of context update more or less plays the role of ‘#’. Discourse Representation
Theory (DRT van der Sandt, 1992; Geurts, 1999) also formally encodes con-
texts as part of the semantics. It couches this in a representational framework
where contexts are characterized in terms of Discourse Representation Struc-
tures (DRS’s), and adding sentences to a discourse amounts to adding their
own DRS’s to the overall representation of the discourse. Presuppositions are
seen as a type of anaphora in this framework, meaning their contributions to
DRSs have to be linked to existing parts of the Discourse Representation.

1.3 Presuppositions vs. Other Aspects of Meaning

Recent work on presuppositions has reconsidered the boundaries between dif-
ferent aspects of meaning in various ways. For example, Tonhauser et al. (2013)
compare a variety of expressions and constructions which project out of em-
bedded environments, including various types of presupposition triggers as well
as conventional implicatures, and argue for a unified theory of their projection
behavior.\footnote{Syrett et al. (2014) report a recent experimental comparison of these two aspects of
meaning.} In addition, various proposals for distinguishing types of presupposi-
tion triggers have been made, e.g., lexical vs. resolution triggers (Zeevat, 1992),
soft vs. hard triggers (Abusch, 2002), strong vs. weak triggers (Glanzberg, 2005),
and ones that entail their presupposition vs. ones that don’t (Sudo, 2012). Some
of these have seen some initial experimental investigations, discussed below.

One approach that has been particularly important in experimental work
analyzes certain types of presupposition triggers pragmatically, and assimilates
the relevant inferences to those of implicatures (Simons, 2001; Abusch, 2010; Chemla, 2009b; Romoli, 2014). Given prior experimental work on implicatures (for a recent review, see Chemla & Singh, 2014a,b), this lends itself to direct experimental comparisons, and some first results in this realm are discussed in section 3.3.1. More generally, the overall project of classifying different aspects of meaning and their fine-grained properties constitutes an area where experimental work can play a central role, by contributing systematic data on subtle aspects of interpretation.

2 METHODOLOGICAL APPROACHES AND FOUNDATIONAL ISSUES

We now turn to experimental approaches to presuppositions. These range from simple behavioral response measures to sophisticated investigations of the time-course in online processing on the methodological side, and from foundational properties that are typically taken for granted in the literature to more complicated tests of subtle issues differentiating competing theoretical accounts. This section focuses on methodological approaches for detecting presuppositions and investigating their general properties.

2.1 Basic Response Measures

At the most basic level, the challenge of demonstrating experimentally that a presupposition normally assumed to be associated with a given expression is indeed present is largely parallel to the more general challenge of doing so for any aspect of linguistic meaning. A variety of standard tasks and response measures have been employed to this end.

2.1.1 Interpretation Judgments

One general method for determining the presence of some specific aspect of meaning is to present a linguistic stimulus in form of a sentence and to have subjects provide a judgment that directly reflects how they interpret it. Schwarz (2007) used a paraphrase selection task with ambiguous sentences to that effect. This study utilized syncretism for N(ominative) and A(ccusative) case marking in German, as in the following:

(2) Die Frau, die das Mädchensah, hatte auch der Mann
The womanN/A whoN/A the girlN/A saw had also the manN
sehen
‘The woman that (saw the girl/ the girl saw) had also been seen by the man.’

5
Subjects had to select one amongst various paraphrases, which differed in whether the woman was said to have seen the girl or vice versa. Based on syntactic processing preferences, the former is independently preferred. However, the other interpretation ensures that the presupposition introduced by also (that someone else had seen the woman) is satisfied. The results indicate that subjects indeed take this into consideration, as the paraphrase in line with the presupposition was chosen more frequently than in a presupposition-less control condition. Thus, even in abstract experimental settings with sentences out of context, interpretation choices seem to be affected by a desire for coherent interpretations, which may override independent processing factors biased in the opposite direction.

Abrusán & Szendrői (2013) employ a truth value judgment task with sentences containing definites. Given the standard observation that non-referring definites lead to a sense of ‘squeamishness’ Strawson (1950), i.e., reluctance to judge them to be either true or false, these authors provided a third option labeled as ‘can’t say’. Furthermore, they looked at a number of variations, based on notions such as topicality and verifiability, which have been argued to affect the strength and/or presence of squeamishness in the literature (Reinhart, 1981; Lasersohn, 1993; von Fintel, 2004), as well as negated versions. Somewhat surprisingly, affirmative sentences were found to be judged as ‘false’ quite consistently by subjects, with little use of the ‘can’t say’ option. However, the negated versions displayed significant variation in the distribution of judgments, which suggests that the existence condition of definite descriptions indeed has a status distinct from basic entailments, whose impact on judgments can furthermore be modulated by a variety of pragmatic effects. More recently Zehr (2015) reports a similar study presenting sentences with the presupposition trigger stop paired with visual contexts. In this study, the third choice is introduced as ‘neither’, which subjects choose about 50% of the time, suggesting that squeamishness can indeed be captured for affirmative sentences with this general method.

