4

Constructing Alternatives: Evidence for the Early Availability of Contextually Relevant Focus Alternatives

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4.1 Introduction

Determining the focus of an utterance is an essential component of sentence interpretation. In English and other languages, focus (indicated here with $[\cdot]_F$ brackets) contains a prominent element, signaled by morphosyntactic or suprasegmental reflexes such as pitch accent (marked by underlining here), though the scope of focus usually depends on the context of utterance (Jackendoff, 1972; Selkirk, 1984). Typically, theoretical accounts of focus emphasize that the focus of an utterance is interpreted against a contextually determined set of alternatives (Krifka, 1992; Rooth, 1985, 1992). For instance, the sentence in (1) not only conveys that the referent corresponding to the focused phrase *Merle*

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N. Gotzner et al. (eds.), *Alternatives in Grammar and Cognition*, Palgrave Studies in Pragmatics, Language and Cognition, https://doi.org/10.1007/978-3-031-76676-3_4

Haggard plays the fiddle, but also (by default) an implicature that there is some relevant set of individuals who do not play the fiddle.

(1) [Merle Haggard]$_F$ plays the fiddle.

Intuitively, membership to this set of alternatives is determined by the context. If the discourse concerns country singers, then the alternatives to *Merle Haggard* in (2) might include individuals such as *Willie Nelson* or *Dolly Parton*. Crucially, though, any individual could theoretically serve as an alternative to the name in focus, if warranted by the context.

Focus is realized in different ways, both across and within languages, and can be categorized into multiple types (Büring, 2009). A major distinction is between *bare* (or *free*) and *associated* focus. In bare focus, the focused element is not situated within the scope of a focus-sensitive operator. In general, the interpretive effect of excluding other salient possibilities in bare focus is considered an implicature and thus can be canceled by explicit denial (2)a. In instances of *associated* focus, focus-sensitive operators such as *only* and *also* are said to associate with focus to produce truth-conditional effects. For example, the effect of *only* (2)b is to exclude other contextually-salient possibilities not as an implicature, but as asserted or entailed content, and attempts to deny it are thus infelicitous.

(2) a. [Merle Haggard]$_F$ plays the fiddle.
Implicature: No other contextually-relevant individual plays fiddle
Denial: In fact, Dolly Parton plays the fiddle too.

b. Only [Merle Haggard]$_F$ plays the fiddle.
Entailment: No other contextually-relevant individual plays fiddle
Denial: # In fact, Dolly Parton plays the fiddle too.

In general, successful comprehension of an utterance containing focus requires inferring the set of alternatives intended on the part of the speaker. As (nearly) all sentences within a discourse contain focus, this inference process is likely an inescapable part of regular sentence comprehension. Yet, only recently has psycholinguistic research attempted to characterize how focus is processed in detail. This paper addresses how the alternative set required for focus interpretation is established and at what time point the language comprehension system has access to its members.

Early research from Cutler and Fodor 1979 using phoneme monitoring established that comprehenders are sensitive to the presence of focus during online comprehension, conclusions later supported by a host of reading studies (Beier & Ferreira, 2022; Benatar & Clifton, 2014; Birch & Rayner, 1997, 2010; Hoeks et al., 2023; Morris & Folk, 1998). Multiple visual-world studies have also established that comprehenders rapidly search for contextually relevant alternatives after encountering focus (Dahan et al., 2002; Ito & Speer, 2008; Kim et al., 2015; Watson et al., 2008; Weber et al., 2006). More recent research, using cross-modal forced-choice tasks, has investigated the cognitive mechanism used to identify alternatives and the time point at which those alternatives become available (Braun & Tagliapietra, 2010; Gotzner, 2017; Gotzner & Spalek, 2019; Gotzner et al., 2016; Husband & Ferreira, 2016; Jördens et al., 2020; Lacina et al., 2023).

Much of the recent literature has pursued a two-stage model which uses lexical activation to represent and select alternatives (Gotzner, 2017; Husband & Ferreira, 2016). After processing an element in focus, all of the words semantically related to that element will become highly activated through semantic priming. These highly activated words are often referred to as semantic *associates* and include potential alternatives to the relevant focus. In the second stage, a focus-sensitive mechanism selects the contextually relevant alternatives from among the associates and maintains their raised levels of activation. Eventually, only relevant alternatives will remain highly activated, yielding a representation of the appropriate alternative set.

The two-stage model presents a number of open issues regarding the role of semantic priming in alternative formation. The key feature of this model is that focus alternatives are first generated by a context-insensitive process, and then later *constrained* by the discourse. However, contextually relevant alternatives need not be semantically associated with the word in focus. To our knowledge, the case of semantically unrelated yet contextually relevant focus alternatives has not been directly investigated in experimental designs probing focus. This case is crucial to understanding the architecture of focus processing in a two-stage model, as the initial stage of semantic priming could not in principle provide these words with the increased activation necessary for inclusion in the initial focus alternative set.

To address these issues, we present the results of a cross-modal probe recognition task study. We employ discourses that make salient an *Associate alternative* (i.e., one which is semantically related to the focus) and another *Non-associate alternative* (i.e., one which is semantically unrelated to the focus). In doing so, we test the predictions of alternative models which emphasize the role of discourse representations over semantic priming in identifying alternatives. Counter to the predictions of a two-stage model, the results of our experiment suggest that both associate and non-associate alternatives are selected immediately upon encountering a focused element.

We first begin with a brief overview of the Alternative Semantics framework and survey the most directly relevant psycholinguistic research to date on focus alternatives. We then discuss the predictions of the two-stage model and its competitors with respect to the availability of focus alternatives during real-time comprehension. We conclude by arguing that the generation of focus alternatives is *constructive*, rather than *destructive* in nature, in that the set of focus alternatives is assembled according to contextual considerations in the earliest moments of focus processing.

4.1.1 Alternative Semantics

In formal semantics, syntactic constituents are associated with semantic values via an interpretation function (Heim & Kratzer, 1998). However, focus can enrich interpretation in multiple ways depending on the placement of focus, the focus structure, and the context. For example, both utterances in (3) consist of the same string and thus contribute the same core proposition: *Dolly likes Willie*, represented as $\textsc{like}(w)(d)$. However, the different locations of focus result in different ways that the proposition is interpreted in the context.

We follow the Alternative Semantics framework developed by Rooth (1985, 1992), in which a focused element is interpreted against a set of alternatives, abbreviated as ALTS, consisting of semantic values that can be substituted for the element in focus, in this case, any individual in the context, e.g., *Merle Haggard*, *Johnny Cash*, *Loretta Lynn*, etc. Focusing *Dolly* in (3)a expresses that *Dolly* does not like any contextually relevant individual in ALTS, $\forall x \in \text{ALTS}.[\neg\textsc{like}(x)(d)]$. In contrast, focus on *Willie* in (3)b expresses that no other contextually relevant individual in ALTS likes *Willie*, $\forall x \in \text{ALTS}.[\neg\textsc{like}(w)(x)]$.

(3) a. $[\underline{\text{Do}}\text{lly}]_F$ likes Willie
Assertion: $\text{LIKE}(w)(d)$
Implicature: $\forall x \in \text{ALTS}.[\neg\text{LIKE}(x)(d)]$
Dolly likes Willie and she doesn't like anyone else

b. Dolly likes $[\underline{\text{Will}}\text{ie}]_F$
Assertion: $\text{LIKE}(w)(d)$
Implicature: $\forall x \in \text{ALTS}.[\neg\text{LIKE}(w)(x)]$
Dolly likes Willie and no one else likes Willie

In Alternative Semantics, the interpretation of focus relies on a phonologically null anaphor C, which takes the contextually relevant set of alternatives as its referent.[1] For example, a highly plausible set of alternatives to *donuts* in (4) might be the class of other baked goods (5), e.g., *cookies*, *cupcakes*, etc.

(4) Willie eats only $[\underline{\text{do}}\text{nuts}]_F \sim C$

In this case, C would take the form depicted in (5)b. Focus-sensitive operators such as *only* in (5)a quantify over C when computing the specific effect of focus on interpretation in context.

[1] There is considerable variation in how alternatives are modeled in the theoretical literature. For instance, C is often treated as referring to a set of alternative propositions rather than a set of alternative semantic values to the focus as described here. The difference is subtle and it is unclear whether a propositional treatment of alternatives would make any distinct predictions with respect to processing. For ease of presentation, we will continue to treat C and the related notion of the alternative set as non-propositional, but we are not committed to this view. In general, while we assume a roughly Roothian framework in what follows, we intend to remain agnostic with respect to the formal implementation of alternatives.

(5) a. $[\![(4)]\!] = \text{EATS}(d)(w) \wedge \forall x \in \text{ALT}_C.[\neg\text{EATS}(x)(w)]$

b. $C = \{[\![\text{cookies}]\!], [\![\text{cupcakes}]\!], \ldots\}$

Importantly, while the class of baked goods is a highly plausible alternative set, the actual set will depend almost entirely upon the particular discourse context. For example, one could certainly imagine a context in which Willie has especially selective culinary taste, eating donuts to the exclusion of all other food. In this case, C would range over all types of food, not just baked goods, e.g., $C = \{[\![\text{cookies}]\!], [\![\text{cupcakes}]\!], [\![\text{pasta}]\!], [\![\text{kale}]\!], ...\}$.

In fact, the only restriction (beyond contextual relevance) which Rooth (1985, 1992) places upon the referent of C is that the alternatives must be semantically (type-theoretically) intersubstitutable with the focus (following the assumption that $C \subseteq$ ALTS). For example, a property P cannot serve as an alternative to an entity such as *Willie* in (6), nor can an entity serve as an alternative to a property such as *likes Willie* in (6b), as they belong to different semantic types.

