

Informational sources and discourse in the generation and maintenance of alternatives

E. Matthew Husband¹ and Nikole D. Patson²
¹University of Oxford, ²The Ohio State University

ABSTRACT

Successful language communication requires comprehenders to not only process what speakers say, but to also infer what speakers mean. Many of these inferential processes are thought to rely on alternatives to what is said. By making specific choices in utterances when alternative options were available, speakers can guide comprehenders to draw inferences about the status of those alternatives. But how do comprehenders identify these alternatives given that they may not be currently in mind and might only be implicitly related to the utterance? This chapter addresses the mechanisms that comprehenders use to recover and encode the relevant set of alternatives, focusing on how different sources of information trigger different processes and lead to differences in comprehension over time. Gaps in our theories of alternative generation and maintenance are highlighted, with the hope to spur future research and bring us closer to a complete theory of language comprehension.

1. Introduction

Expressing the complete meaning that is intended by any particular sentence is difficult if not impossible for speakers. Speakers often must leave implicit much of the meaning they intend to express with any specific utterance. Luckily, comprehenders can often recover a speaker's implicit meanings by considering what the speaker could have said but did not. These *alternatives* to what was said are frequently used to enrich a sentence's meaning, and language provides speakers with a variety of devices to mark when such enrichment should take place within a sentence. These include changes in prosody, the use of focus particles or clefts, changes in word order, and the presence of scalar items, among others. But recognizing that alternatives are relevant is just the beginning for comprehenders. They must use these cues to recover the correct alternatives and use them to infer what the speaker intended them to infer. How is it that comprehenders recover the relevant set of alternatives? In this chapter, we consider how comprehenders use different sources of information to recover different kinds of alternatives. For example, alternatives that are unmentioned may need to be recovered implicitly via semantic associations, scalar relations, or situational familiarity to the utterance, while explicit mention in discourse context can set up alternatives which are anaphorically related to the current sentence's content.

Psycholinguistic research has examined the time course in which comprehenders recover and use alternatives, revealing the cognitive mechanisms at play that generate and shape the set of alternatives that ultimately form a durable part of a sentence's meaning. In this chapter, we frame this literature around whether an alternative is explicitly mentioned or left unmentioned in discourse and propose that this distinction draws upon different cognitive processes. Within this distinction, we also examine the relationship an alternative has to a marked constituent. In doing so, we identify some gaps in what is currently known about alternatives from the psycholinguistic perspective. There are still many open questions for future research to investigate.

The chapter proceeds as follows: Section 2 explores the landscape of alternatives with an eye to their lexical and discourse sources. Section 3 then takes up this framing over the time course of processing, starting with the early processes that play out for unmentioned and mentioned

alternatives before turning to their longer term encoding and maintenance. Two pilot studies will be reported: one on memory retrieval of mentioned alternatives, and the other on longer term maintenance of unmentioned scalar alternatives. Section 3 concludes with a call for further theorizing around linking hypotheses tying measures of processing to the products of comprehension.

2. The (processing) landscape of alternatives

Speakers must make choices about what to say and how to say it. Some of these choices reflect *alternatives*; when there are options available to speakers, the choice of one option can be used as a signal to communicate about the others. When speakers intend for comprehenders to draw these inferences, they can mark their choices through a variety of linguistic markings, including pitch accents, focus particles, word order, clefts, and scalar items that trigger implicatures. Alternatives are also argued to be involved more widely in the interpretation of negation, questions, and (counterfactual) conditionals, although these constructions are outside the scope of this chapter.

Focus constructions have long been considered primary markers for alternatives. For example, in response to the question, *Did John eat cake?*, a speaker might say, *John ate PIE*. The pitch accent on *pie* suggests that there were multiple dessert options, cake, pie, and perhaps even ice cream, and John chose to eat pie and not the other selections. As this example indicates, pitch accented constituents alone can evoke the relevance of a contrast. However, speakers can also choose to use a focus particle which further identifies a relevant semantic relation, e.g., whether alternatives should be excluded (*only*) or included (*even/also*) as part of the sentence's interpretation.

When speakers use linguistic markers like focus to indicate the relevance of alternatives, comprehenders need to infer what alternatives a speaker had in mind. There are two main sources of alternatives. One source is discourse context in which alternatives that are overtly mentioned can be anaphorically related to the meaning of the current sentence. These alternatives need not be related to the alternative-marked constituent in any particular way apart from their relationship in discourse, and therefore comprehenders must keep the contextual relationships established between discourse entities in mind. Another source for alternatives is implicit recovery of unmentioned alternatives from an alternative-marked constituent which signals some kind of relation (e.g., lexical, semantic, conceptual, or situational) with that constituent's meaning.¹

Because alternatives can be purely contextual, only requiring that they be mentioned in the discourse, the semantic value of alternative marking such as focus must permit a very wide range of possible alternatives. Rooth (1992) suggests that these need only have the same semantic type of the focused constituent, while Katzir (2007) and Fox and Katzir (2011) propose a somewhat more constrained set of elements, any of which is at most as structurally complex as the focused constituent – still a very unconstrained set of possibilities.

This wide set of possibilities for alternatives may be likely when the source of alternatives is the discourse where there need not be any prior relation established between alternatives and marked constituents. Unmentioned alternatives, however, likely involve more constraint, relying on conceptual/semantic categories, situational knowledge, or scale structure to constrain what would otherwise be too wide a potential set of elements. Scalemates provide one constrained source of alternatives, where the alternative is related to the overt constituent via asymmetric entailment

¹ Unmentioned alternatives may also arise from the shared environment, e.g. as visual referents. These require the speaker and comprehender to reason about what is in the common ground more broadly, an issue we will set aside here.

(Horn, 1972), or some ordering by rank, space, or time or underlying scale of quantity or other metric, like size, temperature, luminance, among others (Hirschberg, 1985; Solt, 2015). Other alternatives are related to the way a language carves up different semantic fields such as color, animals, types of accommodation. Event and situational knowledge built up over a lifetime of experience may also play an important role in accessing alternatives that are not semantically or conceptually associated.

This suggests that the alternative set may be a bit of a mixed bag. Alternatives may enter the set because they are lexically/semantically related to the marked constituent in various ways but may also enter by dint of their discourse relation with the alternative-marked constituent. Often, both lexical/semantic and discourse relations may support certain alternatives, especially in natural everyday speech. Examining these factors independently, therefore, is important and will play a key role in our theorizing.

While much of the literature on alternative semantics assumes a very wide range of alternatives that arise from the discourse or same semantic type of the focused constituent, most psycholinguistic studies have examined a narrower range of alternative relations (though see Gotzner, 2015; c.f., Gotzner & Romoli, 2022, and Repp & Spalek, 2021, for review).² Table 1 provides a non-exhaustive survey of the landscape from the viewpoint of discourse status and relational source. As can be seen, the vast majority of studies have investigated alternatives that are lexically related to an alternative-marked word, either because they are semantically associated or related to one another on a scalar dimension. Much less is known about alternatives that are only situationally related to the utterance. While such a narrowing of potential relations may be unsurprising when it comes to unmentioned alternatives, this has also been the case for alternatives mentioned in prior discourse where very few studies have teased these sources apart.

		Mentioned	Unmentioned
Lexical relation	Semantic	Byram-Washburn, Kaiser, & Zubizarreta (2011); Calhoun, Yan, Salanoa, Taupi, & Va'ai (2023); Fraundorf, Watson, & Benjamin (2010); Fraundorf, Benjamin, & Watson (2013); Gotzner & Spalek (2017); Gotzner & Spalek (2018); Gotzner, Spalek, & Wartenburger (2013); Gotzner, Wartenburger, & Spalek (2016); Kim, Gunlogson, Tanenhaus, & Runner (2015); Spalek, Gotzner, & Wartenburger (2014)	Braun & Tagliapietra (2010); Calhoun, Yan, Salanoa, Taupi, & Va'ai (2023); Fraundorf, Watson, & Benjamin (2010); Fraundorf, Benjamin, & Watson (2013); Gotzner (2019); Gotzner & Spalek (2016); Gotzner & Spalek (2018); Gotzner, Wartenburger, & Spalek (2016); Husband & Ferreira (2016); Kaldi, Szollosi, & Babarczy (2021); Kim, Gunlogson, Tanenhaus, & Runner (2015); Koch & Spalek (2021); Spalek & Oganian (2019); Tjuka, Nguyen, & Spalek (2020); Yan, Calhoun, & Warren (2019; 2023)
	Scalemate		Benz, Bombi, & Gotzner (2018); Bott & Frisson (2022); Chevallier, Noveck, Nazir, Bott, Lanzetti, & Sperber (2008); de Carvalho, et al., (2016); Doren, et al., (2009);

² Current psycholinguistic research has also been primarily limited to nouns and adjectives, though see Gotzner, Sturt, and Lacina (in press) for recent work on verbs and verb phrases.

