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Exploring Long-Distance Dependencies in Dutch: The Role of 'Waar' and 'Er'

Bachelor's Project Thesis

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Abstract: Extensive research has been done on the long-distance dependency (LDD) that English WH-phrases create when taking the role of a grammatical function in an English sentence, leaving behind a syntactic gap and causing difficulty with processing the sentence. While this effect has been found in English and other languages, it has not been found in Dutch between the WH-phrase *waar* and a syntactic gap, and pronominal *er* and a syntactic gap. This research focused on trying to find a slowdown in reading speed at the gap created by *waar* and *er* compared to a baseline sentence using a self-paced reading task (SPRT), to argue for the existence of an LDD between *waar* and *er* and the respective syntactic gaps. A likelihood ratio test using a linear mixed effects model did not find any significant effect of *waar* or *er* on the reading speed at the gap. The results on the lack of an existence of an LDD with *er* may indicate a true null result, where researching alternative effects for both *waar* and *er* may provide different insights.

1 Introduction

In certain English sentences, the meaning of a particular phrase in one position can be dependent on information that is in another part of the same sentence. This is what is called a long-distance dependency (LDD) (Stowe, 1986). LDDs have been studied broadly in the English language (Dąbrowska, 2008; Stowe, 1986; Kaplan & Zaenen, 1989), where one particular instance of an LDD involves a WH-phrase. An example of such a sentence is the following:

(1) What is Mary hitting that woman with— ? (Stowe, 1986, p.227)

In this sentence, the WH-phrase is "what" and takes the syntactic role of the object that is missing in this sentence (Stowe, 1986). At the position of the dash, a syntactic gap has been created where a prepositional object would normally appear. Compare this to the following example without an LDD caused by a WH-phrase, where the prepositional object "a stick" appears after the preposition "with":

(2) Mary is hitting that woman with **a stick**.

Now, we have a baseline sentence, where no syntactic gap is left behind. This is because the prepositional object "a stick" comes after the preposition "with". The LDD that is present in Gloss 1, is caused by the the WH-phrase "What" taking the syntactic role of the prepositional object that is missing after the preposition "with". Only once the reader realizes there is no prepositional object, they know to assign the syntactic role of the prepositional object to the WH-phrase. Like this, the meaning of the WH-phrase is dependent on the information that there is no prepositional object after the preposition.

Stowe (1986) investigated how people assign grammatical meaning to these WH-phrases in WH-sentences. In the first experiment, Stowe compared four different conditions with each other. The first condition (IF-CLAUSE) contained an if-clause, where no syntactic gap was present. The second condition (WH-SUBJ) contained a WH-phrase that took the syntactic role of the subject, leaving a gap in the subject position. In the third condition (WH-OBJ), the WH-phrase took the object position, and in the fourth (WH-POBJ), it took the prepositional object position. Stowe compared the reading times at the subject, object and preposi-

tional object positions between each condition.

A slowdown in reading speed was found for object noun phrases in general in the WH-clauses compared to the if-condition. Additionally, there was a significant slowdown at the object noun phrase in the WH-POBJ condition compared to the object noun phrase in the WH-SUBJ condition. Stowe interpreted these results in the sense that people expect a gap to appear in the object position and need extra processing time when there is no gap in that position (Stowe, 1986). Stowe also found a similar effect in sentences where people would most likely expect a gap at the prepositional object, but found a noun phrase in that location instead.

Thus, in these types of sentences a slowdown occurs at the position where a gap is expected to occur, where it does not. Therefore, if people are expecting a gap at, for example, the prepositional object position, it is not unrealistic to expect additional processing as well when the gap does appear. That is, their expectation of a gap location, has to be resolved when the gap is actually found, resulting in a possible slowdown as well.

This type of dependency between a WH-phrase taking over the syntactic role of a phrase, which has now been replaced by a syntactic gap later on in the sentence, is often referred to as a *filler-gap dependency* (e.g. Lewis & Phillips, 2015). While research has been done on these filler-gap dependencies with WH-phrases in English, this has not been researched thoroughly yet in Dutch.

1.1 Waar

Dutch also has WH-phrases like: "wie" (who), "wat" (what) and "waar" (where). The focus will be on *waar* in this research. *Waar* is a Dutch interrogative adverb and can be used similarly to English WH-phrases, taking over the syntactic role of a phrase in a sentence, leaving a syntactic gap behind. In particular, *waar* can take the syntactic role of the prepositional object in the sentence in the following manner:

(3) Waar heb ik het brood mee —
Where have I the bread with –
gesneden?
cut?
'What did I cut the bread with?'

In Gloss 3, the syntactic gap is created after the preposition "mee", where normally the prepositional object would occur. Compare this to the baseline sentence in Gloss 4, where the prepositional object comes after the preposition:

(4) Ik heb het brood met het mes
I have the bread with the knife
gesneden.
cut.
'I have cut the bread with the knife.'

Now, similarly to the comparison between Gloss 1 and Gloss 2, in Gloss 4 the prepositional object "the knife" comes after the preposition again, leaving no syntactic gap.

1.2 Er

Another word that can also take the syntactic role of a prepositional object, leaving a gap behind, is the Dutch word *er*. Non-native Dutch speakers often have a difficult time understanding *er*. This is no surprise, as *er* can have four different functions: repletive, partitive, pronominal and locative (Donaldson, 2008).

The repletive er_R describes how *er* is used together with an indefinite subject in a sentence and in passive sentences. When a sentences contains an indefinite subject, er_R introduces the verb that often comes before the indefinite subject. In this case, er_R can be translated to "there". An example of er_R is shown in Gloss 5.

(5) Er loop een man op straat.
Er_{R}(*There*) *walks a man on street.*
'There is a man walking in the street.'

An example of where er_R is used in Dutch passive sentences, where there is no grammatical subject, is given in Gloss 6.