(6) a. Dolly likes $[\underline{\text{Wil}}\text{lie}]_F \sim C$
$\text{LIKE}(d)(w) \wedge \forall x \in \text{ALT}_C.[\neg\text{LIKE}(d)(w)]$
Dolly likes Willie and she doesn't like anyone else relevant in the context

b. Dolly $[\text{likes } \underline{\text{Wil}}\text{lie}]_F \sim C$
$\text{LIKE}(d)(w) \wedge \forall P \in \text{ALT}_C.[\neg P(d)]$
Dolly likesW illie and she has no other contextually relevant properties

Although we have concentrated on how Alternative Semantics captures the compositional contribution of focused material, other theories of focus (e.g., Büring, 2016b; Krifka, 1992; Schwarzschild, 1999; Von Stechow, 1991) also treat focus as a kind of context-dependent abstraction that enriches the meaning of an expression against a set of contextually relevant alternatives. Implementational details may vary, but these long-standing intuitions are generally preserved across approaches.

Thus, although much of this paper and much of the experimental literature are framed in terms of Alternative Semantics, the majority of the discussion should straightforwardly extend to other frameworks.

In short, focus is a complex interface-spanning phenomenon. It enriches the meaning an expression by establishing a variety of potential relationships (e.g., exclusive, additive, etc.) between the focus and its contextually determined set of alternatives. Interpreting focus online requires a comprehender to infer the contents of this set within strict time constraints. This raises a number of interesting psycholinguistic questions. Chiefly, to what extent is language processing sensitive to the presence of focus online? It is clear that focus is crucial to interpretation given theoretical intuitions, but how incremental is the process of generating this interpretation? In the following section, we review evidence that interpreting focus is achieved by incremental processes, not merely post-sentential ones.

4.1.2 The Processing of Focus

4.1.2.1 Incremental Focus Processing

A large body of psycholinguistic research has established that comprehenders are sensitive to focus during incremental sentence comprehension. In a phoneme monitoring task, Cutler and Fodor (1979) found that subjects were faster to identify a phoneme when the containing constituent was in focus. They argued that a focused constituent attracts attention, yielding faster response times when the target phoneme occurs within that constituent (see Beier & Ferreira, 2022, for replication). However, the results of later reading time studies have been more mixed. While some studies found that, in keeping with the interpretation of Cutler and Fodor (1979), focus increases reading times (Benatar & Clifton, 2014; Birch & Rayner, 1997), others reported a decrease in readings times (Birch & Rayner, 2010; Morris & Folk, 1998). As Hoeks et al. (2023) note, the different results could be on account of conflating focus with the related but independent notion of newness. Using a maze task (Forster et al., 2009), Hoeks et al. (2023) found that new foci elicited slower response times than given foci, but that the penalty was reduced when alternatives to new foci were contextually mentioned. Together, these studies indicate that focus demands additional processing resources, which prior mention can reduce.

Visual-world studies have provided further evidence for the rapid inference of alternatives. Ito and Speer (2008) recorded the eye movements of subjects hanging ornaments onto a holiday tree according to auditory instructions. The authors manipulated whether these instructions contained a contrastive L+H* pitch accent (a strong cue to the presence of focus) or an H* pitch accent (a weaker cue to the presence of focus). They found that L+H* pitch accents generated a higher percentage of early fixations toward ornaments contrasting with previously mentioned ones (i.e., contextually relevant alternatives) than H* pitch accents did. Other visual-world studies concerning focus have found similar results (Dahan et al., 2002; Kim et al., 2015; Watson et al., 2008; Weber et al., 2006). As in other studies using different methods, these results support the conclusion that the processing of focus is not post-sentential. Rather, comprehenders immediately identify the presence of focus and subsequently engage in a search for contextually relevant alternatives.

While there is clear evidence for selecting focus alternatives during comprehension, the nature of the selection process and the representation of alternatives involved are less certain, and numerous foundational questions remain. Under Alternative Semantics, a variable C has as its referent a set of contextually relevant alternatives. Is such a set represented during comprehension? And, if so, how closely does this representation resemble the offline judgments which motivated the C variable? In principle, it is possible that the alternative set is less constrained online, including both contextually relevant alternatives and a large set of possible but contextually irrelevant ones. Or perhaps, more in-line with offline judgments, only contextually relevant alternatives are ever represented. A plethora of factors determine which alternatives are relevant in any given context. How and when does this mechanism tap into each of these information sources? Now, we turn our attention to models that address these issues.

4.1.2.2 The Selection of Alternatives

A number of lexical decision and probe recognition experiments have further investigated the selection of alternatives. Here, the emerging picture is that in the earliest moments after encountering focus, contextually relevant alternatives are activated along with irrelevant alternatives and semantically associated non-alternatives. Over time, however, only contextually relevant alternatives remain activated. The delayed influence of context provides evidence for a two-stage model of alternative selection.

Fraundorf et al. (2010) investigated whether deriving an interpretation for contrastive focus strengthens the encoding of a focused element and its alternatives in memory. Subjects listened to short recorded dialogues which introduced two alternatives (e.g., *British* and *French* in 7a), followed by a continuation mentioning only one (e.g., *British* in 7b). The type of pitch accent (H* vs. L+H*) on the focus was manipulated in the continuation sentence. Twenty four hours after the initial test, subjects were given probe sentences in one of three conditions, depicted in (8) below, targeting memory for the focused continuation and indicated whether the sentence was accurate.

(7) *Sample discourse pair from Fraundorf et al. (2010)*

a. Both the British and the French scientists had been searching Malaysia and Indonesia for the endangered monkeys.

b. Finally, the [<u>Bri</u>tish]$_F$ spotted one of the monkeys in Malaysia and planted a radio tag on it.

(8) *Probe sentence*

a. *Focus:* The British scientists found the endangered monkey.

b. *Alternative:* The French scientists found the endangered monkey.

c. *Unmentioned:* The Portuguese scientists found the endangered monkey.

Contrastive focus helped subjects correctly accept the probe sentences that contained foci and correctly reject probe sentences that contained mentioned alternatives. This suggests that contrastive focus not only creates the need to represent contextual alternatives, but to negate them during processing, possibly producing a stronger memory trace.

However, contrastive focus did not help subjects to correctly reject probe sentence containing unmentioned alternative (e.g., *Portuguese*). One possible explanation is that unmentioned alternatives are not represented in the alternative set and so are not explicitly negated, making it harder for subjects to correctly reject them later on. This result provides some evidence for a contextually restricted representation of the alternative set in processing, one which excludes unmentioned alternatives, at least in long-term memory.

Braun and Tagliapietra (2010) hypothesized that the alternative set is realized online through lexical activation. Under this view, alternatives are words which become activated from semantic association with the focused word. The authors presented subjects with recorded sentences in Dutch containing or lacking contrastive focus as indicated by pitch accent. In their study, immediately after the hearing the sentence, subjects performed a cross-modal lexical decision task on written target words. The targets were either plausible alternatives semantically associated with the focus (e.g., *hiking tour*), non-alternatives semantically associated with the focus (e.g., *jungle*), or non-alternative controls not semantically associated with the focus (e.g., *karate*).

(9) *Sample sentence targets from Braun and Tagliapietra (2010)*

  a. *Contrastive focus:* In the spring, they went on [sa<u>fa</u>ri]$_F$

  b. *No contrastive focus:* In the spring, they went on safari

(10) *Target word*

  a. *Alternative*: HIKING TOUR (TREKTOCHT in Dutch)

  b. *Associate Non-alternative*: JUNGLE

  c. *Control:* KARATE

In two experiments, Braun and Tagliapietra (2010) found that alternatives were accepted faster than controls, but only when the critical word was presented with contrastive pitch accent (i.e., L+H*). Braun and Tagliapietra (2010) also found a weak priming effect for associate non-alternatives, which was not influenced by the presence of focus. The authors argue that alternatives receive increased activation after encountering focus which distinguishes them from non-alternatives during processing. This difference in lexical activation between alternatives and non-alternatives can be thought of as instantiating the alternative set.

In order to investigate how the representation of alternatives evolves over time, Husband and Ferreira (2016) varied the point at which the lexical decision task was administered. They hypothesized that alternatives are selected online in a process similar to two-stage models of ambiguity resolution, in which context-appropriate senses are selected only after an initial context-insensitive stage (Swinney, 1979). In their model, all words that are semantically primed by the focus, including potential focus alternatives, are automatically activated, regardless of context. After a delay in which contextual information is accessed, only focus alternatives remain activated.

Husband and Ferreira (2016) ran a cross-modal lexical decision experiment with a between-subjects stimulus onset asynchrony (SOA) manipulation. In one experiment, a lexical decision task was administered immediately (i.e., 0 ms) after a potentially focused word in the prime (e.g., *sculptor*). In the other experiment, a lexical decision task was administered after a 750 ms delay.

(11) *Sample materials from Husband and Ferreira (2016)*

a. *Focused:* The museum thrilled the [sculptor]$_F$ ...

b. *Unfocused:* The museum thrilled the sculptor ...

(12) *Lexical decision targets*

a. *Alternative:* PAINTER

b. *Associate Non-alternative*: STATUE

c. *Control*: REGISTER

Without a delay, there was a priming effect, in which alternatives (e.g., *painter*) and associate non-alternatives (e.g., *statue*) were accepted faster than non-associate controls (e.g., *register*) independent of the pitch accent manipulation. However, after a 750 ms delay, an effect of focus was observed such that alternatives were accepted faster than either associate non-alternatives or controls, but only in the presence of a contrastive pitch accent.

The results clearly support a two-stage model for alternative selection. In the first stage, words which are semantically associated with the word in focus receive increased activation from semantic priming. Crucially, the first stage is not sensitive to context, in that semantic associates depend on the lexical-level properties of the item, not the discourse context. However, in the second stage, a focus-sensitive mechanism selects the set of contextually relevant alternatives, maintaining their activation, while the activation of non-alternatives decreases.[2] The two-stage model can explain both the observed effect of semantic priming and the delayed influence of focus in the lexical decision task.