			Lacina, Alexandropoulou, Ronai, & Gotzner (2023); Gotzner, Solt, and Benz (2018); Rees and Bott (2018); Ronai & Xiang (2023); Schwarz, Clifton, & Frazier (2008); Waldon & Degen (2020); van Tiel, et al. (2016)
Contextual Relation	Situational	Byram-Washburn, Kaiser, & Zubizarreta (2011); Jördens, Gotzner, & Spalek (2020)	Kim, Gunlogson, Tanenhaus, & Runner (2015)
	Ad hoc scale		Rees and Bott (2018); Tomlinson, Gotzner, & Bott (2017); Waldon & Degen (2020)

Table 1: Overview of psycholinguistic studies on alternatives investigating mention and relation.

While there are clear gaps in the empirical landscape, the research that has been reported already shows that these different sources of alternatives lead to different processing profiles and long-term meaning representations. We take this up in the next section.

3. Alternatives in time

3.1. Recovery of alternatives in early processing

Accessing the relevant alternatives to any utterance and using them to enrich sentence meanings may seem like a demanding time-intensive process, but much psycholinguistic research has found that comprehenders are able to rapidly access and use alternatives very early in the time course of language processing (Gotzner & Spalek, 2019). There now exists a body of evidence concerning the cognitive mechanisms that make this possible. Which mechanisms, however, depends on the source of alternatives. Fairly clear are unmentioned alternatives, which rely on an activation/selection mechanism that uses some relationship to the marked constituent to access these alternatives. Less well understood are mentioned alternatives, which we will propose rely on retrieval mechanisms that can navigate discourse structure. We will first examine the activation/selection of unmentioned alternatives before turning our attention to the retrieval of mentioned alternatives.

3.1.1. Activation/selection of unmentioned alternatives

Activation/selection mechanisms are often proposed as part of the cognitive architecture of language processing. Several lines of research have found that the set of relevant alternatives that comprehenders use is generated and rapidly refined over time in early processing. Evidence has accumulated that at first a very broad set of candidates for the alternative set are initially activated through their relationship to the marked constituent and its context. This initial set of candidates includes both true alternatives as well as elements that are merely associated. Selection mechanisms have been proposed to weed out mere associates, leaving the comprehender with just those true alternatives that are relevant for comprehension.

3.1.1.1. Unmentioned focus alternatives

Much of the evidence for this rapid activation and selection process comes from lexical decision studies which ask participants to respond whether a letter string forms a word of their language. Response times in lexical decision tasks are known to be quicker when the letter string is a word that is semantically primed by prior stimuli, indicating that the concept related to the word's meaning is

already active, or primed, in participant's minds. Braun and Tagliapietra (2010) used a lexical decision task with target strings appearing immediately after the offset of the critical word (SOA³: 0 ms) in Dutch sentences like *In Florida fotografeerde hij een FLAMINGO* 'In Florida he photographed a FLAMINGO'. They found that both true alternatives, like *pelikaan* 'pelican', and mere semantic associates, like *roze* 'pink', to a contrastively accented word were primed relative to an unrelated word (*beroemdheid* 'celebrity'). This suggests that participants initially activate a wide pool of possible candidates for the alternative set, including those that are appropriate alternative meanings for the focused word, as well as those that are merely present via their semantic association with the focused word. While this could suggest that comprehenders are unclear about which candidate items should be alternatives, it seems that comprehenders ultimately use their representation of a sentence's focus value to select from the set of candidates just those that are true alternatives. Using a similar design in English, Husband and Ferreira (2016) found that priming was maintained only for true alternatives 750 ms after the offset of the contrastively accented word. That is, mere semantic associates were no longer primed. This continued priming of true alternatives was also reported at a later SOA of 1,500 ms in Mandarin Chinese by Yan, Calhoun, and Warren (2023) who also found that mere semantic associates remain unfacilitated with longer SOAs.

Related results with longer SOAs have also been reported using probe recognition studies where participants were asked if a word appeared in the previous sentence/discourse. Because unmentioned alternatives are, by hypothesis, active in a comprehender's mind but unmentioned in the discourse, response times to probe words related to unmentioned alternatives in probe recognition tasks are inhibited, the slower response times indicating that participants find it more difficult to reject the probe word because it forms part of the sentence/discourse representation. Gotzner and Spalek (2017) manipulated the presence/absence of German focus particles *nur* 'only' / *auch* 'also' in critical sentences, shown in (1), to mark a constituent where alternatives are relevant. Probe words were presented 2,050 ms after the critical sentence. They found that alternative probe words were rejected more slowly when a focus particle was present compared to when it was absent, while mere semantic associates were rejected at the same rate regardless of a focus particle's presence/absence.

- (1) Carsten wollte gern Obst essen und griff in einen Korb.
'Carsten wanted to eat some fruit and reached into a basket.'
Er nahm sich (nur) Äpfel heraus.
'He (only) took out apples out of it.'
Er ernährte sich stets ausgewogen.
'He always lived on a balanced diet.'

Probe: Beeren 'berries' (Contrastive Alternative) / Maden 'maggots' (Non-contrastive associate)

Spalek and Oganian (2019) investigated even later stages of early processing, with probe words appearing 6,000 ms and 10,000 ms after critical sentences.⁴ They used a distinct prosodic pattern, manipulating the presence of a pitch accent falling on the relevant constituent (*Kirschen* 'cherries') or earlier in the sentence (on *Carsten*), shown in (2). They found that the speed with which probe words that are semantically associated with a sentence constituent are rejected depended on the placement of a contrastive accent. When the contrastive accent was on the associated constituent, probe words were rejected at the same speed as unrelated probe words, but when the contrastive

³ Stimulus Onset Asymmetry: The amount of time between the start of one stimulus and the start of another.

⁴ The late SOAs were conducive to Spalek and Oganian's (2019) fMRI study where the sluggish hemodynamic response is better detected at jittered longer lags.

accent was elsewhere in the sentence, the same probe words were rejected significantly more slowly. They propose that the inhibition is only found for probes that are generally related to the event but are not good alternatives for the focused constituent.

- (2) a. Carsten hat KIRSCHEN vom Baum gepflückt. (Alternative Related)
Carsten has picked CHERRIES from the tree.
- b. CARSTEN hat Kirschen vom Baum gepflückt. (Nonalternative Related)
CARSTEN has picked cherries from the tree.
- c. Thorsten hat die ZIEGEN auf dem Bauernhof gefüttert. (Unrelated)
Thorsten has fed the GOATS on the farm.

Probe: Pfirsiche 'peaches'

While the studies reviewed thus far have relied on a semantic relation between a marked constituent and the probed alternative, semantic relations are not the only possible relationships an unmentioned alternative can have. Unmentioned alternatives may also be accessed when they are related situationally to the sentence context of the marked constituent. Kim et al. (2015) investigated whether comprehenders can rapidly access situation-related alternatives by introducing scenarios that are relatively constrained in terms of alternatives given general world knowledge. They used a visual world paradigm where participants view visual displays of objects and listen to spoken language while their eye movements are tracked. Eye movements can rapidly converge on target object images when they become active in the mind during comprehension, sometimes leading to fixations that anticipate spoken language input. Kim et al., reasoned that comprehenders could use the presence of a focus particle in conjunction with a constraining context to rapidly fixate the target object image of a situationally related alternative before receiving auditory input that names that object. They manipulated the context prior to a target sentence to be constraining or neutral, shown in (3). The visual displays were also manipulated to include either four compatible referents in the neutral condition or one compatible referent (target picture: hot dogs) in constraining contexts. The proportion of fixations to the target picture were higher in bias contexts with *only* prior to the onset of the target word, suggesting that comprehenders can rapidly use the presence of a focus particle to activate a relevant situational alternative prior to its overt mention.

- (3) a. Constraining Context: Niel and Alex went to a baseball game. Alex wants to buy some Coke and some nachos.
- b. Neutral Context: Niel and Alex are at the supermarket. Alex wants to buy some bell peppers and some cherries.

Target Sentence: Neil (only) wants to buy some hot dogs.

Jördens, Gotzner, and Spalek (2020) also investigated situationally related alternatives using contrastive accent manipulation similar to Spalek & Oganian (2019). In their probe recognition study (SOA: 4,000 ms), they found that a probe word like *cows* was rejected at a slower rate when it was situationally related and an alternative to a contrastively accented word but not when it was situationally related but a nonalternative. Response times to situationally related probe words (*Kühe* 'cows') in the nonalternative condition were not significantly different from unrelated probe words (*Aufzüge* 'lifts').