(6) Er wordt aan de deur geklopt.
Er_{R}(*There*) *is on the door knocked.*
'There is a knock at the door.'

The partitive er_{PA} is used together with numerals and quantity adverbs (Donaldson, 2008). Whenever a sentence answers the question of "How many?", you need to use er_{PA} in that sentence (Voortman, 2005). An example of the use of er_{PA} is shown in Gloss 7.

(7) Hij heeft er genoeg.
He has er_{PA} *enough.*
'He has enough (of it/them).'

The pronominal er_{PR} can also be described as *er* with a preposition, where er_{PR} replaces the personal pronouns "hem", "het" and "ze" after prepositions and if the pronoun refers to a thing (Voortman, 2005) (Donaldson, 2008). An example of er_{PR} in a sentence is given in Gloss 8.

(8) Ik heb er het brood mee gesneden.
I have er_{PR} *the bread with cut.*
'I cut the bread with it/them'

The locative er_{LOC} replaces "daar", which means "there", when "daar" is not stressed in a sentence (Donaldson, 2008). For example, in Gloss 10, "Daar" is stressed in the sentence, where er_{LOC} cannot replace "Daar". In Gloss 9, which shows an example of the use of er_{LOC}, er_{LOC} is not in a stressed position, allowing for the substitution. Er_{LOC} can also replace "hier", which means "here".

(9) Ik ben er nooit geweest.
I am er_{LOC}*(there) never been.*
'I have never been there.'

(10) Daar ben ik nooit geweest.
There am I never been.
'I have never been *there*.'

Only the pronominal er_{PR} is able to take the syntactic role of a prepositional object similarly to how *waar* did. The reason for this, is that *waar* and er_{PR} can create something called a *pronominal adverb*. Pronominal adverbs are created when a pronoun cannot occur together with a preposition, similarly to how er_{PR} replaces personal pronouns. Examples of pronominal adverbs are: *waarmee* (therewith) and *ermee* (therewith). In Gloss 3, *waar* is used as a split pronominal adverb, as it can be rewritten to a declarative sentence with a pronominal adverb as follows:

(11) Het mes, waarmee ik het brood heb
The knife, wherewith I the bread have
gesneden, is scherp.
cut, is sharp.
'The knife, with which I cut the bread, is sharp.'

Now, "waarmee" is the pronominal adverb and refers to the prepositional object "het mes". For er_{PR}, Gloss 8 can be rewritten in the same way:

(12) Ik heb het brood ermee gesneden.
I have the bread therewith cut.
'I cut the bread with it/them'

Now, "ermee" is now the pronominal adverb and refers to the prepositional object that was used to cut the bread with.

Additionally, both *waar* and *er* belong to a group called R-pronouns (Noonan, 2017), which precede certain prepositions, allowing the preposition to be stranded (i.e. the preposition is not attached to its relevant object) in sentences like Gloss 11 and 12 (Zwarts, 1997). P-stranding *waar* from "mee" in Gloss 11 would look as follows:

(13) Het mes, waar ik het brood mee heb
The knife, where I the bread with have
gesneden, is scherp.
cut, is sharp.
'The knife, with which I cut the bread, is sharp.'

An example of p-stranding for er_{PR} compared to Gloss 12 is given in 8.

Note now, that through the p-stranding of the prepositions, *waar* has taken the syntactic role of the prepositional object "Het mes" in the relative clause in 13, leaving a gap after the preposition "mee":

(14) Het mes, waar ik het brood mee — heb gesneden, is scherp.

Er_{PR} has taken the syntactic role of a prepositional object, for example "the knife", that would have to be introduced in a context sentence:

(15) Ik heb er het brood mee — gesneden.

By creating these sentences, both *waar* and er_{PR} create something similar to a filler-gap dependency as Stowe (1986) did. Therefore, we believe that it is within reason to wonder whether a slowdown might occur at these syntactic gaps after the preposition. In the same way as was previously theorized for the slowdowns Stowe (1986) found, we believe that the slowdown will occur at the syntactic gap, due to the resolving of the gap created by the WH-phrase for *waar* and er_{PR}.

1.3 Self-Paced Reading Task

In both of her experiments, Stowe (1986) used a self-paced reading task (SPRT) to find the slowdowns in reading speed. *"SPR is a computerized method of recording a reading time for each designated segment (i.e., a word or phrase) of a sentence or series of sentences that is presented as an experimental stimulus."* (Jegerski, 2013, p.21). In an SPRT, the participant determines their own reading pace by repeatedly pressing a button, which causes the consecutive words in a sentence to appear one by one (Jegerski, 2013). In such a task, the rest of the sentence is masked by either dashes or another symbol. There are different variations of the SPRT, but for the purpose of this thesis, I will only consider the noncumulative, linear variation. Noncumulative SPRT entails that only one segment of the sentence is visible at a time, and the previous segment is remasked after a button press (Jegerski, 2013). This prevents the reader from being able to re-read previous words. When the task is linear, the segments will appear in a linear succession from left to right (Jegerski, 2013). SPRTs can be used to draw inferences about the cognitive processing of language, where relatively longer reading times indicate difficulty with processing (Jegerski, 2013). Like with Stowe (1986), an SPRT can be used to find where in the sentence a slowdown occurs and make an inference regarding LDDs from that (Jegerski, 2013).

1.4 Research Aim

With the SPRT being an established method to examine LDDs in sentences, I will be using an SPRT to investigate whether there is evidence for an LDD relationship between *waar* and a syntactic gap, and between er_{PR} and a syntactic gap.

