Anna-Lisa Ndao & Katharina Spalek

2019

What's the Alternative? Experimental Research on the Extent of Focus Alternative Sets

In

A. Gattnar, R. Hörnig, M. Störzer & S. Featherston (Eds.)

Proceedings of Linguistic Evidence 2018: Experimental Data Drives Linguistic Theory

Tübingen: University of Tübingen

https://publikationen.uni-tuebingen.de/xmlui/handle/10900/87132

In A. Gattnar, R. Hörnig, M. Störzer & S. Featherston (Eds.) (2019). *Proceedings of Linguistic Evidence 2018: Experimental Data Drives Linguistic Theory.* Tübingen: University of Tübingen. https://publikationen.uni-tuebingen.de/xmlui/handle/10900/87132

What's the Alternative? Experimental Research on the Extent of Focus Alternative Sets

Anna-Lisa Ndao & Katharina Spalek
Humboldt-Universität zu Berlin
ndaolisa@hu-berlin.de

1 Introduction

People have countless conversations every day in which they seemingly effortlessly exchange vast amounts of information with their interlocutors. The information structure of a sentence is said to support listeners in identifying the core message of an utterance as intended by the speaker, as the speaker uses information structure to "pack" the information in a way that best serves his current communicative needs (Chafe, 1976). One notion of information structure is focus.

In many languages, including German and English, focus can be realised by using a pitch accent. Through prosodic marking, the focused element(s) become privileged in language comprehension. There has been evidence that focus structure guides listeners' attention (e.g., Cutler & Fodor, 1979) and that focused elements seem to have a special representation in memory as they are better remembered than non-focused elements (e.g., Fraundorf et al. 2010). However, according to Alternative Semantics (Rooth, 1985, 1992), the primary function of focus is to introduce alternatives to the focused element into the computation of the sentence. Consider example (1), where (1a) and (1b) differ with respect to their focus structure. Here (and in the remainder of this paper), the focus position is indicated by the subscript *F*, while capital letters indicate that a pitch accent was used as the means to realise focus.

(1) a. Tom broke the $[\text{MUG}]_F$
b. $[\text{TOM}]_F$ broke the mug

(2) Ordinary semantic value: {broke (Tom, mug)}

(3) a. Focus semantic value: {broke (Tom, x) | x ε *E*}
b. Focus semantic value: {broke (y, mug) | y ε *E*}

Alternative Semantics advocates that there are two components to the meaning of a sentence with a focused element, the ordinary semantic value and the focus semantic value. The ordinary semantic value, which equates to the meaning as derived by conventional compositional semantics, is identical for (1a) and (1b), namely (2). In both sentences, someone called Tom broke the mug. The focus semantic value is added by focus and therefore changes with the position of focus. It corresponds to the set of propositions containing elements that match the focused element in semantic type and that could substitute it in the given context, namely, alternatives to the focused element. The focus semantic value of (1a) could therefore be described as (3a), *Tom broke x*. Here, x stands for all the possible things Tom could have broken, including the focused element *mug*. *E*, that is, the set of alternatives from which the focused element derived, could thus be described as [mug, plate, glass, shelf, (…)]. The focus semantic value of (1b) corresponds to (3b), where y stands for all the possible people who could have broken the mug. Here, the alternative set *E* might look something like [George,

Susan, Tom, John, (…)]. Thus, focus influences the interpretation of a sentence, or to be more exact, the pragmatic inferences a listener draws from it.

A number of experimental studies have provided evidence in support of Alternative Semantics, showing that alternatives are cognitively real entities which are being activated in listeners' minds when processing a focused element (e.g., Braun & Tagliapietra, 2010; Gotzner, 2015a; Gotzner et al., 2016; Husband & Ferreira, 2016). However, only little is known about which specific elements are considered as alternatives.

The aim of the current study was to identify which elements are part of this set of alternatives and therefore to specify the value of the meaning that is added to a sentence by focus.

In the next section, we will first provide a brief overview of previous psycholinguistic studies investigating focus, before introducing two theoretical accounts that make opposing claims about the extent of alternative sets. Then, after outlining our experiment in detail, we will discuss our findings with respect to these two theories.

2 Background

2.1 Previous empirical studies on focus alternatives

As Alternative Semantics is a formal semantic account, it does not directly provide any information about the actual computation of focus or its underlying cognitive processes. What does it mean when we say that a listener 'entertains' a set of focus alternatives or that he 'considers' them as part of the sentence's interpretation? While some experimental research has investigated the general processing of focus by looking at its effect on, for example, eye movements during silent reading (e.g., Birch & Rayner, 1995, 2010), guiding ambiguity resolution (e.g., Almor, 1999; Almor & Eimas, 2008), ellipsis processing (e.g., Carlson et al., 2009) or the ability to make predictions about upcoming referents (e.g., Weber et al., 2006), in recent years, some studies have specifically looked at focus alternatives.