2.1.2 Acceptability Ratings

Acceptability ratings of sentences offer a straightforward way of assessing the common assumption that presuppositions have to count as being taken for granted. However, it has been well-known since early on that this condition is not met in many felicitous uses. Such cases are commonly characterized as involving the repair mechanism of accommodation (Lewis, 1979, see Beaver & Zeevat (2007) for a recent survey), which essentially involves the hearer adjusting their assumptions about what the common ground is. One way of assessing the extent to which accommodation is available then is to collect acceptability ratings in contexts that do not directly support the presupposition. This can be compared both to contexts that explicitly support the presupposition as well as to ones that are explicitly inconsistent with it. Some early psycho-linguistic studies investigated related issues based on definite descriptions. For example, Carlson & Tanenhaus (1988) find that a sentence like The suitcases were heavy is judged to make sense more frequently following the sentence Bill hurried to
catch his plane than the sentence Bill hurried to unload his car, presumably because the presence of suitcases is more salient in the former case.

In the more recent literature, one rather comprehensive set of studies involving acceptability measures comes from (Tiemann et al., 2011). These authors look at contexts with varying degrees of support for a variety of German presupposition triggers, including possessives, factives, iteratives, and aspectual verbs. For all these triggers, the use of presupposition triggers in contexts that do not explicitly support the presupposition is rated as less acceptable than both non-presuppositional controls and variations with contexts that support the presupposition. At the same time, they are rated consistently as more acceptable than variants where the context is directly inconsistent with the presupposition (also see Schwarz & Tiemann, 2012). This suggests that while there is some cost associated with accommodation, the associated decrease in acceptability is only a moderate one.

While Tiemann et al. (2011) find the same overall pattern for the various triggers in their study, the strength of the accommodation effect appears to be somewhat varied. This comes as no surprise, as it is commonly claimed that triggers differ substantially in their ease of accommodation, although it is by no means clear how to account for this theoretically (Beaver & Zeevat, 2007). Indeed, Kripke (1991) claimed that triggers like too resist accommodation altogether. However, Tiemann et al.’s (2011) intermediate acceptability findings for auch, ‘too’ (as well as for wieder, ‘again’) indicate that accommodation is better than baseline controls with completely implausible adverbs or contexts that directly conflict with the presupposition. This is in line with observations by von Fintel (2008) and Chemla & Schlenker (2012) that accommodating too is possible when in line with plausibility in context. Singh, Fedorenko & Gibson (2015) addressed this issue experimentally, using a stops-making-sense task, where subjects see a sentence unfold word by word as they press one button and are instructed to abort the trial with another button if it no longer makes sense to them. They compare the triggers the and too to presupposition-less controls in both plausible and implausible contexts, as in the following sentences:

(3) Context: Bill went to {a club / the circus} on Friday night.
   Target: {A / the} bouncer argued with him there for a while.

(4) Context: John will go to {the pool / the mall} this morning.
   Target: Peter will go swimming {tomorrow / too} after he gets back from school.

Rather strikingly, they find that in plausible contexts (...a club and ...the pool, respectively), the presence of the presupposition trigger has no impact on the stops-making-sense task, and subjects overwhelmingly accept the sentences for both triggers. In contrast, the presence of the trigger has a strong effect in implausible contexts, suggesting that accommodation is not viable. But in the plausible context, accommodation seems to be just as readily available for the and too. Reading time effects suggest that it may nonetheless be slightly harder in the case of too, but it is nonetheless clearly possible in plausible contexts.
In sum, acceptability rating tasks help to shed light on the relation of presupposition triggers to context. The results to date support the traditional notion that presuppositions in general impose constraints on felicitous contexts of utterance, but also suggest some need for distinctions between different types of triggers.

2.2 Assessing Continuations

Another set of tasks that has proven useful in investigating presuppositions involves comparisons between different versions of continuations of a presuppositional sentence. Onea & Beaver (2011) and Destruel et al. (2015) used this to investigate the exhaustive inference of focus and clefts (also see Velleman et al., 2011, for other triggers). Example 5, from Destruel et al. (2015), illustrates a force choice version of the task, where subjects had to indicate which of several continuations, including the ones below, best matched the context:

(5) It was a necklace that Phillip bought his sister.
   a. Yes, but Phillip also bough his sister a bracelet.
   b. No, Phillip also bought his sister a bracelet.

For clefts, as compared to exclusive statements with only, subjects frequently selected continuations like the one in 5a. The authors explain the difference between clefts and exclusives in terms of the status of the exhaustive inference, which is at-issue in the latter but not in the former, and thus is more or less likely to be targeted by Yes and No.