All of the previous studies tested instances of *bare* focus which lacked a focus-sensitive operator. Recall that bare focus contrasts with instances of *associated* focus in which operators such as *only* and *also* interact with focus with truth-conditional effects. Addressing this gap in the literature, Gotzner et al. (2016) performed a cross-modal probe recognition experiment in German comparing *bare* and *associated* focus. The authors hypothesized that the truth-conditional nature of *associated* focus might encode alternatives more strongly in memory yielding different behavior from *bare* focus.

Subjects were presented with short two speaker discourses. Speaker A introduced a set of three alternatives (e.g., *peaches*, *cherries*, and *bananas*) and Speaker B selected one (e.g., *peaches*) using bare or associated contrastive focus. Roughly two seconds (2050 ms) after hearing the focus, subjects were presented with a written word and asked to indicate as quickly as possible whether or not that word had occurred anywhere in the audio. These probe words came in one of three conditions: mentioned alternatives (e.g., *cherries*), unmentioned but plausible alternatives (e.g., *melons*), and unmentioned non-alternative controls (e.g., *clubs*).

[2] Husband and Ferreira (2016) remain agnostic as to whether or the decreased activation of non-alternatives stems from an active process of suppression or a passive process of decay.

(13) *Sample discourse from Gotzner et al. (2016)*

a. **Speaker A:** In the fruit bowl, there are peaches, cherries, and bananas I bet Carsten has eaten cherries and bananas

b. **Speaker B:** No, he (only) ate [peaches]$_F$

(14) *Probe words*

a. *Mentioned*: CHERRIES

b. *Unmentioned*: MELONS

c. *Control*: CLUBS

Correct rejection of controls was fastest, followed by correct rejection of unmentioned alternatives, and lastly correct recognition of mentioned alternatives. The addition of a focus particle *only* increased average response times, but did not interact with the probe type. The authors argued that the increased response times reflect greater competition between elements for membership in the alternative set. In a follow-up, Gotzner and Spalek (2019) performed the same experiment with an SOA of 0 ms instead. Here, the authors found that controls were correctly rejected faster than the other two conditions were accepted, which did not significantly differ from one another. Again, the addition of the focus particle increased average response times across each condition.

While the results from these probe recognition tasks are highly informative, the fact that different response types correspond to different conditions presents some challenges for interpretation. To correctly respond to the different probe types, subjects would have to *accept* probes that occurred in the discourse, but would have had to *reject* probes that did not appear in the discourse. Consequently, the correct response to a mentioned alternative is a *Yes*, whereas the correct response to an unmentioned alternative is a *No*. However, it is difficult to directly compare behavior across these conditions as accepting and rejecting probes is known to engage different kinds of processing biases (Rotello & Macmillan, 2007). This is not to say that the results from these studies are invalid, but rather that some caution should be taken in interpreting them. To preview, the issue of mixed response types is addressed in the study we present below in that all correct responses are of the same type.

Taken together, these studies paint a cohesive picture in which processing focus occurs in two stages. First, an unrestricted alternative set is formed from lexical-level associative priming from the word in focus. This unrestricted set contains (i) mentioned alternatives, (ii) unmentioned yet plausible alternatives, and (iii) non-alternatives semantically associated with the focus. Soon after, contextual information is used to restrict the alternative set to mentioned alternatives, as well as unmentioned (but still plausible) alternatives. It appears that this restricted representation is the set according to which contrastive focus is interpreted and stored in long-term memory. Nonetheless, we note a number of questions and open issues with a two-stage view of focus alternative selection in the following section.

4.1.2.3 Limitations of Semantic Priming in Selecting Alternatives

While the experimental literature appears to support a two-stage model for selecting alternatives, numerous questions of implementation remain. In particular, the two-stage model emphasizes the role of automatic lexical-level associative priming in the early stages of processing focus. This choice appears to overlook evidence for the highly flexible and context-sensitive nature of focus. There are a number of examples which the two-stage model seemingly cannot capture and which the experimental literature has not previously tested. We discuss these concerns below.

Certain aspects of the two-stage model are undoubtedly attractive. As Gotzner and Spalek (2019) argued, the two-stage model shares a basic pattern with the Alternative Semantics framework: focus evokes a large initial set of alternatives which pragmatic processes then constrain. The large initial set can be thought of as the focus-semantic value in Alternative Semantics and the first stage of the two-stage model. The pragmatic processes of selecting alternatives in the second stage could correspond to resolution of the C variable in Alternative Semantics. In this sense, the two-stage model creates an attractive correspondence between theories of competence and performance.

However, as others before us have emphasized, Alternative Semantics was not intended as a psycholinguistic theory, and there remain multiple ways in which the central insights of the framework might be realized within the sentence or discourse processing system. To this point, we discuss two important differences between Alternative Semantics and the two-stage model: the contextual flexibility of alternatives and the scopal flexibility of focus projection.

In Alternative Semantics, the unrestricted set of alternatives initially evoked by focus is defined type-theoretically, rather than by the semantic priming that is assumed in the two-stage model. Consequently, in Alternative Semantics, almost any element which can replace the focus is capable of serving as an alternative given the proper pragmatic support. As we understand it, a two-stage model in which alternatives are defined solely through associative priming lacks sufficient contextual flexibility.

Imagine a context in which a group of artists has painted a mural that depicts a tank driving through a meadow. In such a context, *tank* is a likely alternative to *flowers* in (15) despite the fact that these words presumably do not prime one another.

(15) Simon only painted the [<u>flow</u>ers]$_F$ on the mural

As the second stage selects the relevant alternatives from semantic associates, it is not clear how contextually relevant yet lexically unrelated words like *tank* could ever enter the alternative set. While contextually relevant alternatives are often associates of the focused word, examples like (15) show that this relationship is not strictly necessary. For instance, *Pete* is clearly the relevant alternative to *Linda* in (16), but it is unlikely that names in general would be semantic associates of one another.[3]

(16) a. **Speaker A:** Pete didn't like the borscht I made yesterday

b. **Speaker B:** Well, only [<u>Lin</u>da]$_F$ likes borscht

[3] However, certain strongly associated names such as *Jack* and *Jill* might be potential exceptions.

Jördens et al. (2020) addressed a similar but crucially different case of semantically related alternatives of a different taxonomic category than the focus (e.g., *straw*—FEED vs. *cow*—ANIMAL). In a cross-modal probe recognition experiment, the authors found a response time advantage for semantically related alternatives over non-alternatives that were also associates of the focus. These results do provide some important evidence for the presence of contextual flexibility in the real-time processing of focus. However, they do not address the more extreme case of alternatives which are not semantic associates of the focus and thus lack the initial boost in activation from semantic priming.

Similarly, although the experimental literature has predominantly investigated the processing of individually focused words, larger elements can be focused as well. Theoretically, at least, constituents of any size can be put into focus (17). It not clear how complex constituents would generate the initial alternative set under the two-stage model, as associative priming is typically understood with respect to individual lexical items (Neely, 2012).

(17) a. **Speaker A:** I went to the gym and made borscht yesterday

b. **Speaker B:** I only [played <u>vi</u>deo games]$_F$ yesterday

Lacina et al. (2023) is the only experimental study we are aware of which has investigated the representation of alternatives under broad focus. Across three probe recognition experiments, the authors find mixed evidence for the representation of associate alternatives (nouns, verbs, and entire VPs) given broad VP focus. Thus, the extent to which alternatives under broad focus are represented during real-time language processing remains uncertain. However, certainly on the basis of Alternative Semantics and pre-experimental intuitions, such examples seem to present a conceptual challenge for the two-stage model.

The central observation that a two-stage model must contend with is that the contents of the focus alternative set are highly flexible with respect to context and scope. These properties constitute fundamental aspects of focus and are part of what makes it such a rich phenomenon for linguistic inquiry. For these reasons, constraining the mechanism responsible for alternative selection to a context-independent stage of semantic priming appears untenable to us. In the following section, we briefly sketch a number of alternative approaches. In particular, these alternative models, and our experiments testing them, address the contextual flexibility of focus rather than that of scope. We leave such further refinements to future research.

4.1.3 Alternative Models of Alternative Selection

There are many possible ways that the focus-alternative set could be formed during processing. Evidence from Fraundorf et al. (2010) suggests that the end product is restrictive in nature, in that the set of alternatives is eventually limited to those that are relevant given the context. The immediate question then is what mechanism generates the contextually constrained set of alternatives.

We contend that the formation of focus alternatives (at least those which are not semantically primed by their focus) must derive from some source other than semantic association. We do not attempt to characterize the precise nature of this source here. Rather, we consider the point at which such information becomes available after encountering focus. We consider two broad possibilities: (i) a *delayed-access model*, in which alternatives require cognitive resources (and thus time) to be established, and (ii) an *immediate-access model*, in which alternatives are established immediately upon encountering focus. See Table 4.1 for comparison.

Despite open conceptual issues with the two-stage model discussed above, selecting alternatives could nonetheless proceed in two stages. For example, contextual information required for identifying relevant alternatives may not be available during the initial moments of focus processing. Instead, the early advantage observed for words that are semantically associated with the focused word (including alternatives and non-alternatives) would be due to an independent process of associative priming, without feeding into the set of focus alternatives. The alternative set would then be formed at a later stage, including contextually relevant alternatives as well as semantic associates, provided that they too are relevant focus alternatives. Only at this later stage would the processor access the full set of alternatives. We call this the *delayed-access model*.

Table 4.1 Schema of the information available and predicted behavior at potential probe points for the original two-stage model, the delayed-access-focus model, and the immediate-access model

Model	Probe point	Information utilized	Increased activation for …
Two-stage	Early	Semantic association	Words primed by the focus
	Late	Discourse information	Relevant associate alternatives
Delayed-access	Early	Semantic association	Words primed by the focus
	Late	Discourse information	All relevant alternatives
Immediate-access	Early/late	Discourse information	All relevant alternatives

While there are technically two stages in this model, it differs from previous versions of the two-stage model in that the stages are independent from one another. Crucially, the second stage of the delayed-access model does not rely upon the first stage to generate the alternative set. Instead, an independent focus-sensitive mechanism utilizes the available contextual information to identify and activate relevant alternatives; priming and the selection of focus alternatives remain wholly independent processes. Consequently, the delayed-focus model is not necessarily a serial model in the classic sense, in which one process feeds another. That is, there are not two stages comprising a single process, but rather, two independent processes with different time courses that both influence lexical activation.