In a pioneering study, Braun & Tagliapietra (2010) used a cross-modal priming paradigm to examine whether focus alternatives are cognitively real. More specifically, they investigated whether a contrastive intonation (L+H* pitch accent) elicits those focus alternative sets. Participants first heard a sentence with either a neutral intonation (control condition) or a double contrast, that is, with two contrastively accented constituents (critical condition), one of which was the prime word in final position ([*In FLORIDA]$_F$ he photographed a [FLAMINGO]$_F$*). Afterwards, participants performed a lexical decision task on a visually presented target word that was either a contrastive associate (i.e., an alternative to the prime: *pelican*), a generic, non-contrastive associate (i.e., not a contrastive alternative to the prime; *pink*) or a word unrelated to the prime and both associates (*celebrity*).

The rationale behind this experimental paradigm is that if a target word is an alternative to the focused prime word, that is, part of its alternative set, it should be activated when computing the focused adjective. This activation should then positively affect the subsequent lexical decision task, meaning that an alternative should be recognised faster as being a real word than an unrelated target. Building on this, the authors predicted that contrastive associates should be recognised faster compared to unrelated targets when hearing the sentence with contrastive intonation than with neutral intonation. However, the recognition of the non-contrastive associates should not be affected by the contrastive intonation, as they are no alternatives to the prime word and thus should not be more activated when hearing the prime word with a contrastive pitch accent than when hearing it with a neutral intonation. If both types of associates were to be affected by the contrastive intonation, one could assume that focus activates all kinds of associates, not only a set of focus alternatives. The results were in line with the authors' first predictions. Contrastive associates were recognised faster than unrelated ones, but only when the prime word was presented with a contrastive intonation. Non-

contrastive associates were recognised slightly faster than unrelated ones. However, this facilitation occurred in both prosodic conditions, suggesting that non-contrastive associates were not influenced by contrastive intonation. Braun & Tagliapietra concluded that only contrastive associates are facilitated by contrastive intonation because only they are part of the set of alternatives that is being activated during the processing of focus, thus presenting concrete evidence for the cognitive reality of alternatives.

Husband & Ferreira (2016) followed up on Braun & Tagliapietra (2010), investigating the time course of and mechanisms related to the establishment of alternative sets. In two cross-modal priming experiments, they compared the activation of contrastive and non-contrastive associates, using two different stimulus onset asynchronies (SOA) to observe how alternative sets are established over time. Husband & Ferreira found that initially, a wider set of related words is activated, including contrastive and non-contrastive associates of the focused element. However, when targets are presented with a delay of 750 ms after the offset of the focused element, only contrastive associates remain activated, that is, only those, that form the true set of focus alternatives. The authors thus concluded that any mechanism restricting the alternative set seems to take time to come into effect.

To summarise, the studies by Braun & Tagliapietra (2010) and Husband & Ferreira (2016) seem to provide evidence that a possible substitute (i.e., an alternative) for a prime word is more accessible when the prime word is realised in a contrastive focus accent. Thus, prosodic focus alone seems to create representations of alternatives to a focused element during online language processing. Studies investigating the processing of focus sensitive particles, such as *only* or *even*, instead of bare prosodic focus support these findings (e.g., Gotzner et al., 2016).

Although all previous studies show that alternative sets are cognitively real and seem to consist of elements that are possible substitutes for the focused element, as would be predicted by Alternative Semantics, they do not yet answer the question which specific words are considered as possible substitutes for the prime word. Are, for example, only other colour adjectives, such as *black*, *blue* and *white*, considered as possible substitutes for *pink* in (4), or also adjectives that describe other properties of the trousers, such as *used, ripped* or *tight*?

(4) Ben bought $[\text{PINK}]_F$ trousers

Before moving on to our study that aimed at investigating this question, we will present two theoretical accounts, a permissive and a restrictive account[1], that make different claims about what constitutes a good substitute, and, as a result make different predictions about the extent of alternative sets.

2.2 The extent of alternative sets: Theoretical accounts

According to Rooth's Alternative Semantics theory (1985, 1992), whose fundamental claims we outlined earlier on, only elements that match the focused element in (semantic) type and that are not identical to it are considered to be alternatives. Thus, if the focused element is, for example, a transitive verb of the type <e, et>, only elements of the same type would be possible alternatives.

However, Rooth points out the necessity to restrict the alternative set in some way and therefore introduces the variable C (Rooth, 1985). The value of this covert variable is not semantically fixed but instead constrained by the focus semantic value and further restricted by context. Therefore, Rooth bases the contextual restriction of alternative sets entirely upon pragmatic processes, without specifying which underlying factors or mechanism could distin-

[1] We will follow Katzir (2013) and Gotzner (2015a, 2015b) in using the terms *permissive* and *restrictive*. Note, however, that neither of the two authors of the two accounts, i.e., Rooth (1985, 1992) or Wagner (2006, 2012), used them to describe their theories.

guish between contextually appropriate and contextually inappropriate replacements. However, in his 1992 paper (p.79), Rooth gives an example to illustrate how these pragmatic processes might construct a domain of quantification.

(5) Mary only $[\text{read}]_F$ *The Recognitions*.