- (4) a. Der Bauer hat STROH in den Stall gebracht. (Situationally Related Alternative)
'The farmer has STRAW into the barn brought.'
- b. Der BAUER hat Stroh in den Stall gebracht. (Situationally Related Nonalternative)
'The FARMER has straw into the barn brought.'

Probe: Kühe ‘cows’ (Situationally Related) / Aufzüge ‘lifts’ (Unrelated)

3.1.1.2. Unmentioned scalar alternatives

A second prominent source for unmentioned alternatives arises from the scalar relations introduced by scalar items. There is now a large psycholinguistics literature investigating scalar implicature, with much of it focused on whether and when comprehenders calculate a scalar implicature (see Chemla & Singh, 2014, for an empirical review). While these studies can be seen as addressing whether and when stronger scalar alternatives are active during comprehension, we focus here on those studies that directly concerned scalar alternatives.

Several studies directed at this source of alternatives have investigated how untimed responses to comprehension questions change when those questions probe an alternative, following important work on scalar implicature variability reported in Doran et al. (2009, 2012). van Tiel et al. (2016) presented participants with a sentence that included a scalar item (*intelligent*) and asked whether they inferred the negation of a stronger scalemate (*not brilliant*), shown in (5). Affirmative responses indicated that participants had adopted a sentence meaning enriched by the scalar implicature. As in Doran et al., they found high variability in the inference rates for different scalar items, but also observed higher implicature rates when the stronger alternative was more semantically distant from its scalemate. This was especially true when the stronger alternative denoted the upper bound of the scale (e.g., *free* as an upper-bounded stronger alternative to *cheap*). Surprisingly, higher word frequency, association strength, and semantic relatedness were not significant factors affecting rates of scalar implicature. This suggests that it is selection, not activation, that is more tightly tied to alternative processing, as these factors that should make the stronger alternative more available to comprehension because they are independently known to facilitate activation during lexical access.

- (5) John says: She is intelligent.
Question: Would you conclude from this that, according to John, she is not brilliant?

Following this work, Gotzner, Solt, and Benz (2018) provided further evidence that the variation in scalar implicature rates is more systematic. They investigated how the scale structure of scalemates factors into rates of scalar implicature by adding measures of extremeness (Morzycki, 2012), standard type (Kennedy & McNally, 2005), and polarity to van Tiel et al.’s task. They also investigated rates of negative strengthening, where negation of a stronger scalemate implies a scalar value below that of the weaker scalemate (Horn, 1989), e.g., where *John is not brilliant* is taken to mean that John is ‘less than intelligent’ or ‘rather stupid’. They used van Tiel et al.’s task to measure rates of scalar implicature for scalar pairs and added a second set of stimuli to measure their rate of negative strengthening, shown in (6). They found that scale structure factors influenced implicature rates, suggesting that additional factors related to the distinctness of alternatives matter. They also reported a strong anti-correlation between rates of scalar implicature and negative strengthening, suggesting that comprehenders sometimes do not calculate an implicature because they applied negative strengthening to the stronger scalemate.

- (6) Mary says: He is not brilliant.
Question: Would you conclude from this that, according to Mary, he is not intelligent?

How all these factors contribute to comprehension in real time is at present not well understood, though experimental work is beginning to shed light on this issue. de Carvalho et al., (2016) provided some initial evidence for a priming asymmetry between weaker and stronger scalar alternatives

using lexical decision with masked priming (34 ms prime + 34 ms pre- and post-prime masks; SOA: 34 ms). They presented participants with 43 scalar items drawn from 18 different scales, with primes being either weaker than the target (prime: *pouvoir* ‘can’, target: *devoir* ‘must’) or stronger than the target (prime: *jamais* ‘none’, target: *peu* ‘few’). Both prime-target orders showed priming relative to a consonant string control, with the weak-strong order showing greater facilitation over the strong-weak order.

In contrast, Ronai and Xiang (2023) used a lexical decision task with a 650 ms SOA and found that stronger scalar alternatives were not primed in isolation without sentence contexts (just *good/foreign* preceding the target *excellent*), but showed robust priming with sentence contexts (*The movie is good*) and in sentence contexts with focus particles (*The movie is only good*). Lacina, Alexandropoulou, Ronai, & Gotzner (2023) also used a lexical decision task to examine the priming of stronger alternatives, using a subset of the items in Ronai & Xiang (2023). They found that negated weaker scalemates in sentence contexts (*The coffee is not warm*) did not prime their stronger alternative (*hot*), while straightforward antonyms in sentence context (*The coffee is cold*) do.

These studies suggest that unmentioned alternatives related to scalar relations may also rely on the same activation/selection mechanisms investigated more broadly in the domain of focus. Scalemates that are relevant to scalar implicature appear to be active post-selection, while those that are not appear to be deactivated post-selection. Questions remain as to when such alternatives are initially activated and whether their continued priming post-selection truly reflects their use by comprehenders. Studying this will require manipulations that control scalar implicature. For example, in an unpublished lexical decision study with a 0ms SOA, Husband (2015) found that upward entailing contexts which encourage scalar implicature (e.g., *The soup was hot...*) actually slowed response times to stronger alternative targets (e.g., *scalding*) relative to downward entailing contexts where such implicature are blocked (*The soup was not hot...*). Weaker alternatives (e.g., *warm*) were unaffected by entailment direction. While this asymmetric processing profile may reflect effects of scalar implicature on stronger alternatives, how these results related to those of Ronai and Xiang (2023) and Lacina et al. (2023) will require further work to be done.

3.1.1.3. Mentioned alternatives and activation/selection mechanisms

Taken together, these and other studies have shown that unmentioned alternatives rely on activation from both marked constituents and more broadly from sentence/situational context followed by a rapid selection process unfolding over a half a second or so which prunes activated candidates that do not fit as alternatives for the sentence context. This activation/selection mechanism leaves the comprehender with a set of appropriate alternatives that can be used to infer a speaker’s intended meaning.

Table 2 summarizes the general state of play for unmentioned alternatives given the research conducted so far. While an activation/selection mechanism is broadly consistent with the empirical results thus far, clearly more research is needed to fill in empirical gaps. This is especially the case when the source for alternatives is situational or scalar in nature where fewer studies have been published. Initial activation is currently underexplored in these areas, though the evidence of activity post-selection requires that these have become active at some point in the time course. Additionally, it is not clear whether mere semantic associates of scalar items are filtered out of the alternative set during the calculation of scalar implicatures, though the priming results with antonyms reported in Lacina et al. (2023) suggest that they may not be.

		Initial Access (0 ms)	After Selection (~> 500 ms)
True alternative	Semantic	Active	Active

	Situational	?	Active
	Scalemate	?	Active
Non-alternative	Semantic	Active	Deactivated
	Situational	?	Inhibited
	Scalemate	?	?

Table 2: Summary of the time course of unmentioned alternatives given their relationship to marked constituents/contexts.

3.1.2. Retrieval of mentioned alternatives

As noted above, candidates for the alternative set need not only arise from implicit relationships to marked constituents. They can also be introduced overtly in the discourse as mentioned alternatives. While one might expect these to be treated similarly to unmentioned alternatives during language comprehension, research sometimes reveals differential behavior driven by their mentioned status.

3.1.2.1. Mentioned focus alternatives

Gotzner and Spalek (2019) used both lexical decision and probe recognition tasks to examine very early effects of mentioned alternatives on the processing of focus particles (SOA: 0 ms). As shown in (7), they constructed contexts to introduce three items and critical sentences with a contrastively pitch accented target word referring to one of them. The presence of a focus particle marking this target word in critical sentences was manipulated. Probe words were then either an alternative mentioned with the target word, an unmentioned alternative semantically related to the target word, or simply unrelated. In their lexical decision study, mentioned alternatives were facilitated more than unmentioned alternatives in conditions without a focus particle, though both showed facilitation overall. In conditions with a focus particle, both continued to show facilitation, with no difference between mentioned and unmentioned alternatives. The presence of a focus particle, therefore, slowed responses to mentioned alternatives, but did not affect unmentioned alternative response times. In their probe recognition study, mentioned and unmentioned alternatives were responded to equally more slowly than unrelated controls, but the presence of a focus particle had no significant effect.

- (7) In der Obstschüssel liegen Pfirsiche, Kirschen und Bananen.
 'In the fruit bowl, there are peaches, cherries and bananas.'
 Ich wette, Carsten hat Kirschen und Bananen gegessen.
 'I bet Carsten has eaten cherries and bananas.'
 Nein, er hat (nur) PFIRSICHE gegessen.
 'No, he (only) ate PEACHES.'