This leads to the aim of this thesis being described as answering the following research question: *Is there a significant slowdown in reading speed on a self-paced reading task at a syntactic gap created by "waar" and "er" in Dutch compared to a baseline sentence?* The hypothesis is that there will be a significant slowdown in reading speed at the syntactic gap after the preposition that has been p-stranded from either *waar* or er_{PR}. This significant slowdown is in comparison to the reading speed at the same position in a corresponding baseline sentence, where the prepositional object remains after the preposition like in 4. To test the hypothesis, an SPRT was used to measure reading times on sets of baseline, *waar*- and er_{PR}-sentences. The assumption about the *waar*- and er_{PR}-sentences, is that the gap is located after the target preposition that has been p-stranded from er_{PR} or *waar*. The reading times within the region of interest (ROI) of three words (see 3.1) at the syntactic gap location were compared against each other between the baseline, er_{PR} and *waar* conditions. This means that a two-way comparison was done between the reading times within the ROI: baseline against *waar* and baseline against er_{PR}.

2 Methods

Using an SPRT, the reading times for every word in constructed baseline, *waar*- and er_{PR}-sentences were measured. Reading times were measured per word as opposed to per phrase, such that the experiment would produce more precise data points. Since it is expected that a syntactic gap causes the slowdown in reading speed, the er_{PR}- and *waar*-sentences were constructed such that they elicit a gap. Additionally, the baseline sentences were constructed to not elicit a syntactic gap. If an LDD were present in the baseline sentences, these sentences would not be a good control condition to compare reading times against from the other two conditions.

2.1 Participants

The experiment was carried out by 16 participants that were all between the ages of 19 and 70. All but one participant had Dutch as their first language, where one participant spoke Flemish Dutch. The participants had no learning disabilities that disrupt how the brain processes written language (e.g. dyslexia), and had either normal or corrected vision. The participants were paid €7.50 for their participation.

2.2 Materials

The experiment was written in OpenSesame (Mathôt et al., 2012) and was conducted in a room

without environmental distractions, on an Acer Aspire 5 laptop. The text colour was black and the font was Cascadia Code SemiLight with a 23 px font size. The background of the experiment was white.

2.3 Stimuli

Both target stimuli and distractor stimuli were created for the experiment. The target stimuli were made up of sets of three sentences. The three sentences corresponded to the three conditions: baseline, *waar* and er_{PR}. The distractor stimuli contained sentences that were meant to distract the participant from figuring out the goal of the research. In total, 24 sets of 3 target stimuli and 36 distractor stimuli were created in collaboration with a parallel study*, which from here on will be referred to as the parallel study.

2.3.1 Target stimuli

The target stimuli sets all had the same format as in Glosses 16, 17 and 18. These glosses are the baseline, *waar*- and er_{PR}-conditions respectively. Each sentence set is built around a different lexical verb with a fixed preposition, selected from a list of all Dutch verbs with a fixed preposition (Tersteeg & Duenk, 2017). The selected fixed prepositions consisted of: *aan, over, op, om, met, naar, van* and *voor*, where this is a subset of the prepositions Zwarts (1997) described as prepositions that allow R-pronouns. In the stimulus set including Glosses 16, 17 and 18, the lexical verb with a fixed preposition is "vragen om", which means "to ask for".

(16) Het kind heeft meerdere keren
The child has multiple times
ongeduldig om een lekker snoepje
impatiently about a tasty treat
gevraagd in de auto.
asked in the car.
'The child has impatiently asked for a tasty treat multiple times.'

(17) Het snoepje, waar het kind meerdere
The treat, **waar** *the child multiple*
keren ongeduldig om heeft gevraagd in
times impatiently about has asked in
de auto, was lekker.
the car, was tasty
'The treat, which the child had impatiently asked for multiple times in the car, was tasty.'

(18) Context: Naast mama ligt een lekker snoepje op de bijrijdersstoel.
'There is a tasty treat next to mom on the passenger seat.'

Het kind heeft er meerdere keren
The child has $\mathbf{er}_{\mathrm{PR}}$ *multiple times*
ongeduldig om gevraagd in de auto.
impatiently about asked in the car.

'The child has impatiently asked for it($\mathrm{er}_{\mathrm{PR}}$) multiple times in the car.'

To elicit a consistent syntactic gap for the er_{PR}- and *waar*-sentences, and avoid such a gap in the baseline sentences, each condition has a particular syntactic structure. Each sentence can be separated into three parts: the *waar*/er_{PR}-clause, the phrase before this clause and the phrase after this clause. This structure is shown in Table 2.1. The highlighted region in the table represents the region in which the hypothesized LDD between *waar*/er_{PR} and the syntactic gap after the target preposition (target prep.) is present in the *waar*- and er_{PR}-condition. This is also where we expect to find no such LDD in the baseline condition. This region is constructed to be as similar between conditions as Dutch syntax will allow, such that the reading times across these regions can be compared fairly. The only differences within this region between the conditions, are that there is a subject in the second position of the *waar*-clause and the lack of a prepositional object (pp-object) in the *waar*- and er_{PR}-clauses. The latter difference leads to the syntactic gap that is hypothesized to be the position in which the slowdown in reading speed will appear.

The phrases 1 and 2 in Table 2.1 for each condition, contain the remaining grammatical relations that make the rest of the sentence syntactically complete. Between sentences, auxiliaries, subjects,

*This thesis was done partly in collaboration with Jules Roboz who did a parallel study. We had the same fundamental research question, but he used an eye-tracking experiment. In this thesis, "we" refers to collaborative efforts and "I" refers to individual efforts.

Table 2.1: The syntactic structure for the target stimuli for all three conditions: baseline, *waar* and *er$_{PR}$*. The highlighted *waar/er$_{PR}$*-clause in blue represents the region in which the hypothesized LDD is present. Phrases 1 and 2 contain the remaining grammatical relations that make the rest of the sentence for each condition syntactically complete.