In (5), the focused element is a transitive verb that describes a certain relation between the subject and the object, namely that Mary has read the book *The Recognitions*. Rooth (1992) explains that applying the whole focus semantic value would lead to inappropriate truth conditions (i.e., inappropriate relations between the subject and object, like e.g., *Mary ate The Recognitions)*. Instead, context restricts C to only two elements, *read* and *understand*. Based on this example, we therefore interpret Rooth's variable C as being bound or restricted by world knowledge

To summarise, according to Rooth (1985, 1992), alternatives need to be of the same semantic type as the focused element, they need to be distinct from it, and they need to be contextually appropriate replacements for it. For (4), here repeated as (6), Rooth would thus predict an alternative set that contains colour adjectives as well as adjectives that describe other properties of the trousers, such as [black, blue, white, ripped, used, tight, (…)], as all of these adjectives satisfy all of Rooth's requirements. Thus, as Rooth predicts a rather broad set of focus alternatives, his account will be referred to as a permissive account.

(6) Ben bought $[\text{PINK}]_F$ trousers

Wagner (2006, 2012) presents a more restrictive account on the extent of focus alternative sets. While he agrees with the main claim of Alternative Semantics, namely that the main function of focus is to introduce relevant alternatives for the focused element into the discourse, he disagrees with the permissiveness of Rooth's theory with regards to the extent of alternative sets. On the basis of examples like (7), Wagner (2006: 297) claims that certain 'Rooth alternatives' (i.e., alternatives according to the permissive account by Rooth) are in fact not appropriate substitutes for the focused element and therefore not part of its alternative sets.

(7) a. Mary only likes $[\text{red}]_F$ convertibles.

b. Mary likes blue convertibles.

c. Mary likes high-end convertibles.

According to Wagner (2006, 2012), the sentence in (7a) automatically negates (7b), as Mary cannot like blue convertibles if she only likes red ones. However, (7a) does not rule out (7c), as (7a) does not seem to imply anything about the price or quality of the convertibles Mary likes. She could like red convertibles that are high-end or cheap, (7a) does not provide information in this regard. Thus, *high-end* seems to be ignored as a possible replacement for *red*. Wagner (2006, 2012) argues that in example (7) only *blue* is a true alternative for the focused element *red* because these two are contrastive and mutually exclusive (if one is true, the other one cannot be true). *High-end*, on the other hand, is not a true alternative for the focused adjective *red* in this context, as the two elements do not negate one another. Thus, Wagner (2006, 2012) infers that elements need to be contrastive and mutually exclusive to be part of an alternative set, therefore restricting alternative sets to a much greater degree than Rooth (1985, 1992). This account will therefore be called the restrictive account.

So, while both accounts agree on context being an important influencing factor on the establishment of alternative sets, they disagree on the members of the set itself. However, what is important to keep in mind is that the permissive and the restrictive alternative sets overlap. All elements of the restrictive alternative set, namely contrastive and mutually exclusive elements, are also alternatives of the permissive set, making the restrictive alternative set a subset of the permissive alternative set.

3 Current study

3.1 Aims and hypotheses

Previous experimental studies provide evidence that listeners activate contrastive alternatives upon hearing a focused element and thus claim that alternative sets contain contrastive alternatives. The question that previous research cannot yet answer is whether the alternative set only contains these contrastive alternatives or whether non-contrastive alternatives that are grammatically and contextually appropriate replacements are also included.

Therefore, the specific aim of this study is to investigate whether focus alternative sets are restricted to contrastive, mutually exclusive alternatives, as claimed by Wagner's restrictive account (2006, 2012), or if alternative sets contain a broader set of alternatives that includes contrastive alternatives as well as non-contrastive alternatives that are possible replacements for the focused element, as suggested by Rooth's permissive account (1985, 1992).

In our experiment, we used a cross-modal-priming paradigm[2] to investigate which elements are activated when processing a focused word, and therefore to gain evidence in favour of either one of the two accounts. While previous studies investigating the availability of focus alternatives during language processing had used contrastive focus, we used new information focus. Participants first heard auditory dialogues that each consisted of a question and an answer. The answer contained the discourse-new adjective that served as the focused prime word. Each dialogue was followed by a visually presented target word, which was either a Wagner alternative, a Rooth alternative, an unrelated target or a pseudoword. Participants then had to press a button to indicate whether the written target word was an existing German word or not. We measured the time the participants took to identify the critical targets as real German words to then compare the reaction times of all three conditions.

Building on the results of previous studies as well as the two theoretical accounts outlined earlier, we predicted the following for the three different groups of targets. First, we expected that the pitch accent of the prime word would activate Wagner alternatives, which would allow participants to recognise this group of targets faster than the unrelated target words. This prediction would not only be supported by the restrictive but also by the permissive account, as both agree that contrastive alternatives are part of the alternative set. Furthermore, previous experimental studies have provided evidence in support of this prediction, although their research looked at focused nouns (e.g., Braun & Tagliapietra, 2010; Husband & Ferreira, 2016). For the Rooth alternatives, there were two possible outcomes. First, if Rooth alternatives were part of the alternative set as assumed by the permissive account, then this group of target words should also be activated while processing the focused prime word. This should then enable participants to recognise these target words faster than the unrelated targets. Second, if Rooth alternatives were not part of the alternative set as suggested by the restrictive account, then this group of targets words should not be recognised faster than unrelated target words. The results pattern of the Rooth alternatives will allow us to decide between the two theoretical accounts.