Other studies use an acceptability rating version of this approach. Cummins, Amaral & Katsos (2013) and Amaral & Cummins (2015) investigate various triggers in English and Spanish and test the acceptability of Yes, although… and No, because continuations:

(6) Q: Did Brian lose his wallet again?
   A: Yes, although he never lost it before.
   A’: No, because he never lost it before.

The triggers in their results seem to be grouped into two classes, which the authors relate to the distinction between lexical and resolution triggers (Zeevat, 1992). The latter are anaphoric and directly relate back to entities (or events) in the context, and include again, and too. The former involve cases where the presupposition is a requirement that comes with the asserted component of the trigger, as with regret, stop, still, continue, stop. For lexical triggers, the authors find systematically higher acceptability ratings for continuations parallel to 6A’, whereas there is no difference in acceptability between the continuations for the resolution triggers. This is in line with Zeevat’s distinction, as ‘the responses in condition [A] appear self-contradictory, if we assume that the presupposition is a logical prerequisite for the at-issue content of the trigger’ (p. 169 Amaral & Cummins, 2015).
2.2.1 Inference-based Tasks

Another approach to testing for the presence of presuppositions in the interpretation of a sentence is to use tasks where the presence or absence of the potential presuppositional inference in question will be revealed indirectly through subjects’ behavior. One implementation along these lines can be found in the acquisition study by Dudley et al. (2015), which investigates the factive presupposition of attitude predicates such as *know*. A crucial question is to what extent children are sensitive to this aspect of meaning, specifically in contrast to non-factive verbs such as *think*. Dudley et al. (2015) address this question through a guessing game, where an experimenter hid a toy in one of several boxes. Before the child guessed which box contained the toy, a puppet would whisper in the experimenter’s ear. The experimenter would then relay what the puppet said by saying *Lambchop (doesn’t) {know / think} that it’s in the red box*. If children pick up on the factivity of *know*, their response behavior for the two verbs should differ. Dudley et al.’s (2015) results show that at least some of the 3-year olds in their study have an exquisite understanding of the factive component of *know*, including its presuppositional property of projection out of the scope of negation.

Another inference-based task is incorporated into the study of *again* by Tiemann (2014) (also see Tiemann et al., 2015), where sentences such as *Linda received a pink lamp again* are presented in contexts where Linda either had received a pink lamp previously or not. On a third of the items, a comprehension question assessed the extent to which subjects accommodate Linda receiving a pink lamp on a previous occasion when the immediate context did not support this. In particular, subjects had to answer whether Linda had received one or at least two pink lamps in total. Somewhat surprisingly, the presupposition of *again* hardly affected subjects’ answer choices at all in the non-supporting context, i.e., they overwhelmingly chose ‘one’ as the answer. The authors interpret this as suggesting that accommodation is a last-resort mechanism that is to be avoided if at all possible. Alternatively, one might explain subjects’ behavior in terms of narrowly interpreting the question with regards to the immediate context, but even so, it is very interesting that the presupposition does not seem to counter such a restrictive interpretation at all.

Domaneschi et al. (2013) also use comprehension questions to assess the presence of presupposition-based inferences. They auditorily presented short stories that contained a variety of presupposition triggers. The key measure came from a True/False comprehension question, which related directly to the presuppositions, none of which were explicitly supported in the story. A variation in cognitive load, based on a simple visual memory task, served to add an additional perspective on the processing efforts involved. Domaneschi and colleagues were interested in potential differences between triggers in their likelihood of accommodation (or at least processing of the presupposed content in the first place). Their theoretical approach follows Glanzberg (2005) in distinguishing strong and weak presupposition triggers, which differ in whether the presupposed information is obligatorily processed in non-supporting contexts.
(as with strong triggers such as factive verbs) or not (as with weak triggers, such as iteratives like again). Their results suggest that these two types of triggers indeed differ in terms of how present they are when answering questions about the previously heard text, in that accuracy is overall much lower for weak triggers. The results for again in particular seem in line with Tiemann’s (2014) finding, where its presupposition is essentially ignored when answering the relevant question. In addition to the differences in accuracy, Domaneschi et al. (2013) find that change of state verbs and iteratives are particularly sensitive to the cognitive load manipulation, i.e., the effect of cognitive load does not line up directly with the distinction between weak and strong triggers. While these findings are in line with the distinction between strong and weak triggers, alternative explanations, e.g., in terms of the level of backgroundedness or immediate relevance for the current topic of discussion when the trigger is encountered, should also be explored.