Target stimuli structure							
Baseline	phrase 1_B	-	-	adv. phrase	target prep.	pp-object	phrase 2_B
Waar	phrase 1_W	*waar*	subject	adv. phrase	target prep.	*(gap)*	phrase 2_W
Er	phrase 1_E	*er*	-	adv. phrase	target prep.	*(gap)*	phrase 2_E

objects and adverbial phrases were varied to prevent repetition that might have an effect on participants' reading speed.

In the baseline, phrase 1_B is always made up of a subject + an auxiliary, which is *"Het kind heeft"* in Gloss 16. Phrase 2_B is made up of an optional modal verb + the lexical verb + a second adverbial clause, which is *"gevraagd in de auto."* in Gloss 16.

The *waar*-condition always has a matrix clause and a relative clause, where the *waar*-clause is part of the relative clause. Phrase 1_W is always made up of the pp-object, which is *"Het snoepje,"* in Gloss 17. Phrase 2_W is made up of an auxiliary + an optional modal verb + the lexical verb + the second adverbial phrase that are still in the relative clause, which is *"heeft gevraagd in de auto,"* in Gloss 17. The end of the matrix clause contains the matrix verb + the adjective to the object-pp, which is *"was lekker."* in Gloss 17

In the *er*-condition, phrase 1_E is made up of the same components as phrase 1_B, which is *"Het kind heeft"* in Gloss 18. Phrase 2_E is also made up of the same components as phrase 2_B, which is *"gevraagd in de auto."* in Gloss 18.

For every stimulus set, the meaning of the sentence is retained between the conditions, where this is more difficult for the *er$_{PR}$*-condition due to the need of a context sentence. Because the pp-object cannot be present in the *er$_{PR}$*-sentence, it is unknown what *er$_{PR}$* is referring to without a context sentence. The context sentence is always made to fit the *er$_{PR}$*-sentence, introducing the pp-object, such that *er$_{PR}$* refers to the same pp-object across conditions, and the same adverbial phrases can be used across conditions as well.

To ensure that the constructed sentences read naturally, a Dutch native speaker reviewed the sentences without any prior knowledge of the research.

2.3.2 Distractor stimuli

We created three different types of distractor stimuli, where each type consisted of 12 sentences. The first type was a word for word translation of Hungarian sentences to Dutch. This created nonsense Dutch sentences with highly irregular grammar. An example of these translated distractors is shown in Gloss 19.

(19) *De kinderen lachend renden de
A gyerekek nevetve futottak a
waterslang onder de hete zomermiddag
locsoló alatt a forró nyári
op.
*délután*on.

The second type of distractor consisted of single agreement mistakes, where there were eight different agreement mistakes. All the distractors and corresponding agreement mistakes used in this research can be found in Appendix D. An example of a distractor with a noun + adjective gender disagreement is shown in Gloss 20.

(20) *Gisteravond las ik een **spannende**
Yesterday read I an exciting
boek.
book
'I read an exciting book yesterday'

The third type of distractor contained correct Dutch sentences. Analogously to the target stimuli in the *er$_{PR}$*-condition, six of these sentences had a corresponding context sentence, as shown in Gloss 21.

(21) Context: De zon zakte langzaam achter de hoge bergen.
'The sun sank slowly behind the high mountains.'

De eerste sterren werden al
The first stars were already
zichtbaar aan de hemel.
visible on the sky.

'The first stars were already visible in the sky.'

2.3.3 Stimuli distribution

The full set of stimuli was divided equally between the parallel study and this research. Sets 1-12 of the target stimuli, as well as a random sample of 18 from the 36 distractor stimuli were used for this research. The target stimuli for this research are listed in Appendices A, B and C. The distractor stimuli for this research are listen in Appendix D.

The target stimuli were first assigned to each participant using a Latin Square Design, as shown in Table 2.2, and then Python 3.12.0 (Van Rossum & Drake, 2009) was used to pseudorandomise the stimuli for each participant. After that, for each participant trial, either one or two random distractor stimuli appeared after either one or two target stimuli. This way, there were always at most two distractors next to each other, and at most two target stimuli next to each other. Every participant received the same 18 stimuli, meaning every participant received 12 + 18 = 30 stimuli in total. The sentences were masked following the noncumulative, linear variation as described in Section 1.3, using Python *3.12.0* (Van Rossum & Drake, 2009).

Table 2.2: The Latin Square Design used to distribute the target stimuli between the participants. The rows represent the sentence set numbers 1-6 and the columns are participant numbers 0-5. 'b'= baseline condition, 'w' =*waar*-condition and 'e' = *er*$_{PR}$-condition. The sentence sets 7-12 and participant numbers 6-15 are omitted.

Participant:	p0	p1	p2	p3	p4	p5
set 1	1b	1w	1e	1b	1e	1w
set 2	2w	2e	2b	2e	2w	2b
set 3	3e	3b	3w	3w	3b	3e
set 4	4b	4w	4e	4b	4e	4w
set 5	5w	5e	5b	5e	5w	5b
set 6	6e	6b	6w	6w	6b	6e

2.4 Experimental setup

Before the participants agreed to participate, they received information about the experiments. At the start of each session, the participants signed an informed consent form and were not told about the purpose of the research until after the experiments. The experiments for this research and the experiments for the parallel study were conducted right after one another. The order of which experiment was conducted first, was randomly determined by a coin toss for every participant.

Prior to conducting the actual experiments, a pilot study was first carried out with two additional participants to ensure that the instructions were clear. From this pilot, no issues were found with the experiment.

First, participants saw a screen with instructions, where they were informed that they were going to read masked sentences word for word from left to right. They were also informed that some sentences required a context. They would read the context normally, but read the corresponding masked sentence word for word. Additionally, they were informed that some sentences would be ungrammatical. Lastly, they read that after every sentence they would see a hashtag to mark the end of a sentence, and that an exclamation mark marked the end of the practice round or the experiment. Once they understood the instructions, they pressed the space bar and a practice round started with four practice sentences, that were not relevant to the stimuli used in the actual experiment part. Two of these were contextless sentences and two were sentences requiring a context.