Targets/Probes: Kirschen 'cherries' (Mentioned), Melonen 'melons' (Unmentioned), Keulen 'clubs' (Unrelated)

The lack of focus particle effect on lexical decisions to unmentioned alternatives is consistent with our general summary concerning activation/selection for unmentioned alternatives. Slower responses to mentioned alternatives, however, suggest that focus particles were able to affect their processing. Since mentioned alternatives are already available as a potential contrast, the presence of a focus particle may have acted as an early cue to retrieve them as potential candidates for the alternative set. This is distinct from unmentioned alternatives as these rely on activation by the target word and therefore were unaffected by the presence of the earlier focus particle cue. Why a similar pattern did not emerge in probe recognition is less clear, though the decision process to correctly recognize mentioned alternatives and to reject unmentioned alternatives may have played

an intervening role. That both were slower than unrelated controls, however, suggests that comprehenders access mentioned and unmentioned alternatives very rapidly in early processing.

Gotzner, Wartenburger, and Spalek (2016) also investigated the same design exemplified in (7) at a slightly longer SOA (main verb duration + 2,050 ms silence) again with both lexical decision and probe recognition tasks. In lexical decision, mentioned alternatives were now more facilitated than unmentioned alternatives, though both were primed relative to an unrelated baseline. The presence of a focus particle slowed response times equally for all probe word conditions as an independent effect. In their probe recognition study, the presence of a focus particle inhibited correct recognition of mentioned alternatives and rejection of unmentioned alternatives. No effects were found for unrelated controls.

A similar delay was examined in Gotzner, Spalek, and Wartenburger (2013). They used a probe recognition task to examine effects of mentioned alternatives on the processing of contrastive accents and focus particles. They examined contexts that introduced two individuals, followed by a critical sentence where one of those individuals was referred to again either with a neutral accent, a contrastive accent, or a focus particle plus a contrastive accent. For their experimental items, the probe word, presented 2,000 ms after the offset of the sentence, was the alternative individual. An example item is given in (8). Response times to these probe words revealed no sensitivity to their manipulations.

- (8) Der Richter und der Zeuge verfolgten die Beweisführung.
'The judge and the witness followed the argument.'
Der Richter/Der RICHTER/(Nur) der RICHTER glaubte dem Angeklagten.
'The judge/The JUDGE/Only the JUDGE believed the defendant.'

Probe: Zeuge 'witness'

At this later processing time, around 2,000 ms post-target word, the general pattern for focus particles is slower processing in both lexical decision and probe recognition responses. In lexical decision, this slow down merely tempers what is otherwise a priming effect on mentioned and unmentioned alternatives, suggesting that both are affected by focus particle processing at this point. Similarly, in probe recognition, this slow down is in addition to the already inhibited responses to mentioned and unmentioned alternatives. The main difference between tasks, however, is that unrelated controls show effects of focus particles in lexical decision, but not in probe recognition.

A further delay in time was also explored in Gotzner, Spalek, and Wartenburger's (2013) probe recognition study. They added a filler sentence after the critical sentence (e.g., for (8): *Er verkündete das Urteil*. 'He announced the verdict. '), followed by 2,000 ms of silence. At this delay, responses to probes showed significant facilitation with contrastive pitch accents, and some facilitation with focus particles, though this was significantly slower than pitch accent-only conditions, suggesting continued interference effects on alternatives in the presence of focus particles.

Most studies investigating mentioned alternatives, including those above, have manipulated those alternatives to be semantically related to the focused constituent. Byram-Washburn, Kaiser, and Zubizarreta (2011), however, represents an early study that manipulated whether a mentioned alternative (*lock*) to be either semantically associated or unassociated to a word focused by *only* (in (9): *bolt* vs. *nails*). This design teases apart mentioned alternatives that must be retrieved solely from memory from those that could be activated, and thus possibly boosted, by their semantic association with the focused word. Using a lexical decision task (SOA: 250 ms), they found a priming effect for mentioned but unassociated targets when prime sentences included *only*, and a priming effect for

mentioned and semantically associated targets with prime sentences without *only*. These differences again suggest that focus particles are early cues to retrieve candidates for the alternative set, though semantic association appeared to interfere with priming in a way that is not well understood.

- (9) Christina wants to buy a lock, nails, and a bolt.
She needs these to fix her front entrance.
Two days ago, she went to a store that didn't have a wide selection.
At the store, she was able to buy (only) a bolt_{Associated}/nails_{Unassociated}/a lamp_{Unrelated}.

Target: lock

3.1.2.2. Mentioned scalar alternatives

Turning to scalar relations, there appears to be a significant gap in our understanding of how these are affected by mention. The closest cases come from untimed comprehension studies of scalar diversity reviewed above (Doran et al., 2009, 2012; Gotzner, Solt, & Benz, 2018; van Tiel et al., 2016). In these studies, context sentences that contained the scalar item were presented simultaneously with comprehension questions that contained overt mention of an alternative. Comprehenders therefore were allowed to reread and compare context sentences and comprehension questions if they chose to do so, which may have allowed them to consider the scalar item in context sentences in the context of the alternative mentioned in the question prior to making a response. Future research controlling the timing and presentation of alternatives could clarify this.

3.1.2.3. Mentioned alternatives and retrieval mechanisms

In general, evidence suggests that mentioned alternatives form part of the alternative set early on during language comprehension, especially when there is an early marker like a focus particle. As most of the studies on mentioned alternatives have investigated the role of focus particles and used probe recognition, these effects are generally inhibitory in early processing (Gotzner & Spalek, 2019). While this provides solid evidence that mentioned alternatives are recovered early in the comprehension process, suggesting that comprehenders can rapidly navigate discourse context to find them, the mechanisms that bring such alternatives into the alternative set have not been well explored.

One possibility is that comprehenders rely on a content-addressable memory architecture that otherwise supports many other language-related processes (Lewis & Vasishth, 2005; McElree, 2000; Van Dyke, 2007; Van Dyke & McElree, 2011; see Vasishth, Nicenboim, Engelmann, & Burchert, 2019 for an overview). In this architecture, the processing of input that depends on other representations triggers the comprehension system to search its memory and retrieve the relevant representations that that input depends on. This retrieval process is cue-based, in that search is guided by the content of the input representation, which is assumed to be bundles of features/cues. Search in memory happens in parallel; all representations that (partially) match the retrieval cues of the current input are potentially retrieved.

Content-addressable memory architectures have been supported by two key empirical signatures: First, the availability of a representation in memory is degraded by various forms of interference. Representations that share cues with the correct representation interfere with its retrieval, and the addition of intervening material also interferes with correct retrieval, either through temporal decay of the correct representation or an increase in interference from encoding new content. Second, access to a representation in memory is insensitive to the temporal or positional order in which that representation was encoded. These two signatures account for a speed-accuracy trade-off in

processing. Access to representations in memory is insensitive to their distance, reflected in the same initial speed of retrieval regardless of the amount of intervening material, but that distance and the presence of similar representations leads to declines in the availability of relevant representations, reflected in lower accuracy with the more intervening material. This pattern of speed and accuracy has been found for several phenomena that are antecedent in nature, including filler-gap dependencies (McElree, 2000; McElree, et al., 2003), pronominal reference (Foraker & McElree, 2007; Kush, Lidz, & Phillips, 2015), verb-phrase ellipsis (Martin & McElree, 2008), sluicing (Martin & McElree, 2011), and anaphoric presuppositions (Chen & Husband, 2018).

As another type of antecedent phenomenon, mentioned alternatives may also be recovered via content-addressable memory retrieval. Comprehenders are unlikely to have the capacity to maintain all previously mentioned discourse elements active in their focus of attention, and may not know which, if any, will be relevant for the current sentence. Therefore, they must rely on memory storage for maintenance. If access to this memory storage is content-addressable, we expect comprehenders to use cues from the focused constituent to directly access their memory representations of the prior discourse for possible mentioned alternatives to include in the alternative set. This direct access and retrieval of mentioned alternatives is predicted to display the characteristic empirical signatures of distance-insensitive accessibility to representations and distance-sensitive availability of representations.