2.3 Temporal Measures

Much can also be learned from closer investigations of the time course of presupposition interpretation and corresponding response behavior. We first turn to studies of response and reading times, and then to more direct measures of online processing using eye tracking.\(^2\)

2.3.1 Reading and Response Times

One use of response time measures in the study of presupposition is to help establish a systematic empirical basis for the distinction between presupposed and asserted content. As discussed in section 2.1.1, truth value judgment tasks do not always provide straightforward evidence for such a distinction, as speakers quite happily judge sentences that would standardly be assumed to involve presupposition failure as false, rather than infelicitous. Two studies have taken the approach of looking at the time course of truth value judgments to assess whether false-judgments based on false asserted vs. false presupposed content might be differentiated in terms of their time course.

First, Kim (2007) investigates the presupposition of only. Only the girls have books commonly is taken to presuppose that the girls have books. Kim’s experiments present such sentences in visual contexts that either did or did not conform to this presupposition (i.e., showed the girls as having books or not). The truth of the asserted content (whether or not non-girls had books) was also varied across conditions. Subjects took longer in their responses when they were based on an unmet presupposition than when they were based on false asserted content. Kim interprets this result as a reflex of the backgrounded nature of presuppositions, which impacts the verification procedure employed in the task: presuppositions are literally taken for granted, and not initially

\(^2\) Few neurolinguistic studies of presuppositions as a general phenomenon exist to date, but see van Berkum et al. (2003) and Burkhardt (2006) (and following work by these authors) on definite descriptions.
verified, in contrast to asserted content, which leads to longer reaction times in falsifying them. Schwarz (2015a) takes a similar approach to the study of the existence implication of definite descriptions, again by asking subjects to provide truth value judgments on sentences relative to visual contexts which either falsify the asserted or the presupposed content. Indefinites serve as a control, where essentially the same information is asserted in both conditions. The results yield a significant interaction between type of determiner and the contextual information affecting which part of the sentence is falsified. This suggests that the status of the existence implication is indeed distinct from that of the main asserted content, and thus supports presuppositional analyses of definites in the tradition of Frege (1892) and Strawson (1950), in contrast to accounts in the tradition of Russell (1905), which see it as a mere entailment.

Turning to reading studies, Clifton (2013) also looks at definite descriptions, but focuses on the effect of the uniqueness presupposition. A context sentence is used to establish whether there is one or multiple of the relevant items (e.g., In the kitchen... vs. In the appliance store...), and the following target sentence contained either a definite or an indefinite description ( {The / A} stove). Despite clear intuitions about the variation in the felicity of the materials, Clifton finds no effect whatsoever in a simple self-paced reading study. However, a follow-up with memory load in form of a simple arithmetic task between reading the sentence and answering a comprehension question found a clear effect in the region following the definite, with longer reading times in the multiple-item condition. This highlights an important methodological aspect of studying presuppositions, namely that subjects may not fully engage in a linguistic processing in an experimental setting when the task at hand does not require it.

Self-paced reading studies have also been used to study other triggers. In addition to the paraphrase selection task for ambiguous sentences containing also discussed above, Schwarz (2007) also reports self-paced reading results for both German and English on disambiguated versions of the sentences, where the presupposition is either met or not supported within the presented sentence. Reading times increased significantly on the region containing also in the latter case. Along the same lines, Tiemann et al. (2011) report self-paced reading results for various triggers as well, with parallel slow-downs either on the region containing the trigger or the one following it (see Tiemann, 2014, for additional results on again).

The general upshot from these studies is two-fold: on the one hand, presuppositions do not seem to receive much attention in initial phases of sentence verification, given the response-time delays for judgments based on false presupposed information. At the same time, the reading time studies suggest that presupposed information is rapidly integrated with the context in reading, as the slow-downs in reading times on trigger-regions in non-supporting contexts can only come about if the presupposed information is indeed accessed and related to the context. While future work will need to investigate this tension in the findings further, it is likely that the nature of the task plays a crucial role.
2.3.2 Fine-grained Measures of Online Processing

While the response time and self-paced reading studies above help to shed some first light on the time course of presupposition interpretation in online processing, they only do so at a fairly coarse-grained level. A more fine-grained temporal perspective not only serves to increase the general understanding of the cognitive processes involved in interpreting presuppositions, but also helps to assess theoretical comparisons between presuppositions and implicatures. Various authors (including Bott & Noveck, 2004; Huang & Snedeker, 2011) have argued that implicature are delayed in online processing, and if certain presupposition triggers in fact are a type of implicature, we may expect similar effects here.\(^3\)

In recent years, more fine-grained methods for investigating online processing have been used to study presupposition as well. First, some of the self-paced reading studies above has been extended to eye tracking during reading as well. Most relevantly, Schwarz & Tiemann (2012) investigate German sentences with again in contexts that either are or are not consistent with its presupposition. They find slow downs in the earliest fixation measures, including first fixation duration, in reading times on the verb that immediately follows again. These effects provide temporally fine-grained evidence that presuppositions are integrated with the discourse context more or less immediately (at least in unembedded contexts; see section 3.3.3 for embedded cases). Along the same lines, Clifton (2013) also reports the parallel effects to the self-paced reading data above in first-pass time measures.