Before each contextless sentence, a screen with instructions and a fixation dot appeared. The participants first read the instructions, which told them to look at the fixation dot and press the space bar to begin reading the sentence. Once the space bar was pressed, the masked sentence would appear, starting at the place where the fixation dot was. They read through the sentence by pressing the space bar until a screen with a hashtag appeared, marking the end of a masked sentence. Before every sentence requiring context, a warning was given on the screen that a context sentence would follow. After pressing the space bar, they read the context sentence first and then looked at the fixation dot before pressing the space bar. The

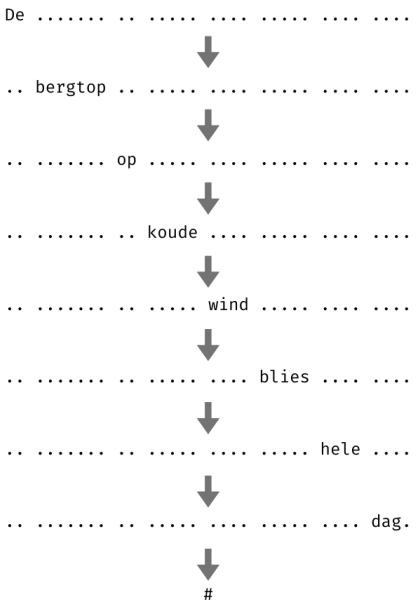


Figure 2.1: A flowchart of how the screen changed when pressing the space bar during a trial with a contextless stimulus. This particular sentence shows a distractor stimulus translated word for word from Hungarian.

fixation dot appeared below the context sentence. After pressing the space bar, the masked sentence appeared in the same manner as for the contextless sentences. A screen with a hashtag also appeared at the end of each masked sentence that required a context sentence. Figure 2.1 shows a flowchart of how participants saw the masked sentences, where the arrows represent pressing the space bar.

At the end of the four practice sentences, a screen with the exclamation mark appeared. After pressing the space bar, participants would see a warning that the practice round had ended, and that the experiment was about to begin once they pressed the space bar. At this point, the participants were asked by the researcher whether they had any questions before they started the experiment. After they pressed the space bar, the stimuli would appear in the same manner as explained in the practice block. After the participant had read all stimuli, an exclamation mark appeared again to mark the end of the experiment. Once they pressed space again, they were thanked for their participation and the experiment would end.

3 Results

During the experiment, the time between each press of the space bar while the participants read a stimulus was recorded in milliseconds. During the analysis, the data for the distractor stimuli was filtered out, leaving only the reading times of every word in the three target conditions.

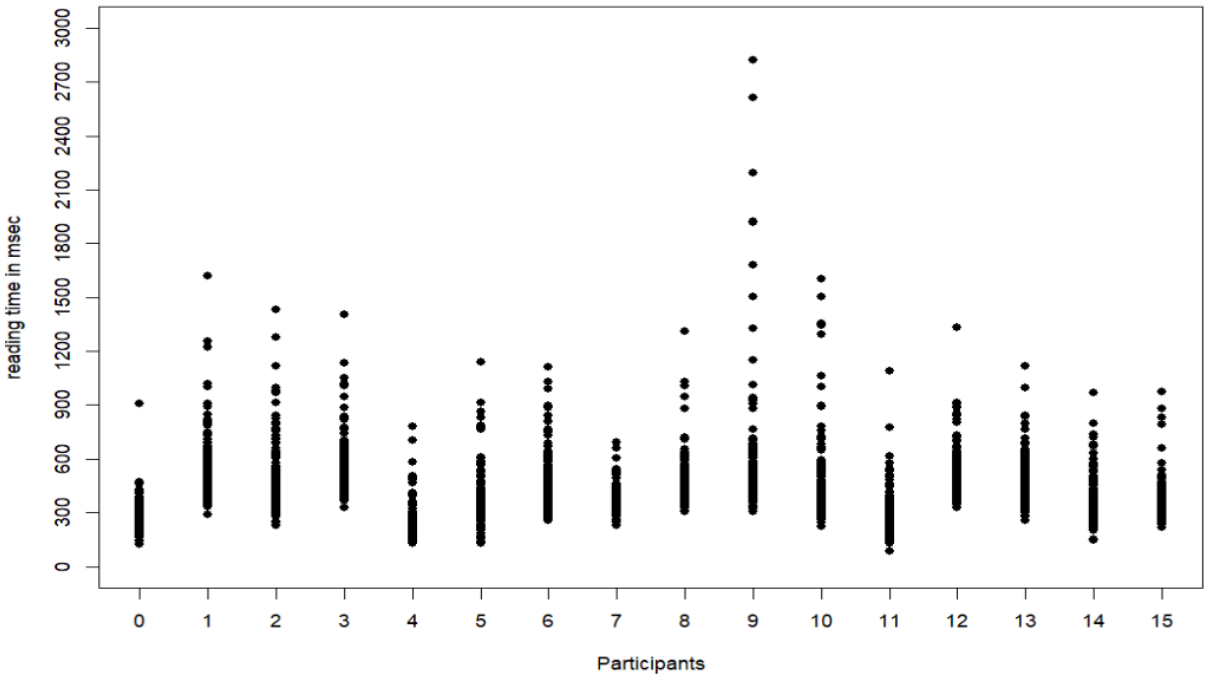
Before the experiment, one problem did occur with the assignment of the stimuli to four of the participants. For these participants, the ordering of the stimuli was not psuedorandomized. This may have contributed to an additional effect on the reading times that was not accounted for.