Selecting alternatives could also proceed in a single focus-sensitive stage independent from semantic priming. Under such a model, the contextual information identifying relevant alternatives would be available from the earliest moment of processing focus. Thus, immediately after encountering focus, both associate and non-associate alternatives would be highly activated. Non-alternatives that are semantically associated with the focus will be activated as well, but this fact simply reflects independent semantic priming rather than the mechanism responsible for generating the alternative set. We call this model the *immediate-access model*.

At first glance, the immediate-access model appears to be incompatible with results from the previously discussed forced-choice task experiments. Husband and Ferreira (2016) found that alternatives were not distinguished from associate non-alternatives immediately after the presentation of focus. Similarly, Gotzner and Spalek (2019) found that mentioned alternatives were not distinguished from unmentioned alternatives immediately after the presentation of focus. However, these studies only tested *associate* alternatives. Consequently, it is impossible to disentangle the influence of semantic priming from that of contextual relevance.

Associate non-alternatives might yield similar response times to associate alternatives at early SOAs on account of semantic priming, but this does not necessarily mean that the mechanism responsible for generating the alternative set depends upon semantic priming or that the contextual information identifying relevant alternatives is unavailable. Instead, semantic priming and the selection of alternatives might be independent processes. However, having limited the scope of investigation to associate alternatives, the prior literature would not disentangle these processes.

In order to determine whether early moments of focus processing are truly insensitive to context, we must also consider contextually relevant alternatives which are semantically primed by their focus. We refer to such alternatives as *non-associate* alternatives in order to contrast them with *associate* alternatives. Take the example discourse in (18) below.

(18) a. **Speaker A:** Andy used a muffin and a pistol as props in an independent movie that he was directing

b. **Speaker B:** No, he only used a $[\underline{\text{cake}}]_F$

In this example, the focused word (*cake*) has two salient contextually relevant alternatives. One of these is an associate of the focus (*muffin*) and the other is not (*pistol*). We test such examples experimentally to tease apart the role of contextual information from semantic priming in selecting alternatives.

If the earliest moments of processing focus purely reflect semantic priming as the two-stage and delayed-access models predict, then associate alternatives should be highly activated immediately after encountering focus. On the other hand, if the earliest moments of processing focus are context sensitive, as predicted by the immediate-access model, then both associate and non-associate alternatives should be highly activated immediately after encountering focus.

In order to test these possibilities, we conducted two cross-modal probe recognition task experiments. We probed subjects' recall on associate alternatives, non-associate alternatives, and non-associate non-alternative controls. Each of these probe words was mentioned in a previous discourse. This design ensured that the conditions did not engage different response biases or processing strategies, allowing for clear comparison across conditions (Table 4.2).

We utilized probe recognition as our forced-choice task rather than lexical decision for two main reasons. One, the vast majority of experimental work concerning the representation of alternatives has utilized probe recognition (e.g., Fraundorf et al., 2010; Gotzner, 2017; Gotzner & Spalek, 2019; Gotzner et al., 2016; Jördens et al., 2020; Lacina et al., 2023, etc.). We aimed to build upon this literature and facilitate comparison with our results by means of methodological consistency. Two, as Gotzner et al. (2016) discussed, a correct response in a lexical decision task only requires low-level orthographic information that is largely irrelevant to the interpretation of focus. On the other hand, a correct response in a probe recognition task requires a subject to access

Table 4.2 Schema of the probe task response time predictions made at an early SOA by the original two-stage model, the delayed-access model, and the immediate-access model. The Non-associate condition is crucial to these predictions (hence the bold and underline). In particular, these predictions differ as to whether Non-associate alternatives will have a response time advantage like Associate alternatives or a response time penalty like Non-associate non-alternative controls

Model	Predictions by condition
Two-stage	Associate faster than **<u>Non-associate</u>** and control
Delayed-access	Associate faster than **<u>Non-associate</u>** and control
Immediate-access	Associate and **<u>Non-associate</u>** faster than control

some mental representation of the discourse. This is not to say that a lexical decision task will never reflect the presence of alternatives, but rather, that a probe recognition task might more deeply engage the kind of high-level pragmatic processing that is of interest here.

To preview our results, we found that, even at a 0 ms SOA, subjects were faster to correctly accept associate and non-associate alternatives than non-alternative controls. Further, we find evidence that the *Associate* and *Non-associate* alternative conditions failed to elicit different response times from one another. The overall results of our study provide evidence in favor of an immediate-access model for selecting alternatives and experimental evidence against models in which the access of contextual information is delayed.

4.2 Experiment

4.2.1 Materials and Method

Thirty short dialogues were constructed as in (19). Dialogues were immediately followed by a probe word after the final, focused word (*cake*) in B's utterance. Probe words were drawn from one of three conditions (20). In two conditions, the probe word was a discourse alternative to the focused word, but was differentiated by whether they were semantically associated with the focused word (Associate: *muffin*) or not (Non-associate: *pistol*). The third condition provided an experimental control (Control: *movie*), in which the probe appeared in the prior utterance context but did not present a focus alternative given the target sentence and the discourse context.

(19) *Sample dialogue*

a. **Speaker A:** Andy used a muffin and a pistol as props in an independent movie that he was directing.

b. **Speaker B:** No, he only used a [<u>cake</u>]$_F$.

(20) *Probe words*

a. *Associate*: MUFFIN

b. *Non-associate*: PISTOL

c. *Control*: MOVIE

In the first utterance, Speaker A described a situation using the Associate alternative, the Non-associate alternative, and the Control. The alternatives were always conjoined arguments of a main verb.[4] The control always appeared within an adjunct which occurred utterance initial in half of the items and utterance final in the other half. This between-items control ensured that neither condition was more active or prominent in memory across the experiment purely on account of recency.[5] In the second utterance, Speaker B contradicted Speaker A's statement with *No*, followed by the focus particle *only* with an utterance final noun in corrective contrastive focus. All of the material in Speaker B's utterance was discourse-given except for the focus, which was always discourse-new.

Speaker B was a male speaker trained in the Tones and Breaks Indices intonational system (ToBI; Pierrehumbert & Hirschberg, 1990) and was instructed to produce the focus with an L+H* pitch accent—the canonical prosodic marking for focus in English (Büring, 2016a). See Figure 4.1 for an example L+H* accent produced for the stimuli. It is important to note that the focus was always the final word in Speaker B's utterance. As a result, the L+H* pitch accent was technically ambiguous between marking focus and English's default Intonation Phrase (IP) final placement of Nuclear Pitch Accent (NPA). However, due to the presence of *only* and the givenness of the non-focused material in Speaker B's

[4] It is possible that in using conjunction, rather than say disjunction, the associate and non-associate words are treated as a single conjoined alternative (e.g., ALTS = {[pistol and muffin]} rather than ALTS = {pistol, muffin}). However, given that both words would still be present in the alternative set, we do not consider this to be a confound of our design. That being said, disjunction itself has been proposed to introduce alternatives (Alonso-Ovalle, 2006; Harris, 2019), so an experimental comparison of these two operators could prove fruitful.

[5] We did not explicitly control for the order of the alternatives in the conjunct, however. The Associate alternative was first in 29 of the 30 critical items, but we have no reason to believe that this asymmetry could explain our results. See Husband & Patson in this volume for relevant discussion of how distance interacts with the recognition of focus alternatives.

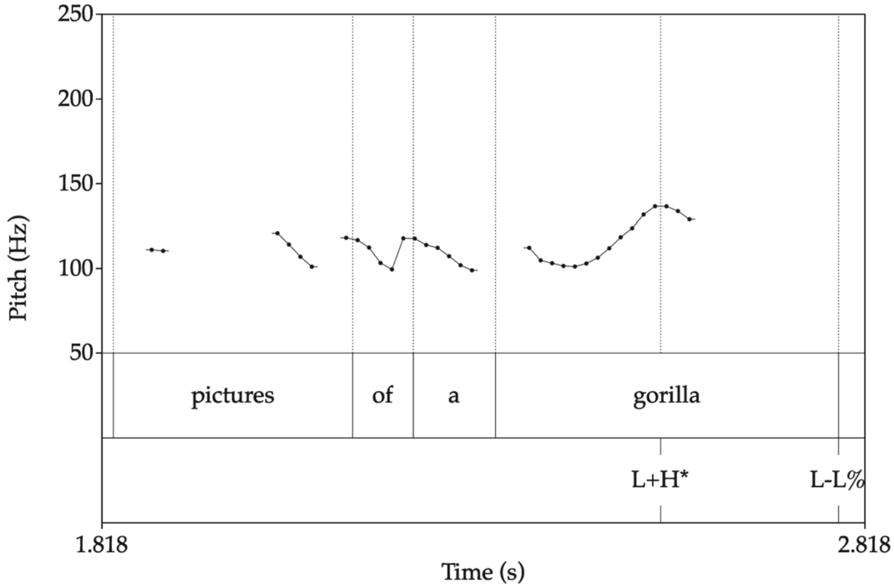


Fig. 4.1 Example pitch track including the final focused word; ToBI transcription is provided in the bottom tier

utterance, the focus structure was in fact unambiguous. Thus, the pitch accent served more to generate perceptual salience for the word in focus, rather than to determine focus structure itself. Before each of Speaker B's recordings, another speaker produced Speaker A's corresponding utterance to license the use of corrective focus and make production more natural. Speaker A was a female speaker who had received formal voice training, though not familiar with ToBI, and was instructed to produce the items naturally rather than with a specific contour.