3.2 Method

3.2.1 Participants

35 participants took part in the experiment and were given monetary compensation for their participation. Two participants were excluded before the analysis due to their multilingual background, which was discovered after the data collection was completed. The remaining 33 participants (22 female, mean age 26.6 years; range 19-31) were German native speakers (no

[2] Here, we followed previous experimental studies (e.g., Braun & Tagliapietra, 2010; Husband & Ferreira, 2016; Gotzner et al., 2016) which showed that this is a suitable experimental design to investigate alternative sets.

other language before the age of five) and students. No one reported any visual or hearing impairments. None of the participants took part in either of the two pre-studies that were conducted to finalise the study's materials (cf. 3.2.2 Materials).

3.2.2 Materials

The experimental item set consisted of 45 short dialogues, each containing a question and a corresponding answer, as illustrated in (8). Question-answer-scenarios were chosen because they provide a very natural context setting for focus, as it is here commonly used for pragmatic purposes (e.g., Krifka, 2007).

(8) Speaker 1 – Question (context sentence):
Was für ein Buch hat Georg in der Schule gelesen?
'What kind of book did Georg read at school?'

Speaker 2 – Answer (critical sentence):
Er hat ein [SPANNENDES]$_F$ Buch gelesen.
'He read a [THRILLING]$_F$ book.'

Written target words in three conditions:
Wagner alternative: *langweilig (boring)*
Rooth alternative: *historisch (historical)*
Unrelated target: *zufrieden (satisfied)*

The answer was the critical sentence, containing an adjective that functioned as the focused prime word, corresponding to the *wh*-phrase in the question. Each prime word was realised in a H* pitch accent, which is said to be the standard accent type for new information focus (e.g., Pierrehumbert & Hirschberg (1990), Katz & Selkirk (2011); see Watson et al. (2008) for a more detailed discussion). Figure 1 shows the average pitch contour of the focused adjectives across all experimental items. The fundamental frequency was measured across eight intervals around the stressed syllable of the focused adjective: Two intervals corresponded to the syllable preceding the stressed syllable of the prime, two to the stressed syllable itself, and four to the following two syllables. To ensure that the results of the acoustic analysis were in line with listeners' perception, we conducted a pre-study. German native speakers (n=40) were asked to listen to the recorded answer of each item and identify if a constituent in the sentence was particularly emphasised, and if so, to indicate which one. The results of the study verified that each of the critical items bore a perceivable pitch accent on the adjective.[3]

Each dialogue was paired with a visually presented target word in one of three conditions, on which the lexical decision task was performed (cf. (8)). The target word was either a Wagner alternative (*boring*), a Rooth alternative (*historical*) or an unrelated target word (*satisfied*). In line with the restrictive view, all Wagner alternatives (WA) were not only contrastive but they and the focused adjective were mutually exclusive (**ein spannendes, langweiliges Buch*), while Rooth alternatives (RA) were possible alternatives that could be substituted for the focused adjective but they did not negate one another (*ein spannendes, historisches Buch*). The unrelated targets (UT) were adjectives (i.e., same semantic type (et)) that were no alternatives for the focused adjectives, as they were not appropriate replacements in the given context (**ein zufriedenes Buch*).

[3] Note that the participants listened to critical as well as filler items, meaning that they listened to sentences with narrow focus on the adjective (critical items + filler items), with narrow focus on the subject (filler items) and wide focus (filler items).

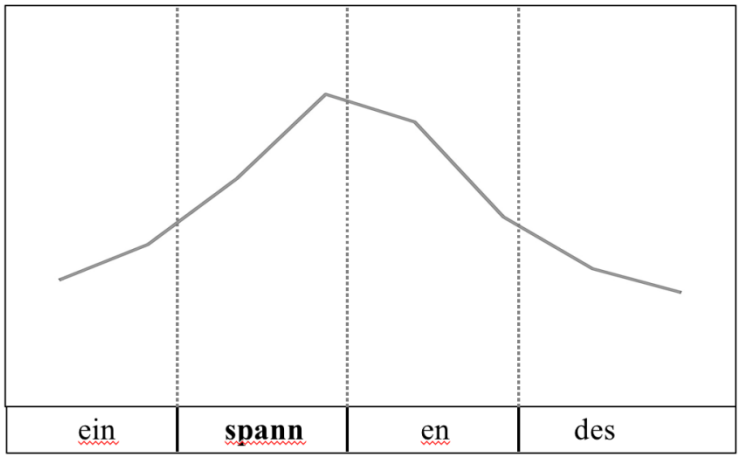

Figure 1. Average pitch contour (F0) of focused primes across all experimental items. Each segment corresponds to two intervals. The example *ein spannendes* is only used to visualise the segmentation

The number of letters, number of syllables as well as frequency information (type and lemma frequency (absolute and normalised)) for each target word were extracted from the lexical database for German, dlexDB (Heister et al., 2011), and statistical analyses (ANOVA) were performed to compare the three target type groups with respect to word length and frequency. As the results in Table 1 show, the three target groups did not significantly differ in any of the properties.