In addition to these reading studies, several recent eye tracking studies have used the visual world paradigm (Tanenhaus et al., 1995) to investigate presupposition processing. These involve visual stimuli with a number of alternative candidates for reference, paired with auditory linguistic stimuli. Participants’ eye movements are monitored as the linguistic input unfolds, and the general design is set up so that looking preferences can be interpreted as indicating the availability of the interpretation of interest at a given point in time. Chambers & Juan (2005, 2008) investigate another and return with this method, and find rapid shifts of fixations based on the respective presuppositions. More recently, Romoli et al. (2015) look at English also in comparison with the asserted part of only. They find shifts in eye movements based on the presupposition of also as early as 400ms after its onset, indicating that the presupposition is utilized in determining the referent before further disambiguating information is introduced.

Schwarz (2015b) contrasts the same two expressions, and observes a shift in fixations as early as 200-300ms after the onset of also, suggesting that the presupposition introduced by also is immediately available and utilized in identifying the referent. A second experiment looks at the interpretation of stressed also, which associated with the subject of the sentence, again in comparison to only. While also again gave rise to an essentially immediate shift in fixations

\(^3\)But note that there is an ongoing debate on whether implicatures are indeed delayed (Grodner et al., 2010; Breheny, Ferguson & Katsos, 2013; Degen & Tanenhaus, 2015).
towards the target (starting at 300ms after the onset of also), the exclusive inference introduced by only did not give rise to a parallel shift until 700ms after its onset. Extending this approach, Schwarz (2014) compares a hard and a soft trigger, again and stop, to assess whether the potentially pragmatic nature of the latter might lead to differences in processing speed, given related findings for implicature (Huang & Snedeker, 2011). However, both triggers very much parallel the time-course observed in the previously discussed studies on also, with immediate shifts in fixations based on the presupposed information.

The results from these studies, together with the reading results above, thus do not provide any support for the notion that at least some presuppositions are pragmatically computed in a costly manner associated with processing delays. This may be most naturally compatible with accounts that assume all presupposed content to be encoded conventionally. But it is also possible that we are looking at rapid pragmatic effects, so the results do not per se settle the question about the source of presupposed content. Nonetheless, they provide the most direct and time-sensitive evidence yet that presupposed information is available and utilized as soon as the presupposition trigger is introduced.

3 PRESUPPOSITIONS IN EMBEDDED ENVIRONMENTS

3.1 The Phenomenon of Projection

The second hallmark property of presuppositions concerns the persistent presence of presupposition-based inferences arising from presupposed material introduced in embedded contexts (Karttunen, 1974, see also Chierchia & McConnell-Ginet’s (1990) ‘family-of-sentences’ tests). For example, negation, questions, and conditionals have the effect that the at-issue content of the clause they embed no longer is conveyed by the entire sentence. But presupposed content remains untouched, as can be seen in the following variations:

(7) a. John didn’t climb Mt. Everest again this year.
    b. Has Professor Jones stopped failing all of his students?
    c. If it was Sue who broke the window, she’ll have to pay for it.

Yet another intricacy of projection phenomena is that they interact with the linguistic environment. While 8a displays standard projection and requires a context where a prior climbing is taken for granted, the variant in 8b comes without any contextual contraints.

(8) a. If John was in Nepal, then he climbed Mt. Everest again this year.
    b. If John climbed Mt. Everest last year, then he climbed it again this year.
While it is intuitively clear that this is due to the content of the antecedent, it is no small feat to capture the effect theoretically. Indeed, this has been a key challenge in the literature.

3.2 Theoretical Approaches to Projection

In Stalnaker’s pragmatic approach, projection phenomena are seen as the result of how context updates proceed for complex sentences, as is most simply illustrated for conjunction:

(9) John climbed Mt. Everest last year and he climbed it again this year.

Stalnaker explains the lack of an overall presupposition here by arguing that the first conjunct is added to the context before the second conjunct is considered, thus guaranteeing that any initial context can be updated with the conjunction as a whole. Stalnaker proposes to extend this line of reasoning to other connectives as well.

In dynamic semantic approaches, capturing projection requires formulating the appropriate context change potentials for the relevant connectives. For 9, this entirely mirrors Stalnaker’s approach. For conditionals, assuming the equivalent of a material implication analysis, the update procedure removes those worlds from the initial context where the antecedent is true and the consequent is false. More technically, the procedure for updating a context \( c \) with a conditional \( \text{If } p \text{ then } q \) is characterized as follows:

\[
(10) \quad c + (\text{If } p, \text{ then } q) = c - ((c + p) - ((c + p) + q))
\]

Crucially, interpreting the consequent \( q \) only involves an update relative to the original context as updated with the antecedent \( c + p \), and not the original context \( c \) alone. This accounts for the fact that 8b imposes no constraints on \( c \), as the fact that \( c + p \) is a subset of \( p \) (and thus entails the presupposition of \( q \), that John climbed Mt. Everest prior to this year) ensures that update with \( q \) cannot fail. DRT offers an alternative dynamic approach, which sees projection on par with anaphora resolution within discourse representations. While the overall empirical predictions are similar, there are some key differences, some of which play a direct role for the experimental investigations discussed below.