Because this has not been investigated in the prior literature, we manipulated distance in a pilot probe recognition study based on 36 items from Fraundourf et al., (2013) (see section 3.2 below). 36 participants recruited online first read an initial context, self-paced sentence-by-sentence, which introduced two sets with two alternatives each, with the relevant two alternatives always occurring in the last sentence of the initial context. In the long-distance condition, an additional one to four sentences, also read self-paced sentence-by-sentence, intervened between the initial context and a final sentence. The short distance condition did not include these intervening sentences. The final sentence, read self-paced word-by-word, included all capitals font emphasis on the last or second-to-last word ending the sentence, signaling focus. 2,000 ms after the last word of the final sentence, participants were presented with a probe word and were asked to say whether this word appeared in the last sentence they read. Initial contexts and final sentences were manipulated so that the same probe word (*playground*) was either the target word that was focused in the final sentence, or it was a mentioned alternative from the initial context (when *skateboard park* was emphasized) or an unmentioned semantically associated alternative to the focused word (when *dog park* replaced *playground* in the initial context and was emphasized). We also collected data from an additional 36 participants where we removed font emphasis from the stimuli. A sample item is given in (10).

(10) Initial Context: The local parks commission had a busy meeting on Wednesday to decide how to spend its money for the year. People disagreed on whether the commission should focus its resources on expanding the parks or tidying the existing parkland. The parents wanted a playground_{Target/Mentioned}/*dog park*_{Unmentioned} and the teenagers wanted a skateboard park.

Distance: The meeting turned into a rather racuous affair. There were several incidents of shouting and some speakers were interrupted. It didn't seem like anyone was going to be very happy with the decision.

Critical Sentence: After a long debate, a compromise was worked out to tidy the parks and build a PLAYGROUND_{Target}/SKATEBOARD PARK_{Mentioned}/DOG PARK_{Unmentioned}.

Probe: playground

Accuracy, shown in Table 3, was very high. Focusing on contrasts where the probe word was an alternative, we found that mentioned probes were responded to less accurately than unmentioned probes ($z = 8.74, p < .001$), however this did not interact with either distance or emphasis. Interestingly, distance did not hamper retrieval of mentioned alternatives; if anything, distance improved mentioned alternative rejection rates ($z = 1.67, p = .054$). Analysis of accurate trial response times found that mentioned probes were slower than unmentioned probes ($t = -4.01, p < .001$). However, neither distance nor emphasis had an effect.

	Emphasis		No Emphasis	
	Short	Long	Short	Long
Target	98.4%	99.0%	99.0%	99.5%
Mentioned	83.2%	88.1%	80.9%	84.5%
Unmentioned	96.8%	97.8%	97.5%	98.0%

Table 3: Accuracy to probe type given emphasis and distance.

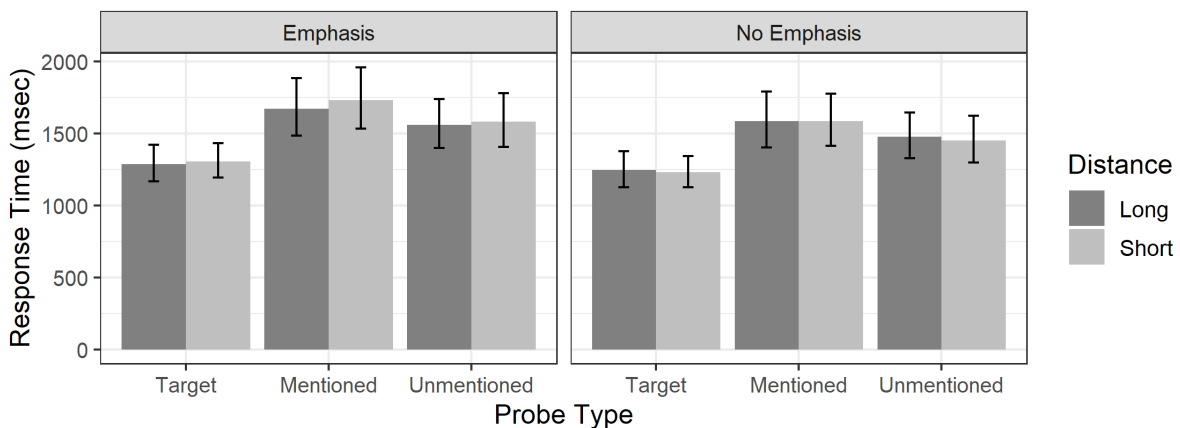


Figure 1: Response times to correctly recognized/rejected probes by emphasis and distance. Error bars represent 95% confidence intervals.

The differences in response times between mentioned and unmentioned alternatives suggest that participants successfully retrieved an alternative when it was mentioned in the context and do not rely merely on semantic association. However, these effects appeared to be independent of whether focus was marked by emphasis or not and it did not interact with distance. This is consistent with a content-addressable memory architecture as accessibility was not affected by distance. Availability of mentioned alternatives was, however, affected by distance, though this effect appears to be inconsistent with the predicted degraded effect expected in content addressable memory architectures as rejection rates improved in long distances. It may be that mentioned alternatives were still being held in active memory in short distance conditions and directly interfered with probe recognition accuracy, while long distance required mentioned alternative storage and retrieval. This may be related to Frazier and Duff's (2019) Activated Syntactic Memory hypothesis which proposes that comprehenders hold the current sentence and the last potentially independent clause in active memory. However, it is unclear how these results bear on mentioned focus alternatives specifically since no differential effects of font emphasis were detected in either accuracy or response times. It may be that participants in the no emphasis study imposed implicit contrastive prosody during silent reading (Fodor, 2002; Speer & Foltz, 2015) since there was no font differentiation between focused and non-focused constituents, or that self-paced reading disrupted the font emphasis manipulation, possibilities that will require further investigation.

Summing up, psycholinguistic evidence has shown that mentioned alternatives are rapidly recovered for the alternative set during language comprehension. How comprehenders navigate discourse memory to retrieve these alternatives in real-time, however, clearly will require further theorizing and research.

3.2. Longer-term maintenance and encoding of alternatives

Much of the experimental work on alternatives has focused on early processing. However, successful communication requires comprehenders to maintain alternatives in long-term memory over longer periods of time. Several studies have investigated whether mentioned alternatives are maintained during an experimental session (Calhoun et al., 2023; Fraundorf et al.; 2010; 2013; Spalek et al., 2014; Kaldi et al., 2021; Gotzner et al., 2013; Koch and Spalek, 2021; Tjuka et al., 2020).

Fraundorf, Benjamin, and Watson (2013) investigated the long-term maintenance of focus alternatives within an experimental session using font emphasis, mimicking contrastive pitch accents in spoken language. They had participants read short stories which introduced two pairs of referents and then mentioned one of the referents in each pair. Font emphasis was manipulated so that the first, second, both, or neither of the mentioned referents were contrastively focused. An example with contrast on the second referent is shown in (11).

- (11) Originally, the space probe was designed to fly past Mars and Jupiter and send photographs and videos back to NASA from both planets. However, due to a glitch in the system, the photos from MARS were lost.

Probe: The photos from Mars_{Target}/Jupiter_{Mentioned}/Saturn_{Unmentioned} were lost.

They found that contrastive focus improved participants' ability to recognize correct targets and reject mentioned alternatives on a memory task following a study phase where participants read all 36 stories. Unmentioned alternatives, however, were unaffected. This suggests that the contrastive focus led participants to better encode both the target and mentioned alternative in long-term memory.

Spalek, Gotzner, and Wartenburger (2014) found similar effects of focus particles on the memory of alternatives as Fraundorf and colleagues. Using the same stimuli as Gotzner and Spalek (2019) in (7), Spalek et al. manipulated the presence/absence of German focus particles *nur* 'only' / *auch* 'also' prior to the critical alternative. After a block of stimuli, participants were given a cued recall test in which they were asked to name the alternatives (e.g., *What was in the fruit bowl?*) They found that memory for the alternatives improved in the presence of a focus particle compared to a context in which there was no focus particle, suggesting that the focus particle enhanced the maintenance of alternatives along with the target word through the duration of the experiment regardless of the focus particle type.

This effect has been replicated in other languages and using other alternative producing constructions. Calhoun, Yan, Salanoa, Taupi, and Va'ai (2023) found similar effects for cleft constructions in Samoan. Participants were given a probe recognition task after a set of six discourses. Focused mentioned alternatives were recognized faster than unmentioned and unrelated alternatives, suggesting that mentioned alternatives maintain activation, while unmentioned do not. Similarly, Káldi, Szöllösi, and Babarczy (2021) used a change detection task to investigate the long-term activation of focus alternatives in Hungarian, which marks focus preverbally both prosodically and syntactically. In their study, participants heard short discourses as in (12).

- (12) A házibuli után Annára és Mikire hárult az elpakolás feladata. Rendeztek mindent, ami a kezük ügyébe került. A konyhában is volt eendő elég.
'After the party Ann and Mike undertook the work of tidying up. They created order everywhere they went. There was a lot to do in the kitchen, as well.'
- a. Miki [egy tányért]_{FOCUS} rakott be a szekrénybe. (Focus)
'Mike put [a plate]_{FOCUS} in the cupboard.'
- b. Miki rakott [egy tányért] be a szekrénybe. (No Focus)
'Mike put [a plate] in the cupboard.'