In addition to the 30 critical items, another 60 filler items were written and recorded as well. These followed the same two utterance two speaker structure as the critical items. Speaker B's responses were of a similar length to the critical items, but never involved negation. Unlike the critical items where the probe words were all mentioned nouns, the probe words in the fillers were of various parts of speech and the majority were not mentioned in the audio dialogue. Of the 60 filler items, 30 had a probe word which was not a noun (predominately adjectives, verbs, and prepositions) and 45 had a probe word which not mentioned. Across the full set of items 2/3 of probes were nouns and 1/2 of probes were mentioned. In five of the filler items, the probe word was identical to the final word in Speaker B's utterance. These fillers acted as catch trials.

The speakers were not instructed to produce any of the filler items with a specific contour.

The three sets of probe words (Associate, Non-associate, and Control) were controlled for length, frequency, number of morphemes, and orthographic neighborhood size, as these factors are known to influence the speed and accuracy of written word recognition (Balota et al., 2007), summarized in Table 4.3. Pairwise differences between each of the conditions were evaluated with a Bayesian t-test. No reliable differences in length or orthographic neighbors were observed, as the 89% credible interval of all pairwise comparisons contained 0 with a $BF < 1$ for each comparison. Frequency of each probe word was estimated with the SUBTLEX_US English subtitle corpus (Brysbaert & New, 2009). There was no evidence that the frequency of the Associate word was different than Non-associate or Control words. While there was weak evidence that the Control was more frequent than the Non-associate word ($Med = 0.34$, $CrI_{89\%} = [0.03, 0.64]$, $BF = 2.12$), the direction of the difference crucially goes against the hypothesis that Non-associate probe words will be recognized faster than Control probe words. Lastly, probe words for a given item were controlled such that each word had the same number of morphemes (max: 2, min: 1) within an experimental triplet.

We used Latent Semantic Analysis (LSA; Landauer & Dumais, 1997) to estimate the expected semantic association from the focused word to each probe word. Probe words were compared against the focused word using a one-to-many comparison with the "General Reading up to 1st year college" embedding space. Mean and standard error cosine similarity

Table 4.3 Means and standard errors in parentheses of lexical factors (length, number of morphemes, orthographic neighborhood size, log frequency according to SUBTLEX_US, cosine similarity with focused word according to latent semantic analysis, and semantic similarity with focused word rating from online norming study) by probe word condition

Condition	Length	Orth. neighbors	Frequency	LSA sim.	Likert rating
Associate	5.80 (0.18)	3.37 (0.70)	2.87 (0.11)	0.59 (0.02)	5.65 (0.08)
Non-associate	5.77 (0.21)	4.30 (0.86)	2.83 (0.12)	0.09 (0.01)	2.67 (0.09)
Control	5.77 (0.20)	4.13 (0.93)	3.20 (0.12)	0.08 (0.01)	2.17 (0.09)

values by condition are shown in Table 4.3. In keeping with the design requirements, words from the Associate condition were more strongly associated with the focused word than those from the Control (Med $= -0.51$, $CrI_{89\%} = [-0.55, -0.47]$, BF > 1000) and Non-associate (Med $= 0.5$, $CrI_{89\%} = [0.45, 0.54]$, BF > 1000) condition. There was no evidence that words from the Control and Non-associate conditions differed in this respect (Med $= -0.01$, $CrI_{89\%} = [-0.03, 0.01]$, BF $=$ 0.41).

We also performed an online norming study to further estimate the expected semantic association from the focus word to each probe word. This study was performed after our probe recognition experiments. In exchange for course credit, twenty-eight self-reported native English-speaking undergraduates from the University of California Los Angeles Psychology Department subject pool rated the semantic similarity of 60 word pairs on a 7-point Likert scale. Half of these word pairs were taken from the thirty foci and probe words used in our stimuli and the other half were fillers which varied in expected semantic association. Word pairs were presented in three counterbalanced conditions such that each subject rated each foci with one of the three possible probe words. This provided us with an estimate of semantic association which was more specific to the population used in the main experiment. These similarity ratings are shown in Table 4.3.

The results show that words from the Associate condition were more strongly associated with the focused word than those from the Control (Med $= -3.47$, $CrI_{89\%} = [-3.70, -3.22]$, BF >1000) and the Non-associate (Med $= 2.98$, $CrI_{89\%} = [2.75, 3.20]$, BF > 1000) condition. There was also evidence that words from the Control and Non-associate condition differed with respect to similarity ratings, but this effect was far smaller (Med $= -0.49$, $CrI_{89\%} = [-0.71, -0.27]$, BF > 100). This might suggest that LSA is a coarser evaluation of semantic association, or at least a less accurate one with respect to our experimental population. Importantly though, when LSA and relatedness norming measures were added as predictors in Bayesian mixed effects models, the overall patterns reported below remained the same.

4.2.2 Analysis

Data from the two studies were analyzed as Bayesian mixed effects models using `brms` (Bürkner, 2017) in R (R Core Team, 2023) with full by-subject and by-item random slopes and intercepts. In the main study, all models were computed on 4 parallel chains sampling from 12,000 iterations with a 2000 iteration burn in. The pilot required fewer iterations. Accuracy was treated as a binary response and modeled as a Bayesian regression (link logit) model. Response times above 2500 ms were removed as we were crucially interested in the earliest moments of focus processing. Similarly, response times below 200 ms were not taken to involve sufficient processing of the stimulus and thus were removed as well. Response times were then log transformed and subjected to a Bayesian linear mixed effects model. As the distribution still showed a rightward skew even after log transformation, the model was specified with a log-normal distribution. No divergent chains were observed and all models converged with $\hat{R} \approx 1$ and sufficient Effective Sample Sizes for each parameter. Posterior predictive checks graphically confirmed that the model was an appropriate fit of the response variable.

We were primarily interested in the effects that alternative status and semantic associate with focus would have on response times. To this end, the contrasts of fixed effects were coded as user-defined to compare (i) alternatives vs non-alternatives (Associate $= 0.5$, Non-associate$= 0.5$, Control $= -1$) and (ii) associate alternatives vs non-associate alternatives ignoring the control (Associate$= -0.5$, Non-associate$= 0.5$, Control $=$ 0).[6] The first comparison allowed us to investigate the effect of alternative status, while the second allowed us to investigate the effect of semantic relatedness among alternatives.

Bayesian models were chosen for numerous reasons. First, models with random slopes tended not to converge in comparable frequentist linear mixed effects models, despite the relatively large number of observations per condition per participant. Second, the non-normal distribution of scores could be better captured with the log-normal distribution available

[6] A more standard sum-coded model was also computed for the online pilot and the main in-person study. The results support the same conclusions, as they mirror the pairwise comparison reported in the text, but are not discussed in detail for sake of brevity.

in Bayesian approaches. Third, a Bayesian approach allowed us to model the effects with a prior obtained from the online pilot study conducted with a subset of items and different subjects, resulting in more powerful inferences. Fourth, and most importantly, the Bayesian approach allowed us to quantify evidence in favor of the null hypothesis. As the immediate-access model predicted a crucial lack of a difference between the Associate and Non-associate focus-alternative conditions, we used Bayes Factors to investigate the extent to which the data provided positive evidence for the lack of a difference between these conditions.

That said, frequentist models were also fit to the data. When the model did not converge, we simplified the random effect structure until convergence was obtained. In all cases, the qualitative findings match those observed under the Bayesian approach. Parameter estimates for models are provided in footnotes. As mentioned, a pilot study was conducted over the internet. We present the results of the pilot before turning to the main experiment. Unless otherwise noted, the analysis in the internet pilot followed the same principles as the main in-person study.

4.2.3 Internet Pilot Study

Prior to the in-person experiment, a pilot study was conducted with a subset of the critical items over the internet. The pilot served two central purposes. First, it allowed us to compare the general effect with different subjects on an alternate experimental platform. Second, it allowed us to extract an informative prior from the posterior distribution for the central study.

Subjects ($N = 47$) were sampled from the same population as the main experiment (undergraduate students at UCLA). Three lists from 12 of the 30 critical items were created in a counterbalanced design. Eighteen of the 60 filler items from the experiment were added to each of these lists resulting in a total of 30 trials. Each participant saw only one list. As in the full experiment, subjects correctly identified the probe with over 75% accuracy and in the analysis of response times, only correct responses were considered.

The pilot was administered over the internet with PCIbex (Zehr & Schwarz, 2018). After reading the instructions, subjects were tested on their understanding of the task. Subjects were instructed to complete the experiment using wired headphones in a quiet distraction-free environment. On each trial, participants listened to the audio dialogue while presented with a fixation cross in the center of the computer screen. Immediately after the audio completed, a written probe word appeared in the center of the screen. Subjects were instructed to provide their responses as quickly as possible without sacrificing accuracy. There was no explicit timeout for long responses. After every trial, participants were presented with a blank screen and an opportunity to take a self-paced break. The pilot took approximately 12 minutes to complete on average.

Accuracy in the probe task was high in the Associate (M = 92%, SE = 1.93%) and Non-associate (M = 90%, SE = 2.15%) conditions, and was lower in the Control condition (M = 80%,SE = 3.09%). However, in a Bayesian logistic regression analysis, there was no evidence that the Control probes reliably differed from the Associate or Non-associate probes.

Mean response times supported the predictions of the immediate-access model. Subjects were faster to correctly recognize the probe word in the Associate (M = 1130 ms, SE = 42 ms) and Non-associate (M = 1134 ms, SE = 43 ms) conditions, compared to the Control condition (M = 1335 ms, SE = 50 ms). Response times were subjected to a Bayesian linear mixed effects model with the same model specifications as the main experiment with a few exceptions. First, the data were fit using a uniform (flat) prior for the purposes of extracting an informative prior for the main study. Second, the models in the main study were specified with a high number of iterations in order to compute Bayes Factors for the parameters. Bayes Factors cannot be computed with flat priors, and fewer iterations were needed to analyze data from the pilot.