To capture projection in trivalent approaches, the relevant connectives are interpreted in terms of non-classical truth-tables. The Strong Kleene version of such a truth table (Kleene, 1952) successfully captures projection phenomena by positing that complex sentences get the value ‘#’ just in case one of its atomic sentences has that value and the truth values of the other atomic statements do not suffice to determine the truth value of the entire sentence based on standard logic. To illustrate, the sentence in 8b always receives a classical truth-value, because if the antecedent is false, the entire conditional will necessarily be true (again assuming a material implication analysis), regardless of whether

\[^{4} + \text{ represents the operation of context update, which in the simplest case amounts to set-theoretic intersection of propositions construed as sets of possible worlds.}\]
the presupposition that John had climbed Mt. Everest before this year is true or not. And if the antecedent is true, then this presupposition is necessarily also true, and the truth of the conditional depends entirely on the truth of the non-presuppositional part of the consequent.

### 3.3 Experimental Approaches to Projection

Given the central role of projection in theoretical work, much of the experimental work has been concerned with projection-phenomena as well. A number of studies have investigated variation in projection, specifically with respect to the strength of the projection effect and the availability of non-projecting (local) interpretations. A second line of work has been concerned with the exact nature of the overall presupposition of sentences containing triggers in embedded positions. Yet another set of studies is concerned with presupposition resolution in context, both within complex sentences and the larger discourse context.

#### 3.3.1 Variation in Projection

Much of the discussion in the literature concerned with identifying differences between (classes of) presupposition triggers is based on the observation that some triggers seem to project more persistently than others. Abusch (2002, 2010) considers examples such as the following, for example:

\[(11) \text{I don't know if Paul participated in the race, } \ldots \]

\[\begin{align*}
\text{a. } & \text{but, if he won, he must be very proud.} \\
\text{b. } & \text{?? but, if Mary participated too, they probably had a drink together just after.}
\end{align*}\]

The presupposition of *win*, that Paul participated in the race, does not seem to be globally present, as it would be inconsistent with the context sentence. However, the global presupposition of *too*, that someone else (salient in the context) participated in the race seems to give rise to a certain amount of oddness. Jayez et al. (2015) investigate this contrast experimentally, by looking at presupposition triggers in the antecedent of conditionals. Looking at French *aussi* (‘too’), *regretter* (‘regret’), and clefts, they present evidence that the distinction is not entirely robust, and that it seems to interact with other contextual factors. They argue their results to be consistent with a three-way distinction between presupposition triggers, in line with Jayez (2013).

Smith & Hall (2011) investigate projection strength of various presupposition triggers, as well as of conventional implicatures, in a host of ‘family of sentences’ environments (Chierchia & McConnell-Ginet (1990)). They use a ‘surprisal’ judgment, where subjects have to assess how surprised they would be to learn that the presupposed proposition holds after hearing a sentence containing the trigger. Their findings are uniform for conventional implicatures and presuppositions (which they argue to speak in favor of a unified treatment of projection, as in Tonhauser et al., 2013), but also suggest that projected
content has a somewhat weaker presence than non-projected (i.e., asserted or unembedded presupposed) content. They also find some variation between triggers, though it does not line up neatly with theoretical differentiations proposed in the literature.

Just because a presupposition does not project doesn’t mean that it disappears entirely. Indeed, many accounts assume that what happens in (at least some of) such cases is that the it gets locally accommodated (as first proposed by Heim, 1983). This offers an explanation for the fact that sentences such as *The king of France is not bald - because there is no king of France*, already discussed by (Russell, 1905), are quite acceptable, despite the incompatibility that would be expected based on a global existence presupposition of *the*. The consensus in the theoretical literature has been that local interpretations are dispreferred (beginning with Heim, 1983), though this is only based on individual intuitions. More recently, Chenla & Bott (2013) offered the first experimental evidence to support that assessment, using a truth value judgment task with sentences such as 12 and looking at reaction time measures.

(12) Zoologists don’t realize that elephants are reptiles.

The factive verb *realize* presupposes the truth of its complement clause, and on its global interpretation, this presupposition prevails even in the context of negation. However, a local interpretation would have that inference negated. In the latter case, the sentence should be judged true, whereas on the former, it should be judged false. Both types of responses are given by subjects throughout the experiment, but the ‘true’ responses take significantly longer than ‘false’ responses. Chenla and Bott interpret this as evidence for traditional, semantic accounts that take local accommodation to be a last resort repair strategy. In contrast, the results are argued to be incompatible with pragmatic accounts à la Schlenker (2008a), which assume that the local reading corresponds to a literal semantic reading, while the global reading requires additional pragmatic inferencing.