After hearing six discourses, participants played a virtual game for two minutes to prevent them from relying on working memory processes before doing a memory probe task. In the memory task, participants were asked to judge whether the probe was a sentence they heard in the previous part of the experiment. Probes were either the unchanged experimental sentence (*tányért* 'plate') or the critical noun was replaced with a semantically related word (*edényt* 'pot') or a contextually related word (*dobozt* 'box'). Káldi, et al.'s results were consistent with previous studies in which focus doesn't occur preverbally: When in the presence of a focused element, contextually suitable alternatives produced interference in the change detection task, suggesting alternatives remained active in long-term memory.

Interestingly, sex differences in alternative maintenance have been documented in the literature. Koch and Spalek (2021) again used the same stimuli described in (7). In this experiment, the cued recall task was given after 10 intervening trials to investigate long-term maintenance of alternatives. They found that recall for contextual alternatives was facilitated by contrastive focus. Interestingly, the observed benefit was predominantly driven by females. Tjuka, Nguyen, and Spalek (2020) replicated this pattern of data, including the finding that the benefit of focus was driven by females, in Vietnamese, a tonal language. Finally, the advantage for focused alternatives disappears when working memory is taxed (Gotzner & Spalek, 2017), suggesting that the retrieval of alternatives requires working memory resources.

Taken together, these studies suggest that alternatives are maintained over the course of an experiment, but comprehension often requires language users to maintain meaning representations for much longer than the course of a single experimental session. To date, only a single study has investigated long-term maintenance of alternatives outside of a single experimental session. Fraundorf, Watson, and Benjamin (2010) tested memory representations for the alternatives after 24 hours. After listening to the experimental stories in (11) above on day 1, participants came back on day 2 and were given a true/false verification task, which contained either the target, mentioned alternative, or unmentioned alternative. As in previous studies, target words in the experimental discourses were either marked with a contrastive or neutral accent. Fraundorf et al., found that contrastive accents increased both the recognition for statements involving the focused target and correct rejections for mentioned alternatives. There was no increase in correct rejections for the unmentioned alternative. This suggests that both a focused constituent and an explicitly mentioned alternative are better represented in memory when contrastive accenting is used, and that this representation is maintained for at least 24 hours. However, the memory benefit does not extend to any possible alternative.

The studies above suggest that unmentioned alternatives are not encoded in long-term memory. However, this may be due to the fact that in these focus constructions, unmentioned alternatives may not be critically relevant for understanding the meaning of the discourse, which may explain why they are not maintained. In (11), used by Fraundorf et al. (2013), Mars and Jupiter were the only planets overtly mentioned in the space mission discourse. While the names of other planets, like

Saturn, might be initially primed by mention of Mars, comprehenders have no compelling reason to encode Saturn as part of their long-term discourse representation as it is much less relevant and unlikely to be mentioned in subsequent discourse.

As these studies have exclusively examined focus alternatives that are derived from semantic associations, we do not know how other kinds of alternatives, such as those generated from scalar relationships or situational alternatives are maintained in memory. There is reason to expect that long-term maintenance of these kinds of alternatives will be different. Consider scalar alternatives. Although they are frequently unmentioned, scalar alternatives are critically relevant to comprehension, as scalar implicatures derive strengthened meanings by negating the scalar alternative. For example, when comprehenders interpret the scalar quantifier *some*, with its lexical meaning ‘at least some’, in upward-entailing contexts, they are often permitted to infer the negation of the stronger scalemate *all*, drawing the strengthened interpretation ‘at least some, but not all’. Given the relevance of stronger scalemate alternatives for the comprehension of the strengthened interpretation of *some*, unmentioned scalar alternatives may be more robustly represented in intermediate and long-term memory compared to unmentioned focus alternatives.

To begin to understand how unmentioned scalemates may be maintained in memory, we conducted a an in-person pilot study in the Language Lab the Center for Science and Industry (COSI) in Columbus, OH. 41 participants read short vignettes in which the second sentence included either the scalar *some* or its alternative *all*, as in (13). Participants read 20 vignettes before seeing a memory probe. During the memory phase, participants saw a version of the second sentence in the vignette in the same order in which they were presented. Either they saw it exactly as it had appeared (correct), or the scalar term was replaced with its alternative (alternative scalemate change), or the scalar term was replaced with *none* (non-scalar alternative ‘none’ change). Participants were asked to judge whether the sentence was the exact sentence they had seen previously. Participants repeated the vignette/memory probe pairs six times for a total of 120 items (60 experimental, 60 fillers).

- (13) Kaine was excited for the science fair.
He won some/all of the awards at the ceremony.
He was excited to share his work with everyone.

Probe: He won all/some/none of the awards at the ceremony.

We calculated d' scores for both critical sentence types as a measure of sensitivity (correct recognitions vs. false alarms). If the stronger scalemate is active in memory as an alternative due to scalar implicature we expect to see a decrease in recognition sensitivity to probe change (e.g., *some* changed to *all* in probes) due to more failures to reject the stronger scalemate (i.e., more ‘false alarms’). Recognition sensitivity for changes to weaker scalemates and non-scalemates should, however, be stronger as they are not relevant alternatives for scalar implicature. As Figure 3 illustrates, this is what we found. Participants showed less sensitivity to changes from *some* to *all* than changes from *all* to *some* ($t = 2.053, p = .043$), but were not differentially sensitive to ‘none’ change given the original quantifier *some* or *all* ($t = 0.819, p = .415$). These data are interestingly different from previous studies showing that unmentioned alternatives seem to be deactivated when they are probed after a delay (Calhoun et al., 2023; Fraundorf et al., 2010; 2013). This suggests that unmentioned alternatives, when relevant for comprehension, are durably encoded by comprehenders.

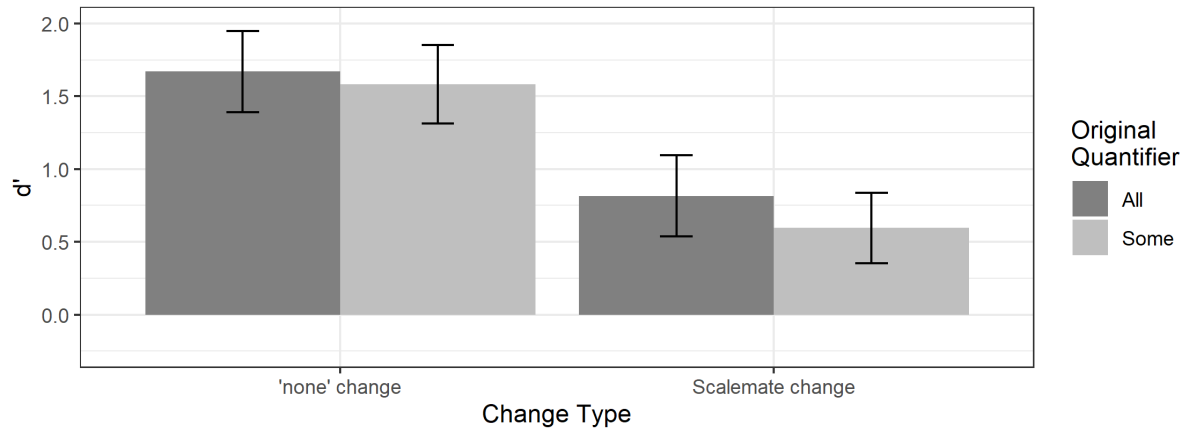


Figure 3. Average d' score by original quantifier and recognition probe change type. Error bars represent 95% confidence intervals.

Table 4 summarizes what is currently understood about the maintenance of alternatives in memory. Importantly, our understanding of the long-term maintenance is less well-understood because fewer studies on this topic have been conducted with fewer manipulations compared to the number of studies on the early activation/selection of alternatives. However, we can currently say that within an experiment, mentioned alternatives to focused elements seem to be maintained in memory as they cause interference during memory probe tasks (Calhoun et al., 2023; Spalek et al., 2014; Fraundorf et al., 2010; 2013; Gotzner et al., 2013; Káldi et al., 2021; Koch and Spalek, 2021; Tjuka et al., 2020). Unmentioned alternatives do not seem to be retained in long-term memory when the alternatives are derived from semantic associations (Calhoun et al., 2023; Fraundorf et al., 2010; 2013). However, our pilot data investigating the activation of scalar alternatives suggests that scalar alternatives may be retained in long-term memory even when they are unmentioned, perhaps because scalar alternatives are relevant for comprehension. Certainly more work must be done to better understand how different kinds of alternatives are differentially represented in memory. Additionally, these finds have been qualified by recent evidence that sex differences (Koch and Spalek (2021; Tjuka et al., 2020) and working memory differences (Gotzner & Spalek, 2017) exist in alternative maintenance. These differences mirror the differences found in the scalar implicature processing literature showing that increasing demands on working memory decreases the likelihood that comprehenders make the implicature (De Neys & Schaeken, 2007; Marty et al., 2013; see Nys, Wong, & Schaeken (2024) for review). Better understanding individual differences in the maintenance of alternatives may help elucidate individual differences in pragmatic processing, such as the finding that some comprehenders are “pragmatic responders” (i.e., they more often compute the implicature than not) while other comprehenders are “semantic responders” (i.e., they do not compute the implicature; Noveck & Posada, 2003, Bott & Noveck, 2004). Clearly, much more work must be done to understand the role of individual differences in the maintenance of alternatives and how this may be related to pragmatic processing.