Table 1. Descriptive statistics and ANOVA results for the number of letters, number of syllables, absolute and normalised type frequency, as well as absolute and normalised lemma frequency for all three target type conditions

	Target type	**Mean**	**SD**	***F***	***p***
N° letters	RA	6.27	1.78		
	WA	6.07	1.86		
	UT	6.42	1.71		
				0.45	.64
N° syllables	RA	1.73	0.58		
	WA	1.67	0.67		
	UT	1.84	0.71		
				0.85	.43
Type freq. abs.	RA	1539.0	2429.3		
	WA	1791.7	2627.5		
	UT	1662.6	2092.9		
				0.13	.89
Type freq. norm.	RA	0.62	0.81		
	WA	0.79	0.70		
	UT	0.74	0.75		
				0.62	.54
Lemma freq. abs.	RA	4392.5	5187.5		
	WA	5015.4	5685.4		
	UT	3949.1	4578.5		
				0.48	.62
Lemma freq. norm.	RA	1.12	0.79		
	WA	1.33	0.61		
	UT	1.23	0.60		
				1.02	.36

Furthermore, a second pre-study was conducted to ensure that each target was a suitable candidate for its designated condition, namely that all Rooth and Wagner alternatives were equally good substitutes for the prime words in the given contexts, while the unrelated targets were not. In an online survey with 25 German native speakers, we investigated how meaning-

ful the critical sentences were perceived, when the prime word was replaced by either the Rooth alternative, the Wagner alternative or the unrelated target. The results confirmed that both alternative types were equally meaningful replacements and therefore relevant adjectives in the given context (ANOVA comparing the three groups: F (2, 132) = 0.351, p = .705), while the unrelated targets were not (Tukey HSD: difference between UT and each of the three other groups (WA, RA and prime): SE = 0.0566, p < .0001).

85 filler items were created, resulting in a ratio of about 2:1 filler items to critical items. There were three type of filler items, namely those with a narrow focus on the adjective (adj-foc), those with a narrow focus on the subject (sub-foc) and those where the whole verb phrase is focused (wide-foc). The structure of the adj-foc fillers was identical to the critical items but they were paired with a pseudoword. 15 of these items were included to ensure that not all sentences with a focused adjective were paired with a target word that required a yes-response in the experiment. Furthermore, 35 fillers each of the type sub-foc and wide-foc were included 1. to distract participants from the importance of adjectives in the experiment, and 2. to provide some variability in the structure and prosody of the items, to avoid participants losing interest and concentration due to a too monotone structure of the sentences. 25 sub-foc fillers and 25 wide-foc fillers were paired with pseudowords, while the remaining ten fillers of each group were paired with a real word. Thus, altogether the ratio of words to non-words in the experiment was balanced (65 each), not allowing participants to develop a bias for one of the two response options.

Furthermore, 30 comprehension questions about the content of some of the auditory stimuli were created. These would be asked at random intervals throughout the experiment to ensure that participants have an incentive to listen attentively to the auditory stimuli, as performing the lexical decision task itself did not require them to do so.

Three lists were created, using the Latin square design. Each list contained 45 critical items, that is, 15 items of each condition (15 target words = Rooth alternatives, 15 target words = Wagner alternative, 15 target words = unrelated targets), ensuring that each list contained every sentence in only one condition. The 85 filler items were added to every list. Each list was pseudo-randomised twice using the programme Mix (van Casteren & Davis, 2006), ending up with six experimental lists in total. Participants were randomly assigned to a list.

3.2.3 Procedure

Participants were seated in an experimental room in front of a 17-inch Belinea LCP-screen, wearing a PC131 Sennheiser headset. The experiment started with written instructions on the screen about the structure of the experiment, including an explanation of the tasks the participants would have to perform. Participants were informed about the structure of the auditory stimuli (question and answer) and that their task was to decide whether the written word that appeared after the dialogue was a real word of German or not. They were asked to listen attentively to the dialogues and to respond as fast and as accurate as possible when deciding about the displayed word. Participants were also informed that detailed questions about the dialogues would be asked at random intervals throughout the experiment and that they could take their time to think before answering these questions.

After reading the instructions, participants performed six practice trials, during which they could adjust the sound volume. Figure 2 illustrates the basic structure of a trial. Each trial began with a fixation cross displayed for 500 ms on the screen to inform participants about the start of a new trial. Afterwards, an audio sign appeared on the screen, while the auditory stimuli were presented over the headphones. With an offset of 100 ms the target word appeared on the screen and participants had to decide whether the written word was an existing word of German or not by pressing a button. The target word remained on the screen until a decision was made. If there was no response within 5000 ms, the trial would be counted as a miss and either the next trial would be initiated or the comprehension question would appear

on the screen. If there was a comprehension question, participants would have to answer the question by pressing a button and the question would stay on the screen until a response was given. Then the next trial would be initiated with an offset of 1000 ms during which a blank screen was presented. This allowed participants some time to prepare themselves for the next trial.

In total, there were five blocks of 26 trials, giving participants the chance to take a short break in between each block. The experiment lasted approximately 25 minutes. Afterwards, participants were asked a set of questions, containing questions about their age, their gender, their mother tongue, their handedness, their subject of study, and a question about the purpose of this study. All participants were tested individually.