Romoli & Schwarz (2015) utilize a different task to investigate the speed of local interpretations of the presupposition introduced by *stop* under negation, namely a ‘Covered Box’ version of a picture selection task (Huang, Spelke & Snedeker, 2013). Subjects have to select a match for a given sentence amongst various pictures, one of which is ‘hidden’. The basic idea is that if the presuppositional inference of interest plays a role in subjects’ interpretation, then they should choose the covered box in cases where no overtly shown image is compatible with the inference. Their experiment compares cases where the overt picture supports the presupposition with ones where it doesn’t. Acceptance rates were much lower for target pictures corresponding to the local interpretation. Furthermore, response times for target choices were slower for local target acceptances than for global ones, in line with Chenla & Bott (2013). Extending this approach to other populations, Bill et al. (2014) and Kennedy et al. (2015) use the same task, though without measuring response times, for testing the interpretation of presuppositions under negation in children and Broca’s aphasic’s
respectively. Both groups turn out to be much more likely than healthy adults to adopt a global presupposition interpretation. Furthermore, they compare presuppositions to implicatures of strong scalar items (not all), and here, the Broca’s aphasics pattern with healthy adults and are more likely than children to base their response on the implicature. This double dissociation provides a strong argument against an entirely uniform treatment of (certain) presupposition triggers and implicatures, e.g., as proposed in Romoli (2014).

3.3.2 What exactly projects?

Presuppositions of Quantified Sentences Chemla (2009a) investigates the presuppositions of quantificational sentences, such as No student knows he’s lucky. The theoretical literature contains opposing views as to whether these introduce universal or existential presuppositions, i.e., whether such a sentence requires a context where all boys have a bike or whether it suffices for some of them to have one (Heim, 1983; Beaver, 2001). Chemla (2009a) presents sentences such as the one above, as well as ones with a range of other quantifiers, to subjects and asks them to judge whether (or, in a second experiment, how strongly) the sentence suggests that all of the students are lucky. Judgments for the quantifier no pattern together with those for every and indicate a universal presupposition, whereas universal inferences for numerical quantifiers (e.g., more/less than 3) are less strongly supported. This finding of variation in the projected presupposition is theoretically important, as traditional theories predict uniform projection one way or another. Chemla proposes to capture the results in terms of Similarity Theory (Chemla, 2009b).

More recently, Tiemann (2014) reports a German study using eye tracking during reading, which manipulates context sentences for quantificational target sentence precisely with respect to whether the relevant presupposition is met universally or not. Her results find slow-downs in reading time for jede (‘every’) in non-universal contexts, but not for ein (‘one’). Parallel to Chemla’s findings, this suggests that the nature of the projected presupposition depends on the quantifier. These results call for further in-depth exploration, both in theoretical and experimental terms.

Another recent study, by Geurts & van Tiel (2015), investigates the effects of presuppositions on domain restriction. Pairing simple geometrical figures with sentences in a truth value judgment task, they look at quantified sentences such as Each of these 7 circles has the same color as the square that it is connected to. Rather strikingly, they find that even a picture where only 2 out of the 7 circles presented are connected to the square next to them and have the same color yields a substantial amount of ‘true’ judgments - up to 68% of the time based on the visual display. The authors analyze this in DRT and propose that such judgments are based on intermediate accommodation. Another finding, which seems to be in direct contrast with Chemla (2009a), is that acceptance of sentences with none are at ceiling level throughout, suggesting an existential, rather than a universal presupposition. While the tasks are quite different in the two studies, this constitutes a puzzle that needs to be further investigated.
Sentential Connectives  Turning to embedding under sentential connectives, there is substantial disagreement in the theoretical literature on whether a presupposition trigger in the consequent of a conditional (such as the possessive definite in (13)) gives rise to a conditional presupposition (13a, e.g., on dynamic semantic accounts) or a non-conditional one (13b, e.g., on DRT accounts):

(13) If Alice goes surfing, she’ll wear her wet-suit.
   a. If he goes surfing, he has a wet-suit.   b. He has a wet-suit.

Both interpretations seem to be attested, but theories differ in terms of which one they see as basic. Romoli, Sudo & Snedeker (2011) provide a first experimental exploration of this topic using a covered box picture matching task discussed above, and argue their results to favor accounts that predict a conditional presupposition as the basic one. Their results also support the notion that whether or not the presupposition intuitively can be seen as dependent on the content of the antecedent affects judgments.