As shown in Table 4.4, the combined focus conditions (Associate and Non-associate) elicited faster response times than the Control, but there was no evidence that the two focus conditions differed from one

Table 4.4 Pilot study. Results from Bayesian linear mixed effects regression model with full random effect structure. Uninformative (flat) priors were used, and so no Bayes Factor could be computed. Contrasts were user-coded to establish the comparisons of interest. The model was run with 5000 iterations and a 1000 iteration warm up, and converged with $\hat{R} = 1$ and at least an 2500 Effective Sample Size per parameter

Parameter	Median	89% CrI
Intercept	1.944	[1.930, 1.957]
Control vs. focus	−0.025	[−0.040, −0.011]
Associate vs. non-associate	0.003	[−0.012, 0.016]

another.[7] The estimated marginal means of the model indicated that response times in the Control condition were slower compared to the Associate, Median = 0.026, HPD = [0.010, 0.042], and Non-associate, Median = 0.024, HPD = [0.007, 0.040], conditions, whereas the focus-alternative conditions did not reliably differ from one another, Median = −0.003, HPD = [−0.016, 0.012].

Our model indicates that non-alternative and alternative probe words elicited distinct response time patterns. Probe words that are focus alternatives (the Associate and Non-associate conditions combined) were associated with lower response times compared to probe words that were simply mentioned (the Control condition). However, the distinction *within* focus alternatives (Associate versus Non-associate probe words) did not produce different response time patterns, indicating that focus alternatives, regardless of semantic association, were equally accessible at the probe point.

Results from the pilot study already lend initial support in favor of the immediate-access model. We observed faster response times for probe words corresponding to focus alternatives, regardless of semantic association, over the Control word. Crucially, the priming effect for focus alternatives that are semantically unrelated to the probe word appeared immediately, rather than at a delay. This finding suggests that discourse-relevant focus alternatives are immediately available in the calculation of

[7] A similar pattern was observed in a frequentist linear mixed effects regression model. Combined focus conditions elicited faster response times than the Control, $\beta = -0.15$, SE = 0.04, $t = -4.06$, $p < .001$, but did not differ from each other, $\beta = 0.02$, SE = 0.03, $t = 0.58$.

the alternative set. We now turn to the main study, where a larger version of the experiment will be presented.

4.2.4 In-Person Experiment

The main experiment was conducted in-person using the full set of items with the addition of comprehension questions. In all other respects, the design was identical to that of the pilot.

4.2.4.1 Participants

Sixty-one self-reported native English-speaking undergraduates from the University of California Los Angeles Psychology Department subject pool participated in this study. All subjects were given course credit in exchange for participation.[8]

4.2.4.2 Method

During the experiment, participants sat in front of a desktop computer in a sound-attenuated booth wearing a pair of Sennheiser HD280 Pro wired headphones. A researcher initiated a Linger script for the experiment and then briefly explained the procedure (Rhode, 2001). Under the supervision of the researcher, participants read through a series of instructions and completed three practice trials which were not related to the manipulation. After answering any questions, the researcher left the subject to complete the experiment alone.

[8] Ninety-nine subjects were recruited, and 61 were used in the final analysis. Although the number of excluded subjects seems high, we have previously observed comparable exclusion rates in studies across multiple experimental paradigms from our population. The 39 excluded subjects were rejected on the basis of accuracy in the probe task and with the comprehension questions on both critical and filler trials. Subjects with less than a mean accuracy of 75% in the probe task were excluded. For the filler trials this resulted in the exclusion of 1 subject, and for the critical trial this resulted in the exclusion of 5 subjects. Most participants were removed on the basis of comprehension question performance. Subjects with less than a mean accuracy of 75% on these questions were excluded. For the filler trials, this resulted in the exclusion of 17 subjects and for the critical trial this resulted in the exclusion of 16 subjects.

On each trial, participants listened to the audio dialogue through the headphones while presented with a fixation cross in the center of the computer screen. Immediately after the audio completed, a written probe word appeared in the center of the screen. Participants then indicated using a PS/2 keyboard whether or not this probe word occurred or did not occur anywhere in the preceding audio. Participants were instructed to provide this response as quickly as possible without sacrificing accuracy. As in the pilot, there was no explicit timeout for long responses.

On a third of the trials, participants were presented with a comprehension question. Subjects were instructed to prioritize accuracy over speed in responding to these comprehension questions. After every trial, participants were presented with a blank screen and an opportunity to take a self-paced break. Once the participant pressed the spacebar, the next trial would begin. The experiment took approximately 30 minutes to complete on average.

4.2.4.3 Results

Accuracy in the probe task corroborated the results from the pilot experiment. Subjects correctly identified the probe in Associate (M = 94%, SE = 0.86%) and Non-associate (M = 91%, SE = 1.03%) conditions with comparable accuracy, whereas the Control condition elicited lower accuracy rates (M = 86%, SE = 1.49%). However, in a Bayesian logistic regression model with user coding, no reliable differences were observed between the Control condition and the combined focus-alternative conditions, Median = 1.25, $CrI_{89\%} = [-0.01, 2.57]$, which also did not reliably differ from each other, Median = 0.53, $CrI_{89\%} = [-0.21, 1.38]$. Pairwise comparisons of the marginal means also failed to provide reliable evidence for a difference in accuracy between any of the conditions.

Response times over 2500 ms were removed from the analysis, resulting in less than 10% data loss across conditions.[9] As in the pilot

[9] Similar results were obtained for various cutoffs, in particular at 5000 ms and for no threshold, i.e., when all response time scores were used in the analysis.

Table 4.5 Response times. Results from the Bayesian linear mixed effects regression model on log response times with full random effect structure and a log-normal distribution. Informative priors from the pilot study were used. Contrasts were user-coded to establish the contrasts of interest. The model was run with 12,000 iterations and a 2000 iteration warm up, and converged with $\hat{R} = 1$ and an Effective Sample Size ≥4000 per parameter. Bayes Factor (BF) was computed over a null point estimate using the Savage-Dickey density ratio

Parameter	Median	89% CrI	BF
Intercept	1.943	[1.937, 1.948]	>1000
Control vs. focus	−0.024	[−0.028, −0.019]	>1000
Associate vs. non-associate	0.002	[−0.002, 0.006]	0.584

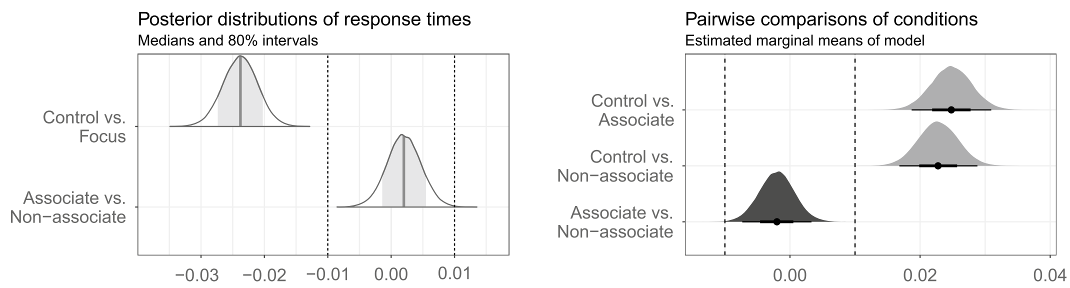
study, subjects were, on average, faster to correctly recognize the probe words in the Associate (M = 1077 ms, SE = 17 ms) and Non-associate (M = 1085 ms, SE = 17 ms) conditions, and were slower in the Control condition (M = 1258 ms, SE = 19 ms). As before, a Bayesian linear mixed effects regression model was computed on log response times with user-defined contrast coding. Results of the model are provided in Table 4.5.

The Bayesian model indicates that the focus-alternative conditions elicited reliably faster response times than the Control.[10] Plots of the posterior distributions of the fixed-effect parameters, excluding the intercept, are shown in Fig. 4.2a.

The Bayes Factor for the intercept is >1000 which is interpreted as extreme evidence supporting a difference between levels (Jeffreys, 1998). The model also fails to find reliable support for a difference between the two focus-alternative conditions. The Bayes Factor of 0.58 further indicates that there is weak evidence in favor of the hypothesis that the two conditions do not, in fact, differ.[11]

[10] A qualitatively similar pattern was observed in a frequentist linear mixed effects regression model. Combined focus conditions elicited faster response times than the Control, $\beta = -0.16$, SE = 0.01, $t = -10.38$, p < .001, but did not differ from each other, $\beta = 0.01$, SE = 0.02, $t = 0.88$.

[11] In lieu of a formal sensitivity analysis, two additional Bayesian models were fit with uninformative prior and a weakly informative prior. All models tested showed the same pattern reported here, except that the informative prior model presented in main text yielded higher Bayes Factor values. The informative prior model was preferred in model comparison, BFs > 30.



(a) Posterior distribution of Bayesian model computed with an informative prior. While there was reliable evidence of an advantage for the two focus-alternative conditions over the Control, there was no evidence supporting a distinction within the focus-alternative conditions themselves.

(b) Pairwise comparisons of the posterior distributions obtained from the estimated marginal means of the response time model. The dark gray color indicates that the contrast between Associate and Non-associate did not meet the criteria for a reliable difference, as the mass of the distribution is centered close to zero.

Fig. 4.2 Posterior distributions associated with a Bayesian model of log-transformed response times obtained in the in-person study

Pairwise comparisons of the estimated marginal means obtained from the model revealed that the Control probe word elicited slower response times than the Associate, $\beta = 0.023$, HPD = [0.017, 0.030], and Non-associate, $\beta = 0.021$, HPD = [0.015, 0.028], probe word conditions. Response times collected from Associate and Non-associate conditions did not reliably differ from one another, β -0.002, HPD = [-0.008, 0.004]. Estimates from the marginal means are depicted in Fig. 4.2b.

4.2.4.4 Discussion

On the whole, the results of the second experiment closely follow the pilot. In both cases, we observed a reliable advantage for focus-alternative probes over Control words in the probe recognition task. In contrast, there was no evidence, in either study, that the Associate and Non-associate focus-alternative conditions elicited different response times. A Bayes Factor analysis of the main study provided positive, though weak, evidence that the two focus-alternative conditions truly did not differ from one another.