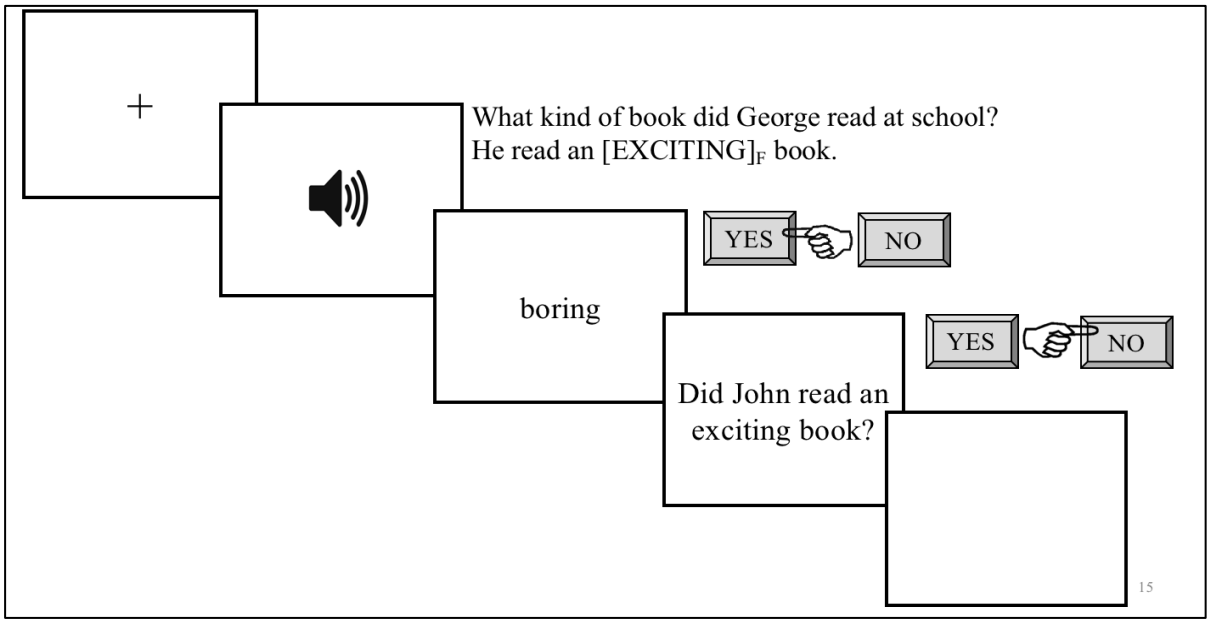

Figure 2. Basic illustration of a trial

3.3 Results

The data analysis was done with R (R Core Team, 2013), more specifically, with RStudio (RStudio Team, 2015). The error rate of three participants was not within normal distribution (i.e., more than seven false answers). As the number of mistakes could have been an indicator that participants were not attentively listening to the auditory stimuli containing the prime, these participants were excluded from further analyses.

For the remaining 30 participants, all inaccurate trials were excluded, resulting in a loss of 1.56 % of the data. For the identification of outliers, we followed a method suggested by Baayen & Milin (2010), namely to combine light a-priori screening for artificial responses with a removal of outliers that were not within normal distribution of the final model's residuals. The a-prior screening resulted in an exclusion of 0.5 % of the data (RT shorter than 300 ms or greater than 1300 ms), while a further 0.2 % were excluded after model fitting.

The descriptive statistics are summarised in Table 2. The mean reaction time for Rooth alternatives was 621.46 ms and 624.67 ms for Wagner alternatives, while the mean reaction time for the unrelated targets was longer, namely 652.79 ms.

Table 2. Descriptive statistics for the mean reaction time of all three conditions (Rooth alternatives, Wagner alternatives and Unrelated targets), including mean, standard deviation, standard error, reaction time minimum and maximum (in ms)

Condition	Mean	SD	Std. Error	Min	Max
Rooth alternatives	621.46	156.83	7.43	359.00	1275.00
Wagner alternatives	624.67	168.27	7.98	367.00	1264.00
Unrelated targets	652.79	157.46	7.50	361.00	1251.00

The reaction times were fitted with a series of linear mixed effect models (LMM), using the function lmer of the R package lme4 (Bates et al., 2015) and the package lmerTest (Kuznetsova et al., 2017) to compute the corresponding *p*-values. Model comparisons was performed to identify the best fitting model. The final model used for the analysis included the reciprocal transformation of reaction times, second order polynomial of the trial number, type frequency (normalised) and the target type as fixed factors, random intercepts for participants, target, and item, and random slopes for the second order polynomial of the trial number for each participant.[4]

The results of the LMM, summarised in Table 3, show that both Wagner alternatives (t = -3.146, p < .0001) and Rooth alternatives (t = -3.594, p < .0001) were recognised significantly faster than the unrelated target baseline. However, there was no significant difference between the two alternative types (t = 0.438, p = .662).