Another line of experimental work on projection investigates the role of incrementality. Standard dynamic accounts assume that presuppositions have to be supported in their context by material that precedes the trigger. A central idea emerging from Philippe Schlenker’s work (Schlenker, 2008a,b, 2009) is that presupposition projection can be broken down into two components: on the one hand, there’s a (trivalent or supervaluationist) semantic component, which crucially is symmetric, i.e., insensitive to effects based on linear order. Secondly, order-based incremental effects (as in (9)) are attributed to left-to-right processing, but are in principle violable. This opens up interesting questions about presupposition processing. Chemla & Schlenker (2012) home in on this issue and test presupposition triggers in conditionals, disjunctions, and unless-sentences in configurations where the presupposition trigger appears either in the linearly first or second clause. In an inference judgment task, they find that subjects endorse conditional inferences more strongly than non-conditional ones, regardless of where the presupposition trigger is introduced. They interpret this as support for a symmetric theory of presupposition satisfaction, where material introduced later on in the sentence in principle can provide support for an earlier presupposition. Schwarz (2015c) varies this paradigm by looking at conditionals in a covered box picture selection task and varying the position of the if-clause. The results here are more mixed, in that if-clause initial conditions suggest a fairly strong role of incrementality, while the if-clause final conditions are more in line with symmetric predictions.

Hirsch & Hackl (2014) investigate the effects of incrementality in disjunctions. These pose a potential challenge to a general processing-based effect of linear order, as they seem entirely symmetric, e.g., in the following example due to Barbara Partee:

(14) Either the bathroom is in a funny place, or there is no bathroom.

Schlenker also argues his account to be more satisfactory than dynamic semantics in terms of explanatory adequacy, as it does not stipulate the projection properties of specific connectives.
Unlike in conjunctions, a trigger in the first disjunct does not generally project globally, i.e., 14 appears to be equivalent to a variant with the disjuncts reversed. However, Hirsch & Hackl (2014) argue that there is an additional confound, as a global presupposition interpretation would be inconsistent with the non-presuppositional disjunct, and each disjunct is independently required to be a live possibility in the global context. Rather than predicting an overall asymmetry in projection parallel to disjunction, an incremental account of projection then will merely predict a processing effect due to a garden path effect. The authors assess this by having subjects select the more natural of two sentences, one parallel to 14, the other with an additional presupposition trigger that is consistent with a global interpretation of the other trigger. The results are in line with the authors’ predictions in that a stronger preference emerges for the version consistent with a global presupposition when the trigger appears in the second conjunct. In contrast, control sentences that at no point suggest a global presupposition interpretation display no effect of order.

3.3.3 Presupposition Projection and Resolution in Context

A final set of studies relating to projection is concerned with the resolution of presuppositions in context, either intra-sententially or in the discourse context, and its time-course in processing. First, in two reading time studies using eye tracking, Schwarz & Tiemann (2015) find embedding of presupposition triggers to modulate processing effects. In the first study (already mentioned in section 2.3.2) immediate eye movement effects on the critical word are found when the context was inconsistent with the presupposition, but only when the trigger (German wieder, ‘again’) was outside of the scope of negation. No effects of context emerged when it was embedded under negation, and follow-up studies suggest that this is not due to a general availability of local interpretations. In a second study, presuppositional support for wieder in the consequent of conditionals is introduced in varying locations, namely in the antecedent or in a context sentence. Schwarz & Tiemann (2015) interpret the results from this study as suggesting that the hierarchical distance in terms of the projection search path assumed by DRT directly affects reading times on the critical region. Such an effect is less straightforward to derive on non-representational accounts (such as dynamic semantics).

Kim (2015), using the visual world paradigm, takes a different angle and investigates the effects of discourse structure on the selection of an antecedent for also. This is done by presenting multi-sentence discourses, which provide various possible antecedents for also in the final target sentence. In two initial comprehension studies, Kim asked subjects to choose one of several descriptions of what the sentence with also conveyed, which reflects how they resolve its presupposition in the discourse. While there was a general preference for linearly local antecedents in the comprehension studies (where also was understood relative to the immediately preceding sentence), a structurally (but not linearly) local interpretation also became available when the discourse structure was manipulated. In a visual world eye tracking experiment, Kim also found a
preference for structurally local interpretations. The eye movement results for
the condition that involves a structurally local antecedent furthermore add to
the evidence from the two studies above, showing that the presupposition of
also is available immediately in online processing.

4 CONCLUSION

While the experimental study of presuppositions is still only in its beginnings,
substantial progress has been made, both in methodological developments and
first steps towards settling controversial issues. With these tools at hand, ever
more intricate issues can now be empirically investigated in a systematic way,
and the future is likely to bring a closer overall integration of theoretical and
experimental work. Beyond informing the specific realm of presupposition the-
ory, results from such work will also bear directly on larger architectural issues
concerning the relation between language-specific and domain general processes
in language comprehension.

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