3.1 Visualizations

Visualizing the data for all target stimuli, reveals that there were some higher reading times for some participants, where the highest was 2820.645 ms for participant 9. The reading times for every word the participants read are shown in Figure 2.2. The higher reading times were either at the start of the sentence or at the end of the sentence due to the wrap-up effect. The higher reading times at the start of the sentences may be due to participants not actually looking at the fixation dot as they begin to read the sentence. Alternatively, they might simply be processing the start of the sentence, which takes a little longer.

At the end of the sentence, the wrap-up effect describes that often people spend some time wrapping up the sentence or processing what they have read (Stowe et al., 2018). In Figure 3.1, an increase in reading time can be observed at the start of the sentence, and the wrap-up effect is evident at the last word of the sentence. To avoid including the wrap-up effect in the analysis, the ROI was three words long, starting from the target preposition. Besides the wrap-up effect, the spillover effect also had to be considered in creating the length of the ROI. This effect describes how it can be expected that a processing difficulty from one effect will spill over to a next reading measure (Vasishth, 2006). Because of this, the slowdown effect might be one or two words after the previously defined syntactic gap, which is taken into account with an ROI of three words. Once the ROI was established, the data was filtered to only include the reading times within this region. Reading times within this ROI

Figure 2.2: Reading times for every word per participant. Participants are on x-axis and reading times in milliseconds on y-axis. Each dot represents the reading time for each word the participant read.



were much lower compared to the previous maximum value. The maximum reading time within the ROI, was 1222.655 ms. Within this ROI, no data indicated the presence of outliers, so no data was excluded from the analysis.

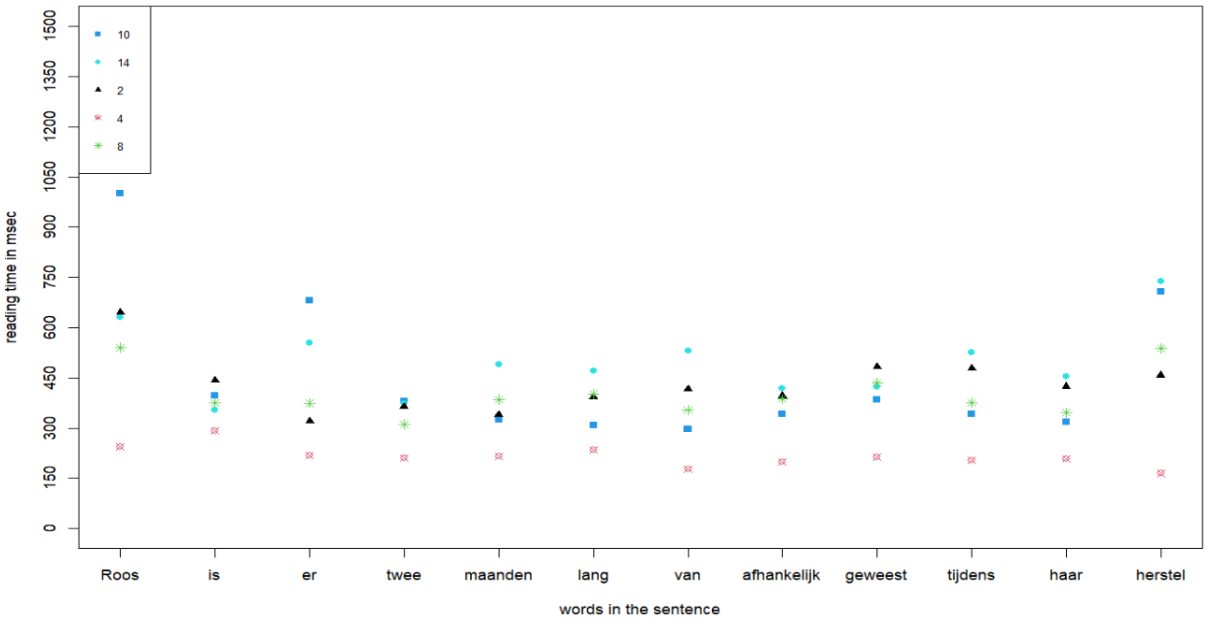
3.2 Statistical analysis

To analyze the effect of the condition of the stimuli on participants' reading speed, a linear mixed effects model was created in R (R Core Team, 2021) using the *lme4* package (Bates et al., 2015). The response value of the reading times was transformed by a natural logarithm, to achieve normality in the data. The fixed effect of the model was the condition of the stimuli, and random effects included both the intercepts for subjects and for set number. The baseline reading times for subjects differed, as well as per set, which is why these random effects are included. Additionally, because it can not be assumed that the effect of condition on the reading times is the same for all subjects and stimuli sets, the random slopes by-subject and by-set were added to the model as well.

The model's residuals did not reveal any obvious heteroskedasticity, nor did it deviate far from normality. One thing to note, however, is that there was a slight pattern of vertical lines in the residuals, as shown in Figure 3.2. This pattern is to be expected, as there is structured variation between the sets and the subjects.

To test the effect of condition on the reading times, a likelihood ratio test was done of the full model with the effect of condition and a null model without this effect. The condition of the stimuli did not affect the reading times significantly ($\chi^2(2) = 0.6671, p = 0.7164$), only increasing the reading time from the baseline with 1.030 ms $\pm$ 1.0 for the *waar*-condition, and with 1.003 ms $\pm$ 1.0 for the er_{PR}-condition. The null hypothesis that the reading times in the baseline condition are the same as the reading times in the *waar*- and er_{PR}-conditions, is accepted.

Figure 3.1: Reading times for the words in an er_{PR}-condition, set number 10. Reading time in milliseconds is on the y-axis and words of the sentence on the x-axis. The participant numbers are referenced in the legend.