Table 3. Results of final LMM, including estimates, standard error, t values and p values
Model:-1000/RT ~ poly(Trial_Nr, 2)+ target_type+ Type_freq+ (1+poly(Trial_Nr, 2)| VP)+ (1|target)+ (1| item)

	Estimate	Std. Error	*t* value	Pr(>|*t*|)
Intercept	-1.56122	0.04776	-32.687	< 0.0001
Poly(trial, 2) 1	2.86181	0.59012	-4.850	< 0.0001
Poly(trial, 2) 2	0.95614	0.44778	2.135	0.0400
Rooth alternatives	-0.08623	0.02399	-3.594	< 0.0001
Wagner alternatives	-0.07565	0.02405	-3.146	< 0.0001
Type frequency (normalised)	-0.08108	0.01515	-5.352	< 0.0001
Rooth vs. Wagner alternatives	0.01059	0.02415	0.438	0.662

4 Discussion

The primary function of focus is to indicate the existence of alternatives for a focused element. The aim of the current study was to investigate which specific elements belong to this set of alternatives that is activated when processing a focused element. More specifically, we wanted to gain empirical evidence that helps to adjudicate between two theories that make different claims about the extent of alternatives set, and thus come closer to identifying the members of focus alternative sets.

We conducted a cross-modal priming experiment in which participants were exposed to auditory discourses that contained a focused adjective. Based on previous psycholinguistic research (e.g., Braun & Tagliapietra, 2010; Husband & Ferreira, 2016; Gotzner, 2015a, 2015b; Gotzner et al., 2016), we expected that alternatives for the focused elements would be

[4] The reciprocal transformation of reaction times was identified as the most suitable transformation (closest to being normally distributed). The random factor 'target' refers to the target words (visual stimuli), while the random factor 'item' refers to the primes used in the experiment (auditory stimuli).

activated when processing the sentence. This activation would then allow participants to recognise the alternatives faster in a subsequent lexical decision task than words that were not previously activated. In order to adjudicate for or against the two theories on the extent of alternative sets, the reaction times of three groups of target words were measured. The first group were contrastive alternatives that satisfied the requirement of mutual exclusion in accordance with the restrictive account by Wagner (2006, 2012). The second group were non-contrastive alternatives that were grammatically and contextually appropriate replacements for the focused element, that is, alternatives according to the permissive account by Rooth (1985, 1992). The third group functioned as the base line, containing unrelated targets that could not substitute the focused element in the given context and were thus no alternatives according to the restrictive or the permissive theory.

The results show that both types of alternatives, contrastive and non-contrastive ones, were activated upon hearing the focused adjectives, and thus provide evidence that alternative sets contain elements that can substitute the focused element in the given context. While Rooth's permissive theory would have predicted that both types of alternatives are part of the alternative set, Wagner's restrictive theory would have not. According to Wagner (2006, 2012), Rooth alternatives should not have been facilitated upon hearing a focused element, as they are not contrastive and do not satisfy the requirement of mutual exclusion. Thus, the results support Rooth's permissive account (1985, 1992), namely, that alternative sets contain a broad set of grammatically and contextually appropriate replacements for the focused element. The findings are also in line with the results of a post-hoc analysis of an existing data set (Gotzner et al., 2016) conducted by Gotzner (2015b). She, too, concluded that "listeners consider […] a broader set of alternatives rather than a limited one" (Gotzner, 2015b: 242).

Furthermore, the results of this study provide additional evidence that context is an important factor for the establishment of alternative set, as claimed by the permissive and the restrictive theory. Studies by Byram Washburn (2013) and Kim (2012) already suggest that listeners use contextual information to create sets of alternatives. This study supports those findings. The results show that alternatives are not necessarily of the same semantic network as the focused element. While Wagner alternatives were semantically closely related to the focused adjectives (antonyms, e.g., *exciting – boring*), Rooth alternatives were not (e.g., *exciting – historical*). The relationship between Rooth alternatives and the focused element was only established through context, showing that the restriction of alternative sets is greatly influenced by context.

Interestingly, this aspect is also linked to a possible caveat one might have regarding the interpretation of the results on the basis of the study's design. As the critical experimental items of our study only included one focus condition (i.e., pitch accent on the adjective) and no condition without focus, one might argue that the observed facilitation of the targets could be due to general semantic priming rather than be the result of focus. We believe that the results do not support this hypothesis. If the observed effect was indeed caused by general semantic priming, then one would expect the effect to be much greater for Wagner alternatives than for Rooth alternatives, as Wagner alternatives and the focused elements were antonyms and thus semantically much more closely related than Rooth alternatives and the focused elements. As no difference between the two was found, semantic priming cannot have been the (sole) source for the facilitation effect. However, it is necessary to conduct a follow-up study including a baseline to confirm our assumptions. Unfortunately, this would involve a complete re-structuring of the items, as question-answer-scenarios require the element in the answer that corresponds to the *wh*-phrase of the question to be focused.

One question that this study is unable to answer is whether or not the alternative sets for new information focus, which we used in this experiment, differ from those for contrastive focus, which was used by, for example, Braun & Tagliapietra (2010) and Husband & Ferreira (2016). There is the possibility that the final set of alternatives could differ for the two types of focus. For example, the final set of alternatives for contrastive focus might not include

Rooth alternatives, as they are not contrastive and therefore of less relevance. Thus, the interpretation of our results with regards to the permissive and restrictive account needs to be limited to information focus only. In order to make a claim about focus in general, one would have to conduct a similar study that includes contrastive focus and compare the results.