	Early (0 ms)	Early (~>500 ms)	Late (same study)	Late (1 day)
Mentioned	Retrieved	Maintained	Maintained	Maintained
Unmentioned	Accessed	Maintained	Lost?	Lost?
Associates	Accessed	Suppressed	N/A	N/A

Table 4. Summary of the time course of maintenance of alternatives in memory

4. Conclusion

Comprehenders are often faced with the task of inferring a speaker's meaning. One way they do this is by considering what *alternatives* the speaker could have said but did not. This chapter has explored what current empirical evidence suggests about the cognitive mechanisms that are used by comprehenders to generate a set of relevant alternatives and to understand whether different sources of information trigger different processes that may impact comprehension over time. We considered whether alternatives were explicitly mentioned in the discourse or unmentioned but implicitly related. We further considered whether alternatives were related by a semantic, situational, or scalar relationship to a marked utterance.

Evidence, predominantly from lexical decision tasks, suggests that comprehenders immediately activate a set of unmentioned candidates for the alternative set through their relationship to the marked constituent and its context and retrieve mentioned alternatives from discourse memory. This initial set of candidates includes both true alternatives as well as elements that are merely associated. Selection mechanisms, operating rapidly afterwards (~500 ms), weed out mere associates, leaving only those true alternatives that are relevant for comprehension activated. Evidence from probe recognition tasks suggests that true alternatives are then maintained in memory, with mentioned alternatives showing the most success at long term encoding, related perhaps to their relevance for successful comprehension.

This research has been important in establishing the time course of processing alternatives, but questions still remain and important theoretical work is still needed. One area that we have not emphasized so far is the linking hypothesis between how active an alternative is in a comprehender's mind and how that alternative is ultimately used for comprehension. Active alternatives affect response times, but it is unclear whether and how that activity is related to what a comprehender encodes as part of the durable mental representation of discourse. For example, Ronai and Xiang (2023) were unable to find evidence for a correlation between the amount of priming of the strong scalar terms and the rate of scalar implicature inferences. Indeed, the measures of other real-time sentence processing phenomena are known to not necessarily reflect comprehenders' sentence interpretations (see Ferreira & Patson, 2007, for a review). While clever theory and experimental design can link activity and use, further research is needed to make these links more direct and clearer in our theories of language comprehension, both concerning alternatives and in phenomena further afield.

REFERENCES

- Benz, A., Bombi, C., and Gotzner, N. (2018). Scalar diversity and negative strengthening. in *Proceedings of Sinn und Bedeutung 22, Vol. 1*, eds U. Sauerland and S. Solt (Berlin: ZAS), 191–204.
- Bott, L., & Frisson, S. (2022). Salient alternatives facilitate implicatures. *PLoS One*, 17(3), e0265781.
- Bott, L., & Noveck, I. A. (2004). Some utterances are underinformative: The onset and time course of scalar inferences. *Journal of memory and language*, 51(3), 437-457.
- Braun, B., & Tagliapietra, L. (2010). The role of contrastive intonation contours in the retrieval of contextual alternatives. *Language and Cognitive Processes*, 25(7-9), 1024-1043.
- Byram-Washburn, M., Kaiser, E., & Zubizarreta, M. L. (2011). Focus facilitation and non-associative sets. In *SemDial 2011: Proceedings of the 15th Workshop on the Semantics and Pragmatics of Dialogue* (pp. 94–102).
- Calhoun, S., Yan, M., Salanoa, H., Taupi, F., & Kruse Va'ai, E. (2023). Focus effects on immediate and delayed recognition of referents in Samoan. *Language and Speech*, 66(1), 175-201.

- Chemla, E., & Singh, R. (2014). Remarks on the experimental turn in the study of scalar implicature, Part II. *Language and Linguistics Compass*, 8(9), 387-399.
- Chen, S. Y., & Husband, E. M. (2018). Comprehending anaphoric presuppositions involves memory retrieval too. *Proceedings of the Linguistic Society of America*, 3(1), 44-1.
- Chevallier, C., Noveck, I. A., Nazir, T., Bott, L., Lanzetti, V., & Sperber, D. (2008). Making disjunctions exclusive. *Quarterly Journal of Experimental Psychology*, 61(11), 1741-1760.
- De Carvalho, A., Reboul, A. C., Van der Henst, J. B., Cheylus, A., & Nazir, T. (2016). Scalar implicatures: The psychological reality of scales. *Frontiers in Psychology*, 7, 1500.
- De Neys, W., & Schaeken, W. (2007). When people are more logical under cognitive load: Dual task impact on scalar implicature. *Experimental psychology*, 54(2), 128-133.
- Doran, R., Ward, G., Larson, M., McNabb, Y., & Baker, R. E. (2012). A novel experimental paradigm for distinguishing between what is said and what is implicated. *Language*, 88(1), 124-154.
- Doran, R., Baker, R. E., McNabb, Y., Larson, M., & Ward, G. (2009). On the non-unified nature of scalar implicature: an empirical investigation, *International Review of Pragmatics*, 1. 1-38.
- Ferreira, F., & Patson, N. D. (2007). The 'good enough' approach to language comprehension. *Language and Linguistics Compass*, 1(1-2), 71-83.
- Fodor, J. D. (2002). Psycholinguistics cannot escape prosody. In *Proceedings of the Speech Prosody 2002 Conference*, 83-90.
- Foraker, S., & McElree, B. (2007). The role of prominence in pronoun resolution: Active versus passive representations. *Journal of Memory and Language*, 56(3), 357-383.
- Fox, D., & Katzir, R. (2011). On the characterization of alternatives. *Natural language semantics*, 19, 87-107.
- Fraundorf, S. H., Benjamin, A. S., & Watson, D. G. (2013). What happened (and what did not): Discourse constraints on encoding of plausible alternatives. *Journal of Memory and Language*, 69 (3), 196–227. <https://doi.org/10.1016/j.jml.2013.06.003>
- Fraundorf, S. H., Watson, D. G., & Benjamin, A. S. (2010). Recognition memory reveals just how CONTRASTIVE contrastive accenting really is. *Journal of Memory and Language*, 63(3), 367–386. <https://doi.org/10.1016/j.jml.2010.06.004>
- Fraundorf, S. H., Watson, D. G., & Benjamin, A. S. (2015). Reduction in prosodic prominence predicts speakers' recall: implications for theories of prosody. *Language, Cognition and Neuroscience*, 30(5), 606–619.
- Frazier, L., & Duff, J. (2019). Repair or accommodation? Split antecedent ellipsis and the limits of repair. *Glossa: A Journal of General Linguistics*, 4(1) : 78.
doi: <https://doi.org/10.5334/gjgl.728>
- Gotzner, N. (2017). *Alternative sets in language processing: How focus alternatives are represented in the mind*. Cham, Switzerland: Palgrave studies in Pragmatics, Language and Cognition, Palgrave Macmillan.
- Gotzner, N., & Romoli, R. (2022). Meaning and alternatives. *Annual Review of Linguistics*, 8(1), 213-234.
- Gotzner, N., Solt, S., & Benz, A. (2018). Adjectival scales and three types of implicature. In *Semantics and Linguistic Theory* (Vol. 28, pp. 409-432).
- Gotzner, N., & Spalek, K. (2016). The role of contrastive and non-contrastive associates in the interpretation of focus particles. *Discourse Processes*, 8(1), 59–95.
- Gotzner, N., & Spalek, K. (2017). Role of contrastive and noncontrastive associates in the interpretation of focus particles. *Discourse Processes*, 54(8), 638-654.
- Gotzner, N., & Spalek, K. (2019). The life and times of focus alternatives: Tracing the activation of alternatives to a focused constituent in language comprehension. *Language and Linguistics Compass*, 13(2), e12310.