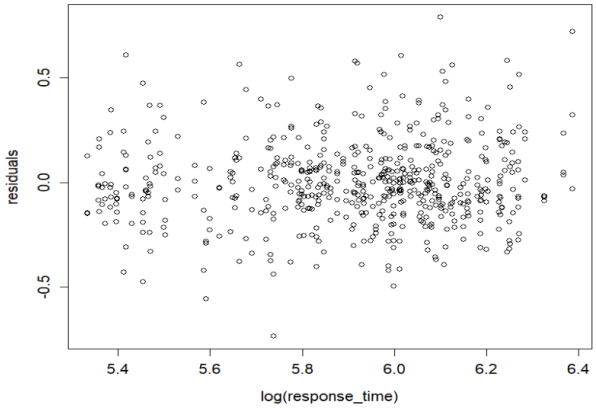


Figure 3.2: Residuals of the model as described in Section 3.2. The x-axis represents the reading times transformed by a natural logarithm.

4 Discussion

The purpose of this research was to answer the question: *Is there a significant slowdown in reading speed on a self-paced reading task at a syntactic gap created by "waar" and "er" in Dutch compared to a baseline sentence?* The results showed that the null hypothesis is accepted, meaning that no significant slowdown in reading speed was found at a syntactic gap for *waar*- and er_{PR}-sentences. Previous bachelors projects, as well as the parallel study, have also attempted to find the presence of an LDD between *er* and a syntactic gap using both eye-tracking and an SPRT, but did not find a significant result either. The results of this research may then imply that it is a true null result that er_{PR} does not cause a slowdown in reading at a syntactic gap.

It is important to note that no effect was found using both an SPRT in this research and an eye-tracking method in the parallel study. On a non-cumulative SPRT, reading is less similar to natural reading than an eye-tracking experiment is. Yet, analyses on SPRTs are often more straightforward than eye-tracking analyses. The value of using both methods to attempt to find an effect of er_{PR} on reading times, is that each method's weaknesses can be offset by the other method. Since neither method found any effect, the lack of an effect in this research might not be due to the artificial reading method allowed by the SPRT, but could instead

represent a true null result.

Nonetheless, a limitation in this research that may have played a role in the finding of a null result, is the lack of a power analysis. A power analysis can tell what population size would be needed for an experiment, given a required significance level, statistical power and an effect size (Cohen, 1992). Since no power analysis was done, there was no way of knowing whether the population size of 16 was large enough to consider finding an effect of a slowdown in reading speed.

Another limitation can be found in the statistical analysis as explained in Section 3.2. There was still a relatively large amount of variance that was not explained by the created model. Due to this, it is possible that there might still be effects within the obtained data that could explain this variance further. By conducting additional statistical tests looking for these effects, perhaps more can be said about the results of the analysis as well. For example, the effect of the lack of a psuedorandomized order for the four participants could be uncovered, if any is present.

Regarding future research, there are several directions to consider. One such direction is doing additional analyses on the collected SPRT data with different assumptions. The assumption made on the size of the ROI, was that more than three words would be too close to including the wrap-up effect, as well as possibly watering down the potential existence of an effect. The other assumption that an ROI of less than three words would be too short, could be revisited. It is plausible that an ROI of two words could narrow down an effect more clearly. Specifically, a potential ROI of two words could include the target preposition and the word after that. This is because the hypothesized syntactic gap appeared right after the preposition. However, using only one word for the ROI would be too short for the ROI to contain the effect due to spillover as described in Section 3.1.

Instead of additional analyses, further research can also be explored by focusing solely on finding a slowdown with the WH-phrase *waar*. In particular, Frazier & d'Arcais (1989) found that a difficulty in processing exists for sentences where the first noun phrase is an object instead of a subject. The Active Filler Strategy describes how they expect this slowdown, because people assign the first noun phrase to the subject position, even when the first noun phrase is an object. They found this effect for questions that started with the WH-phrase "welke". Therefore, instead of attempting to find a long-distance dependency between a gap and *waar*, an initial similar effect could be researched using the Active Filler Strategy for questions that begin with *waar*.

Furthermore, if the results for finding a slowdown at a gap caused by er_{PR} is a true null result, future research should explore the potential existence of other effects for *er* as well. In particular, Grondelaers et al. (2009) found that er_R, called "existential *er*" in their paper, acts as an expectancy monitor. This describes how er_R facilitates the introduction of unpredictable indefinite subjects, decreasing processing difficulty (Grondelaers et al., 2009). Although my research did not focus on er_R, the fact that there is a speed up in processing for er_R, may still indicate that there is a different effect than a slowdown with er_{PR}.

In conclusion, no significant effect of either the *waar* or er_{PR} condition on the reading time at the ROI compared to the baseline condition has been found. This potentially implies a true null effect specifically for the er_{PR} condition. Nonetheless, the complexity of the word *er* could imply that alternative effects might be present for different use cases of *er*. The results of this research are not necessarily a true null result for the *waar* condition, where future research has the potential to find an LDD between *waar* and a syntactic gap using different assumptions.

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A Target Stimuli: Baseline-Condition

1. De studenten hebben vorige week veel geld aan dure kostuums voor Halloween besteed in de feestwinkel.
2. De vrienden hebben zaterdagavond vrij lang over de spannende film gepraat tijdens het eten.
3. Het meisje heeft elke dag veel over schattige huisdieren gekletst met haar vriendin.
4. Het kind heeft meerdere keren ongeduldig om een lekker snoepje gevraagd in de auto.
5. Sanne heeft de vorige keer anderhalf uur op de vertraagde bus moeten wachten in de regen.
6. Sara heeft gisteren tweeënhalf uur lang van de mooie muziek genoten tijdens het concert.
7. De familie heeft de hele avond veel om de grappige show gelachen in de woonkamer.
8. Tom was elke keer erg van de blaffende hond geschrokken onderweg naar school.
9. Anna heeft vanmiddag lang en diep over de lastige wiskunde opdracht nagedacht in haar kamer.
10. Roos is twee maanden lang van de behulpzame organisatie afhankelijk geweest tijdens haar herstel.
11. Het bedrijf wilde eigenlijk vorig jaar al op de hoge personeelskosten bezuinigen om hun winst te verhogen.
12. De atleet heeft afgelopen zaterdagmiddag naar het juichende publiek geluisterd na de wedstrijd.