5 Conclusion

To conclude, the experiment presented here shows that listeners activate sets of alternatives when processing new information focus. Furthermore, the results seem to support Rooth's permissive account (1985, 1992), namely that these activated alternative sets contain a broad set of grammatically and contextually appropriate replacements for the focused elements, and not just contrastive and mutually exclusive ones, as postulated by the restrictive account by Wagner (2006, 2012).

Acknowledgements

We would like to thank Kim Jördens and Emilia Annacker for their assistance in data collection. This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement n° GAP-677742).

References

Almor, A. (1999). Noun-phrase anaphora and focus: The informational load hypothesis. *Psychological Review*, *106*(4), 748-765.

Almor, A., & Eimas, P. (2008). Focus and noun phrase anaphors in spoken language comprehension. *Language and Cognitive Processes*, *23*, 201-225.

Baayen, R. H., & Milin, P. (2010). Analyzing reaction times. *International Journal of Psychological Research*, *3*(2), 12-28.

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models Using lme4. *Journal of Statistical Software*, *67*(1), 1-48.

Birch, S., & Rayner, K. (1995). 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), 740-552.

Braun, B., & Tagliapietra, L. (2010). The role of contrastive intonation contours in the retrieval of contextual alternatives. *Language and Cognitive Processes*, *25*, 1024-1043.

Byram Washburn, M. (2013). *Narrowing the Focus: Experimental studies on exhaustivity and contrast* (Doctoral dissertation). University of Southern California, Los Angeles, CA.

Carlson, K., Dickey, M. W., Frazier, L., & Clifton, C. Jr. (2009). Information structure expectations in sentence comprehension. *The Quarterly Journal of Experimental Psychology, 62*(1), 114-139.

Chafe, W. (1976). Givenness, contrastiveness, definiteness, subjects, topics, and point of view in subject and topic. In C. N. Li (Ed.), *Subject and Topics* (pp. 25-55). New York City, NY: Academic Press.

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

Fraundorf, S., Watson, D., & Benjamin, A. (2010). Recognition memory reveals just how CONTRASTIVE contrastive accenting really is. *Journal of Memory & Language*, *63*, 367-386.

Gotzner, N. (2015a). *Establishing Alternative Sets* (Doctoral dissertation). Humboldt-Universität zu Berlin, Berlin.

Gotzner, N. (2015b). What's included in the set of alternatives? Psycholinguistic evidence for a permissive view. In E. Csipak & H. Zeijlstra, (Eds.), P*roceedings of Sinn und Bedeutung, 19* (pp. 232-247). Göttingen: Georg-August-Universität Göttingen.

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.

Heister, J., Würzner, K.-M., Bubenzer, J., Pohl, E., Hanneforth, T., Geyken, A., & Kliegl, R. (2011). dlexDB - eine lexikalische Datenbank für die psychologische und linguistische Forschung. *Psychologische Rundschau*, *62*(1), 10-20.

Husband, E. M., & Ferreira, F. (2016). The role of selection in generating focus alternatives. *Language, Cognition and Neuroscience*, *31*(2), 217-235.

Katz, J., & Selkirk, E. (2011). Contrastive focus vs. discourse-new: Evidence from phonetic prominence in English. *Language*, *87*(4), 771-816.

Kim, C. S. (2012). *Generating Alternatives: Interpreting Focus in Discourse*. Dissertation, University of Rochester, New York City, NY.

Krifka, M. (2007). Basic notions of information structure. In C. Féry, F. G. Fanselow & M. Krifka (Eds.), *The notions of information structure. Interdisciplinary studies on information structure, 6* (pp. 13-56). Potsdam: Universitätsverlag Potsdam.

Kuznetsova, A., Brockhoff, P.B., & Christensen, R.H.B. (2017). lmerTest Package: Tests in Linear Mixed Effects Models. *Journal of Statistical Software*, 82(13), 1–26.

Pierrehumbert, J., & Hirschberg, J. (1990). The meaning of intonational contours in the interpretation of discourse. In P. Cohen, J. Morgan & M. Pollack (Eds.), *Intentions in Communication* (pp. 271-311). Cambridge, MA: MIT Press.

Rooth, M. (1985). *Association with Focus* (Dissertation). Massachusetts Institute of Technology, Cambridge, MA.

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

R Core Team (2013). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. http://www.R-project.org/

RStudio Team (2015). *RStudio: Integrated Development for R*. RStudio, Inc., Boston, MA. Version 1.0.143, retrieved March 2017 from http://www.rstudio.com/

van Casteren, M., & Davis, M. H. (2006). Mix, a program for pseudorandomization. *Behavior Research Methods*, *38*(4), 584-589.

Wagner, M. (2006). Givenness and locality. In M. Gibson & J. Howell (Eds.), *Proceedings of SALT, 16* (pp. 295-312). Ithaca, NY: Cornell University.

Wagner, M. (2012). Focus and givenness: A unified approach. In I. Kuerová & A. Neeleman (Eds.), *Contrasts and Positions in Information Structure* (pp. 102-147). Cambridge: Cambridge University Press.

Watson, D., Gunlogson, C., & Tanenhaus, M. (2008). Interpreting pitch accents in on-line comprehension: H* vs. L+H*. *Cognitive Science*, *32*, 1232-1244.

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