That the effect of alternatives status manifests immediately after the offset of the focused word indicates that the earliest stages of processing focus do not purely reflect semantic priming and are sensitive to the presence of contextually relevant focus alternatives, as defined by the discourse. The overall finding is compatible with the immediate-access model, in which members of the focus-alternative set are immediately activated during the processing of focus.

Although the advantage for Associate focus-alternative probe words over Controls conceptually replicates previous studies, it is unclear how the delayed-access model or the two-stage model could explain the advantage for Non-associate focus-alternative probe words. If the earliest stages of focus processing reflects semantic priming, unconstrained by the context, then the recognition of Non-associate alternatives would have been delayed. We further elaborate on the theoretical significance of the main findings in the section below, offering a number of speculations and directions for further research.

4.3 Conclusion

Using the cross-modal probe recognition paradigm, we found that two focus-alternative conditions collectively elicited faster response times than non-alternative controls. Further, we found no evidence that response times to the focus-alternative (Associate and Non-associate) conditions differed from one another. Lastly, these results were observed immediately after the presentation of focus. It is unclear how a two-stage model in which focus alternatives are formed from a subset of semantic associates could explain the observed advantage for Non-associate focus alternatives. It is also unclear how a delayed-access model which requires time to access contextual information for selecting alternatives could be compatible with the early time course of the advantage. At present, it appears that only an immediate-access model, in which focus alternatives are immediately determined from the context, is fully compatible with our results.

As discussed in the introduction, the original two-stage model is *destructive* in nature. Under this model, a large set of semantic associates containing both alternatives and non-alternatives is initially activated. Over time, members are removed from this set through a combination of decreased activation and focus-sensitive selection, eventually yielding a restricted set of alternatives consisting of just the relevant mentioned alternatives (Gotzner & Spalek, 2019; Gotzner et al., 2016) or possible alternatives when no alternatives are provided (Husband & Ferreira, 2016).

In some sense, Alternative Semantics is similarly destructive in nature. A large initial set of possible alternatives is generated in a context insensitive fashion and subsequently restricted by context to just the set of relevant alternatives. However, the initial set in Alternative Semantics is the focus-semantic value ($[\![\cdot]\!]^f$) of an expression and it is generated with respect to semantic type rather than semantic priming. Consequently, Alternative Semantics permits far more flexibility with respect to contextually relevant alternatives than the two-stage model would. Given that unrelated words can serve as alternatives according to theoretical intuitions, the strictest conception of such a priming-dependent destructive model is not supported by our study.

We proposed two *constructive* models as alternatives to the two-stage model, in which the formation of the alternative set is driven by the discourse rather than semantic association. In these models, semantic priming and alternative selection are independent processes. While behavior in a forced-choice task might be influenced by both semantic priming and alternative selection, these processes might not be cognitively intertwined. Prior forced-choice task studies have exclusively tested related alternatives. Our results suggest that this comparison has possibly obscured the independence of semantic priming and alternative selection.

While we have argued in favor of a constructive model throughout this chapter, it may still be possible to maintain a destructive model. For example, if both lexical-level associative priming and discourse relevance can influence lexical activation during the initial stage, then the activation for non-associate alternatives could be increased. In other words, the initial stage of alternative set formation could then reflect a mixture of processes from diverse information sources. As in the constructive models, alternatives would be limited to discourse relevant alternatives in the second stage of such a destructive model.

This model is possible in principle, but arguably suffers with respect to parsimony. Under such a destructive model, the discourse representations necessary to increase activation of non-associate alternatives must be immediately accessible. Crucially, to account for our results, discourse representations would have to privilege non-associate alternatives that are mentioned in the discourse over non-associate non-alternatives mentioned in the discourse.

However, if the required discourse information is already available, it is unclear why semantic priming would be necessary to the establish associates as alternatives. A constructive model is arguably more parsimonious in that the selection of associate and non-associate words as alternatives would derive from a single source (discourse representations) rather than multiples sources (discourse representations and semantic priming).

Many discourse-intentional factors (e.g., topicality) determine whether a possible alternative is a relevant one within a given context. However, there is no theory, to our knowledge, in which lexical-level semantic association to the constituent in focus is one of these factors. To be clear, we think it is entirely plausible that there is an early effect of semantic priming on responses; what's far less certain is whether semantic priming serves to generate the set of alternatives. In other words, the priming effect observed in prior studies may simply reflect an independent advantage for related word forms. Nonetheless, it is possible that future results may necessitate some more nuanced compromise between the roles of semantic priming and discourse relevance in the selection of focus alternatives.

We have been intentionally vague in describing the discourse representations utilized by our constructive model to identify contextually relevant alternatives. There are many possibilities and our design largely does not help to distinguish them. Undoubtedly, focus is a context-sensitive phenomenon and our results do suggest that the early processing of focus is similarly context sensitive in nature. Importantly, the probe words in each condition were previously mentioned in our design. Despite this fact, we observe faster response times for Non-associate alternatives than Controls. Thus, the representations involved must distinguish previously mentioned entities with respect to their ability to serve as alternatives for potential foci.

One promising candidate for a discourse representation comes from the Question Under Discussion (QUD) approach to information structure (Roberts, 1996). A great deal of theoretical research has argued that questions, and consequently focus, guide much of discourse organization: some shared line of inquiry between interlocutors introduces a set of alternatives and a focus selects one of these as a possible answer (Beaver & Clark, 2009). Previous experimental work has already demonstrated that both implicit and explicit QUDs can influence incremental processing (Clifton & Frazier, 2018). Perhaps comprehenders are predicting possible QUDs and organizing mentioned entities with respect to their ability to serve as possible answers/foci.

There are a number open question with respect to semantic priming, timing, structural position, and associated focus. Starting with semantic priming, we did not include a condition for non-alternatives semantically related to the focus in our design. This condition was not included in order to improve statistical power and to preserve the naturalness of the sentences. As there was no evidence that Associate alternatives and Non-associate alternatives elicited different response patterns, it is unclear whether the effect of such Associate non-alternatives would pattern like that of alternatives, non-alternatives, or somewhere in-between. Given the possibility that semantic association influences the availability of a related lexical item, independently from its status as a focus alternative, testing such a condition would provide further insight into how semantic priming and alternative status independently influence response times in probe recognition tasks.

Regarding timing, we only investigated response times immediately after the focused word. Prior forced-choice task studies in this literature have explored both early and late probe points (Gotzner & Spalek, 2019; Gotzner et al., 2016; Husband & Ferreira, 2016). Given prior studies, as well as theoretical intuitions, we predict that both Associate and Non-associate alternatives maintain their activation over time. Although investigating the accessibility of alternatives over time is an important task, the central question of this study is whether the Non-associate alternatives are available as early as Associate alternatives in focus processing. The evidence we presented indicates that they are.

Across all of our items, alternatives were conjoined arguments of a main verb while non-alternatives appeared within an adjunct. The use of adjuncts allowed us to easily control for memory effects on account of recency (see Sect. 4.2.1 for discussion). However, recent research by Chromý and Vojvodić (2023) suggests that recall for information conveyed by adjuncts might be worse than that conveyed by arguments. Interestingly, Chromý and Vojvodić (2023) found that this penalty was reduced when the adjunct was put into focus.[12] We cannot rule out the possibility that such structural factors were (at least partially) responsible for the slower response times observed for non-alternatives. However, given that we found no reliable difference in accuracy between alternatives and non-alternatives, we believe that any effects of structure are likely minimal. Further, this difference would not address our core finding: the lack of any reliable differences between the Associate and Non-associate alternatives. That being said, future work should address the undoubtedly complex relationship between memory, structural position, and information structure.

Lastly, there are some open questions with respect to the effect of associated focus on the results. Focus was always associated with a specific focus-sensitive particle (*only*) in our study. We had two motivations for this design. First, the particle *only* provided subjects with a strong cue to the presence of focus in addition to prosodic cues. Second, the particle *only* strengthens the interpretative effect of focus from an implicature to a truth-conditional entailment. We imagined that strengthening the role of focus in this way might further entice subjects to generate a representation of the alternative set for interpretation. Gotzner et al. (2016) and Gotzner and Spalek (2019) found that sentences with associated focus elicited longer response times in a memory probe task. The authors argued that the truth-conditional effect of associated focus triggered increased competition between potential members of the alternative set generating a penalty in response time. Our design does not provide any

[12] We thank Radim Lacima for bringing this paper to our attention.

evidence for or against this analysis, but further comparisons of bare and associated focus using our design could prove informative.

Relatedly, Gotzner et al. (2016) did not find any evidence for response time differences between *only* and *even* in German. Still, the unique interpretive effects of different focus-sensitive particles might induce different relations to the alternative set. For instance, compare the two uses of associated focus given the same context in (21).

(21) a. **Speaker A:** Andy used a muffin and a pistol as props in an independent movie that he was directing.

b. **Speaker B:** No, he only used a [<u>cake</u>]$_F$.

c. **Speaker B':** Well, he also used a [<u>cake</u>]$_F$.

The relevant alternatives (*muffin* and *pistol*) can each felicitously replace the focus (*cake*) in (21B) but not in (21B'). Perhaps given an exclusive focus particle like *only* in (21B), the parser anticipates that one or more of the relevant alternatives will occupy the position of the focus, a prediction which would be inappropriate for an additive particle like *also* in (21B'), cf. *# Well, he also used a muffin*. The initial activation generated for relevant alternatives might well be influenced by whether the focus particle indicates that the item in focus will be added to the items in the focus-alternative set or induce a contrast with those elements.