B Target stimuli: Waar-Condition

1. De Halloween kostuums, waar de studenten vorige week veel geld aan hebben besteed, waren duur.
2. De film, waar de vrienden zaterdagavond vrij lang over hebben gepraat tijdens het eten, was spannend.
3. De huisdieren, waar het meisje elke dag veel over heeft gekletst met haar vriendin, zijn schattig.
4. Het snoepje, waar het kind meerdere keren ongeduldig om heeft gevraagd in de auto, was lekker.
5. De bus, waar Sanne de vorige keer anderhalf uur op heeft moeten wachten in de regen, is vertraagd.
6. De muziek, waar Sara gisteren tweeënhalf uur lang van heeft genoten tijdens het concert, was mooi.
7. De show, waar de familie de hele avond veel om heeft gelachen in de woonkamer, was erg grappig.
8. De hond, waar Tom elke keer erg van was geschrokken onderweg naar school, blafte.
9. De wiskunde opdracht, waar Anna vanmiddag lang en diep over heeft nagedacht in haar kamer, was lastig.
10. De organisatie, waar Roos twee maanden lang van afhankelijk is geweest tijdens haar herstel, was behulpzaam.
11. De personeelskosten, waar het bedrijf eigenlijk vorig jaar al op wilde bezuinigen om hun winst te verhogen, waren hoog.
12. Het publiek, waar de atleet afgelopen zaterdagmiddag naar heeft geluisterd na de wedstrijd, juichte.

C Target stimuli: Er-Condition

1. Context: Iedereen heeft voor het feestje een duur Halloween kostuum gekocht.

   De studenten hebben er vorige week veel geld aan besteed in de feestwinkel.

2. Context: Vorige week speelde een spannende film in de bioscoop.

   De vrienden hebben er zaterdagavond vrij lang over gepraat tijdens het eten.

3. Context: Alle kinderen houden van schattige huisdieren.

   Het meisje heeft er elke dag veel over gekletst met haar vriendin.

4. Context: Naast mama ligt een lekker snoepje op de bijrijdersstoel.

   Het kind heeft er meerdere keren ongeduldig om gevraagd in de auto.

5. Context: Die bus is altijd vertraagd.

   Sanne heeft er de vorige keer anderhalf uur op moeten wachten in de regen.

6. Context: De band speelde mooie muziek.

   Sara heeft er gisteren tweeënhalf uur lang van genoten tijdens het concert.

7. Context: Er speelde gisteravond een grappige show op TV.

   De familie heeft er de hele avond veel om gelachen in de woonkamer.

8. Context: De hond van de buren blafte verschrikkelijk als je langs hun huis liep.

   Tom was er elke keer erg van geschrokken onderweg naar school.

9. Context: De leerlingen hebben tijdens de les de lastige wiskunde opdracht als huiswerk opgekregen.

   Anna heeft er vanmiddag lang en diep over nagedacht in haar kamer.

10. Context: De behulpzame organisatie ondersteunt mensen die een ongeluk hebben gehad.

    Roos is er twee maanden lang van afhankelijk geweest tijdens haar herstel.

11. Context: De personeelskosten zijn nog steeds hoog.

    Het bedrijf wilde er eigenlijk vorig jaar al op bezuinigen om hun winst te verhogen.

12. Context: Het publiek in de arena juichte vol enthousiasme.

    De atleet heeft er afgelopen zaterdagmiddag naar geluisterd na de wedstrijd.

D Distractor stimuli

Word for word translations from Hungarian to Dutch:

1. De bergtop op koude wind blies hele dag.
2. De kamer in comfortabele warmte was de open haard vanwege.
3. De oude bibliotheek in, die vol was stoffige boeken met, een stille hoek in zat ik en las ik een oude roman.
4. Het schaakspel einde van beide stil zaten ze, proberend bedenken de volgende zet.
5. Vanochtend verse groenten kocht ik de winkel in.

Agreement mistakes:

1. De jongen die gisteren bij de wedstrijd waren, zegt dat het erg spannend was. (subject-verb number disagreement)
2. De kinderen spelen buiten, omdat hij veel energie hebben. (pronoun number disagreement)
3. Het kleine meisje zegt dat ze broccoli lekker vindt, maar hij eet het nooit. (pronoun gender disagreement)
4. Alle studenten vindt het examen veel te moeilijk. (subj-verb number disagreement)
5. Ik heb het mooi ingepakte cadeau naar mijn vriendin gegeven. (wrong preposition)
6. Ik herinner zich nog goed wat er die dag is gebeurd. (pronoun number disagreement, reflexive)
7. Gisteravond las ik een spannende boek. (noun-adj gender disagreement)

Correct Dutch sentences:

1. Ze schildert een groot landschap met bergen en rivieren.
2. Hoewel hij niet veel ervaring had met koken, wist hij een heerlijke maaltijd op tafel te zetten.
3. De wind waaide hard, maar de lucht bleef helder en blauw.
4. De trein, die al een half uur vertraging had, arriveerde uiteindelijk op het station, terwijl de reizigers ongeduldig wachtten.
5. Context: De regen viel met bakken uit de lucht.

   Toch besloot hij zijn regenjas aan te trekken en op pad te gaan.
6. Context: In de verte klonk het lage gerommel van naderend onweer.

   De mensen haastten zich om te schuilen van de regen.