- Gotzner, N., Spalek, K., & Wartenburger, I. (2013). How pitch accents and focus particles affect the recognition of contextual alternatives. In M. Knauff, M. Pauen, N. Sebanz, & I. Wachsmuth (Eds.), *Proceedings of the 35th annual meeting of the cognitive science society* (pp. 2434–2440). Austin, TX: Cognitive Science Society.
- Gotzner, N., Wartenburger, I., & Spalek, K. (2016). The impact of focus particles on the recognition and rejection of contrastive alternatives. *Language and Cognition, 8*, 59–95.
<https://doi.org/10.1017/langcog.2015.25>
- Horn, L. R. (1972). *On the semantic properties of logical operators in English*. PhD Thesis, University of California, Los Angeles.
- Husband, E. M. (2015). Inhibition in the computation of scalar implicature. Poster given at the 28th CUNY Human Sentence Processing Conference, Los Angeles, CA.
- Husband, E. M., & Ferreira, F. (2016). The role of selection in the comprehension of focus alternatives. *Language, Cognition and Neuroscience, 31*(2), 217-235.
- Jördens, K. A., Gotzner, N., & Spalek, K. (2020). The role of non-categorical relations in establishing focus alternative sets. *Language and Cognition, 12*(4), 729-754.
- Káldi, T., Szöllösi, Á., & Babarczy, A. (2021). Hungarian Structural Focus: Accessibility to Focused Elements and Their Alternatives in Working Memory and Delayed Recognition Memory. *Frontiers in Psychology, 12*33.
- Katzir, R. (2007). Structurally-defined alternatives. *Linguistics and philosophy, 30*, 669-690.
- Kim, C. S., Gunlogson, C., Tanenhaus, M. K., & Runner, J. T. (2015). Context-driven expectations about focus alternatives. *Cognition, 139*, 28-49.
- Koch, X., & Spalek, K. (2021). Contrastive intonation effects on word recall for information-structural alternatives across the sexes. *Memory & Cognition, 49*(7), 1312-1333.
- Kush, D., Lidz, J., & Phillips, C. (2015). Relation-sensitive retrieval: Evidence from bound variable pronouns. *Journal of Memory and Language, 82*, 18-40.
- Lacina, R., Alexandropoulou, S., Ronai, E., & Gotzner, N. (2023). Which alternatives are relevant in scalar implicature processing? A priming study with antonyms and negation. In M. Goldwater, F. K. Anggoro, B. K. Hayes, & D. C. Ong (Eds.), *Proceedings of the Annual Meeting of the Cognitive Science Society, 45*.
- Lewis, R. L., & Vasisht, S. (2013). An activation-based model of sentence processing as skilled memory retrieval. In *Dictionary of World Philosophy* (pp. 375-419). Routledge.
- Martin, A. E., & McElree, B. (2008). A content-addressable pointer mechanism underlies comprehension of verb-phrase ellipsis. *Journal of Memory and Language, 58*(3), 879-906.
- Martin, A. E., & McElree, B. (2011). Direct-access retrieval during sentence comprehension: evidence from sluicing. *Journal of Memory and Language, 64*(4), 327-343.
- Marty, P. P., & Chemla, E. (2013). Scalar implicatures: Working memory and a comparison with *only*. *Frontiers in Psychology, 4*, 403.
- McElree, B. (2000). Sentence comprehension is mediated by content-addressable memory structures. *Journal of Psycholinguistic Research, 29*, 111-123.
- McElree, B., Foraker, S., & Dyer, L. (2003). Memory structures that subserve sentence comprehension. *Journal of Memory and Language, 48*(1), 67-91.
- Morzycki, M. (2012). Adjectival extremeness: Degree modification and contextually restricted scales. *Natural Language and Linguistic Theory 30*, 567–609. doi: 10.1007/s11049-011-9162-0
- Norberg, K. A., & Fraundorf, S. H. (2021). Memory benefits from contrastive focus truly require focus: evidence from clefts and connectives. *Language, Cognition and Neuroscience, 36*(8), 1010-1037.

- Noveck, I. A., & Posada, A. (2003). Characterizing the time course of an implicature: An evoked potentials study. *Brain and language*, *85*(2), 203-210.
- Nys, B. L., Wong, W., & Schaeken, W. (2024). Some scales require cognitive effort: A systematic review on the role of working memory in scalar implicature derivation. *Cognition*, *242*, 105623.
- Pierrehumbert, J., & Hirschberg, J. (1990). The meaning of intonational contours in the interpretation of discourse. In P. Cohen, J. Morgan & M. Pollack (Eds.), *Intentions in Communication* (pp. 271-311). Cambridge, MA: MIT Press.
- Repp, S., & Spalek, K. (2021). The role of alternatives in language. *Frontiers in Communication*, *6*, 682009.
- Rees, A., & Bott, L. (2018). The role of alternative salience in the derivation of scalar implicatures. *Cognition*, *176*, 1-14.
- Ronai, E., & Xiang, M. (2023). Tracking the activation of scalar alternatives with semantic priming. *Experiments in Linguistic Meaning*, *2*, 229-240.
- Rooth, M. (1985). Association with focus. Unpublished doctoral dissertation, Cornell University.
- Rooth, M. (1992). A theory of focus interpretation. *Natural Language Semantics*, *1*, 75–116.
[https://doi.org/ 10.1007/BF02342617](https://doi.org/10.1007/BF02342617)
- Schwarz, F., Clifton Jr, C., & Frazier, L. (2007). Strengthening ‘or’: Effects of focus and downward entailing contexts on scalar implicatures. In J. Anderssen, K. Moulton, F. Schwarz, and C. Ussery (eds.) *University of Massachusetts Occasional Papers in Linguistics*, *33*(1), 9.
- Spalek, K., Gotzner, N., & Wartenburger, I. (2014). Not only the apples. Focus-sensitive particles improve memory for information-structural alternatives. *Journal of Memory and Language*, *70*, 68–84. [https://doi.org/ 10.1016/j.jml.2013.09.001](https://doi.org/10.1016/j.jml.2013.09.001)
- Spalek, K., & Oganian, Y. (2019). The neurocognitive signature of focus alternatives. *Brain and Language*, *194*, 98-108.
- Speer, S., & Foltz, A. (2015). The implicit prosody of corrective contrast primes appropriately intonated primes (for some readers). In L. Frazier & E. Gibson (Eds.), *Explicit and implicit prosody in sentence processing: Studies in honor of Janet Dean Fodor* (Studies in Theoretical Psycholinguistics 46) (pp. 263–285). Springer. doi:10.1007/978-3-319-12961-7
- Tjuka, A., et al. 2020 Foxes, deer, and hedgehogs: The recall of focus alternatives in Vietnamese. *Laboratory Phonology: Journal of the Association for Laboratory Phonology* *11*(1): 16, pp. 1–29. DOI: <https://doi.org/10.5334/labphon.253>
- Tomlinson Jr, J. M., Gotzner, N., & Bott, L. (2017). Intonation and pragmatic enrichment: How intonation constrains ad hoc scalar inferences. *Language and Speech*, *60*(2), 200-223.
- Van Dyke, J. A. (2007). Interference effects from grammatically unavailable constituents during sentence processing. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *33*(2), 407.
- Van Dyke, J. A., & McElree, B. (2011). Cue-dependent interference in comprehension. *Journal of Memory and Language*, *65*(3), 247-263.
- Van Tiel, B., Van Miltenburg, E., Zevakhina, N., & Geurts, B. (2016). Scalar diversity. *Journal of Semantics*, *33*(1), 137-175.
- Vasishth, S., Nicenboim, B., Engelmann, F., & Burchert, F. (2019). Computational models of retrieval processes in sentence processing. *Trends in Cognitive Sciences*, *23*(11), 968-982.
- Waldon B, Degen J. 2020. Symmetric alternatives and semantic uncertainty modulate scalar inference. In Proceedings of the 42nd Annual Conference of the Cognitive Science Society (CogSci 2020), ed. S Denison, M Mack, Y Xu, BC Armstrong, pp. 123–29. Austin, TX: Cogn. Sci. Soc.

- Yan, M., Calhoun, S., & Warren, P. (2023). The role of prominence in activating focused words and their alternatives in Mandarin: Evidence from lexical priming and recognition memory. *Language and Speech*, 66(3), 678-705.
- Yan, M., Calhoun, S., & Warren, P. (2019). The role of prosody in priming alternatives in Mandarin Chinese. In S. Calhoun, P. Escudero, M. Tabain, & P. Warren (Eds.), *Proceedings of the 19th International Congress of Phonetic Sciences, Melbourne, Australia 2019* (pp. 437–441). Australasian Speech Science and Technology Association.