At various points in this paper, we have described the immediate-access model as a one-stage model of selecting alternatives. We have adopted this terminology in order to contrast the immediate-access model with the delayed-access and two-stage models. However, in doing so, we also evoke many classic debates of the sentence processing literature, particularly those concerning the timing of context (see Altmann & Steedman, 1988; Crain, 1985; Frazier, 1979; Frazier & Fodor, 1978, among others). Historically, one-stage models have been associated with a number of architectural commitments such as interactivity, parallelism, and certain reanalysis strategies. It is not our intention to invoke any of these commitments here. In particular, we are not committed to a processing model under which all forms of contextual information are immediately available and, for example, utilized in early parsing decisions. Rather, we view the early availability of focus alternatives as emerging from the *grammatical* necessity to identify focus alternatives for interpretation (see, Frazier, 1999, chap. 4). In general, we consider these broad architectural considerations, such as interactive parsing, to remain open possibilities.

To conclude, results from a cross-modal probe recognition task indicate that the initial moments of processing focus reflect the selection of contextually relevant focus alternatives, regardless of how semantically related they are to the focus. It remains unclear how a two-stage model or delayed-access model could explain this result. While much more work needs to be done to clarify the representations involved, our results support an immediate-access model where discourse information is utilized to select alternatives immediately upon encountering the focus.

Focus is a pervasive phenomenon in natural language. Naturally, the field is obligated to characterize the inference processes involved in comprehending focus. Further, focus is a fundamentally context-dependent affair. Thus, studying the selection of alternatives will not only serve to better our understanding of focus, but also our understanding of context in language processing at large.

Acknowledgements We'd like to thank Jake Aziz and Neeti Badve for helping to record materials and the RAs of the UCLA Language Processing Lab past and present (Joseph Alamo, Jacob Bower, Dhanya Charan, Katie Chung, Lionel Hu, Iwanka Iwanojko, Jiachen Jin, Ryan Kien, Madeline Kim, Audrey Laun, Iris Shi, Eva Speiser, Marina Suh, Jessica Ti, Amaia Villegas, and Anna Walburger) for helping to run subjects. We'd also like to thank Dylan Bumford, Chuck Clifton, Lyn Frazier, Nicole Gotzner, Tim Hunter, Radim Lacina, Thomas Bye, as well as audiences at XPrag X and the UCLA Psycholinguistics / Computational Linguistics seminar for helpful discussion. All of our data, materials, and analysis are available on the following OSF page: https://osf.io/mctxg/?view_only=664b673f2abf40f6b833e9fddc2931af.

References

Alonso-Ovalle, L. (2006). *Disjunction in alternative semantics*. PhD thesis, University of Massachusetts Amherst.

Altmann, G., & Steedman, M. (1988). Interaction with context during human sentence processing. *Cognition, 30*(3), 191–238.

Balota, D. A., Yap, M. J., Hutchison, K. A., Cortese, M. J., Kessler, B., Loftis, B., Neely, J. H., Nelson, D. L., Simpson, G. B., & Treiman, R. (2007). The English Lexicon Project. *Behavior Research Methods, 39*, 445–459.

Beaver, D. I., & Clark, B. Z. (2009). *Sense and sensitivity: How focus determines meaning*. Wiley.

Beier, E. J., & Ferreira, F. (2022). Replication of Cutler, A., and Fodor, J. A. (1979). Semantic focus and sentence comprehension. Cognition, 7(1), 49–59. *Journal of Memory and Language, 126*, 104339.

Benatar, A., & Clifton, C., Jr. (2014). Newness, givenness and discourse updating: Evidence from eye movements. *Journal of Memory and Language, 71*(1), 1–16.

Birch, S., & Rayner, K. (1997). Linguistic focus affects eye movements during reading. *Memory & Cognition, 25*, 653–660.

Birch, S., & Rayner, K. (2010). Effects of syntactic prominence on eye movements during reading. *Memory & Cognition, 38*(6), 740–752.

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.

Brysbaert, M., & New, B. (2009). Moving beyond Kučera and Francis: A critical evaluation of current word frequency norms and the introduction of a new and improved word frequency measure for American English. *Behavior Research Methods, 41*(4), 977–990.

Büring, D. (2009). Towards a typology of focus realization. In M. Zimmermann & C. Féry (Eds.), *Information structure: Theoretical, typological, and experimental perspectives* (pp. 177–205). Oxford: Oxford University Press.

Büring, D. (2016a). *Intonation and meaning*. Oxford University Press.

Büring, D. (2016b). Unalternative semantics. *Semantics and Linguistic Theory, 25*, 550–575.

Bürkner, P.-C. (2017). brms: An R package for Bayesian multilevel models using Stan. *Journal of Statistical Software, 80*(1), 1–28.

Chromý, J., & Vojvodić, S. (2023). When and where did it happen? systematic differences in recall of core and optional sentence information. *Quarterly Journal of Experimental Psychology, 77*, 111–132.

Clifton, C., Jr., & Frazier, L. (2018). Context effects in discourse: The question under discussion. *Discourse Processes, 55*(2), 105–112.

Crain, S. (1985). On not being led up the garden path. In *Natural language parsing* (pp. 320–358). Cambridge University Press.

Cutler, A., & Fodor, J. A. (1979). Semantic focus and sentence comprehension. *Cognition, 7*(1), 49–59.

Dahan, D., Tanenhaus, M. K., & Chambers, C. G. (2002). Accent and reference resolution in spoken-language comprehension. *Journal of Memory and Language, 47*, 292–314.

Forster, K. I., Guerrera, C., & Elliot, L. (2009). The maze task: Measuring forced incremental sentence processing time. *Behavior Research Methods, 41*, 163–171.

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.

Frazier, L. (1979). *On comprehending sentences: Syntactic parsing strategies.* PhD thesis, University of Connecticut.

Frazier, L. (1999). *On sentence interpretation* (Vol. 22). Springer Science & Business Media.

Frazier, L., & Fodor, J. D. (1978). The sausage machine: A new two-stage parsing model. *Cognition, 6*(4), 291–325.

Gotzner, N. (2017). *Alternative sets in language processing: How focus alternatives are represented in the mind*. Springer.

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., Wartenburger, I., & Spalek, K. (2016). The impact of focus particles on the recognition and rejection of contrastive alternatives. *Language and Cognition, 8*, 59–95.

Harris, J. A. (2019). *Alternatives on demand and locality: Resolving discourse-linked wh-phrases in sluiced structures*. Springer.

Heim, I., & Kratzer, A. (1998). *Semantics in generative grammar*. Blackwell.

Hoeks, M., Toosarvandani, M., & Rysling, A. (2023). Processing of linguistic focus depends on contrastive alternatives. *Journal of Memory and Language, 132*, 104444.

Husband, M., & Ferreira, F. (2016). The role of selection in the comprehension of focus alternatives. *Language, Cognition and Neuroscience, 31*(2), 217–235.
Ito, K., & Speer, S. R. (2008). Anticipatory effects of intonation: Eye movements during instructed visual search. *Journal of Memory and Language, 58*(2), 541–573.
Jackendoff, R. (1972). *Semantic interpretation in generative grammar*. MIT Press.
Jeffreys, H. (1998). *Theory of probability*. Oxford University Press.
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.
Kim, C. S., Gunlogson, C., Tanenhaus, M. K., & Runner, J. T. (2015). Context-driven expectations about focus alternatives. *Cognition, 139*, 28–49.
Krifka, M. (1992). A framework for focus-sensitive quantification. *Semantics and Linguistic Theory, 2*, 215–236.
Lacina, R., Sturt, P., & Gotzner, N. (2023). The comprehension of broad focus: Probing alternatives to verb phrases. In *Information structure—Theory: How and why discourse limits the way we express what we express*. Language Science Press.
Landauer, T. K., & Dumais, S. T. (1997). A solution to Plato's problem: The latent semantic analysis theory of acquisition, induction, and representation of knowledge. *Psychological Review, 104*(2), 211.
Morris, R. K., & Folk, J. R. (1998). Focus as a contextual priming mechanism in reading. *Memory & Cognition, 26*(6), 1313–1322.
Neely, J. H. (2012). Semantic priming effects in visual word recognition: A selective review of current findings and theories. In *Basic processes in reading* (pp. 264–336). Routledge.
Pierrehumbert, J., & Hirschberg, J. (1990). The meaning of intonational contours in the interpretation of discourse. In *Intentions in communication* (pp. 271–311). MIT Press.
R Core Team. (2023). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing.
Rhode, D. (2001). *Linger. A flexible platform for language processing experiments*.
Roberts, C. (1996). Information structure in discourse: Towards an integrated formal theory of pragmatics. In *Ohio State University working papers in linguistics* (Vol. 49). Ohio State University.
Rooth, M. E. (1985). *Association with focus (montague grammar, semantics, only, even)*. PhD thesis, University of Massachusetts Amherst.

Rooth, M. E. (1992). A theory of focus interpretation. *Natural Language Semantics, 1*(1), 75–116.

Rotello, C. M., & Macmillan, N. A. (2007). Response bias in recognition memory. In *Psychology of learning and motivation* (pp. 61–94). Elsevier.

Schwarzschild, R. (1999). GIVENness, avoidF, and other constraints on the placement of accent. *Natural Language Semantics, 7*, 141–177.

Selkirk, E. (1984). *Phonology and syntax: The relation between sound and structure*. MIT Press.

Swinney, D. (1979). Lexical access during sentence comprehension: (Re)Consideration of context effects. *Journal of Verbal Learning and Verbal Behavior, 18*, 645–659.

Von Stechow, A. (1991). Focusing and backgrounding operators. *Discourse Particles, 6*, 37–84.

Watson, D. G., Tanenhaus, M. K., & Gunlogson, C. A. (2008). Interpreting pitch accents in online comprehension: H* vs. L+H. *Cognitive Science, 32*(7), 1232–1244.

Weber, A., Braun, B., & Crocker, M. W. (2006). Finding referents in time: Eye-tracking evidence for the role of contrastive accents. *Language and Speech, 49*(3), 367–392.

Zehr, J., & Schwarz, F. (2018). *Penncontroller for Internet Based Experiments (IBEX)*.