Accentuation of Adpositions and Particles in a Text-to-Speech System for Dutch

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Abstract

In this paper I propose an accent placement algorithm that locates accents on adpositions and particles for the use in a Dutch text-to-speech (TTS) system. The algorithm is intended to be a refinement of the rule that accents only content words, which is used in most TTS systems. Before the algorithm is set up, I discuss when adpositions and particles are accented in Dutch. For this empirical research, I made use of the Spoken Dutch Corpus (CGN) as empirical material. The combination of part-of-speech, syntactic as well as prosodic information for approximately 125,000 words in the CGN made it possible to determine whether the accentuation of adpositions and particles depends on their syntactic use within a sentence, or on the syntactic use of other constituents in the same sentence. The proposed accentuation algorithm takes a dependency tree with part-of-speech information as input.

1 Introduction[1]

It is important that the speech generated by computers sounds as natural as possible. This leads to a more intelligible content and as a result it takes less effort for listeners to understand the meaning of an utterance and it will be easier for them to listen to synthetic speech. An important feature that contributes to the naturalness of the quality of speech is prosody. The word prosody refers to certain properties of speech, such as the location and duration of breaks between two parts of utterances, the duration of a syllable and the absence or presence of accents.

In this paper I will concentrate on one aspect of prosody, i.e. which words in an utterance are spoken with accent and which ones are spoken without accent. To correctly predict the location of accents in a sentence one needs a fully specified syntactic analysis and an interpretation of the utterance. Other helpful information is the context in which the sentence is uttered and the intention of the speaker. In general we cannot expect all this information to be available in a text-to-speech (TTS) system. Therefore, a very simple solution (1) has been proposed to approximate the correct generation of accentuation in a TTS system:

(1) Put accent only on content words but not on function words.

Content words are nouns, adjectives, adverbs and lexical verbs. Function words are articles, prepositions, pronouns, auxiliaries and conjunctions. The only information needed when a system uses this rule (1) is a distinction between content words and function words. For Dutch, this rule correctly predicts accent for 79% of the words in a sentence (Marsi et al. 2002). Though this is an impressive result with such a simple rule, it still means that on average three words in a sentence have an incorrect accent

[1] This introduction is based on Jan Odijk's inaugural lecture (Odijk 2003).

(assuming an average sentence length of 15 words), which shows that improvement is desirable.

The goal of this paper is to change rule (1) in such a way that accentuation in TTS systems improves, and that the speech output becomes more natural and intelligible. This study will focus on the accentuation of Dutch function words such as *in* ('in'), *op* ('on') and *naar* ('to'). These words can be used as adpositions[2] and particles. Examples of prepositions, which are adpositions that precede their complement, are given in (2) (the preposition is in italics). Particles are the separable part of separable compound verbs, such as *opbellen* ('to call (up)'), *aanstaren* ('to stare at'), *uitleggen* ('to explain'). These particles can occur separated from the verb, as in (3), where both the verb and the particle are in italics.

(2) a. Hij zet de bloemen *op* de tafel.
He puts the flowers on the table

b. Ik vlieg morgen *naar* Schotland.
I fly tomorrow to Scotland
'I will fly to Scotland tomorrow.'

(3) a. Ik *belde* hem *op*
I called him up
'I called him (up).'

b. Hij heeft altijd al met haar *uit* willen *gaan*.
He has always already with her out want go
'He had always wanted to go out with her.'

Odijk (2003) notices that words used as a particle are accented, whereas the same words used as an adposition are often not accented. Accentuation rule (1) does not distinguish this difference in accentuation, as both particles and adpositions belong to the group of function words.

The main question to be answered in this paper is given in (4).

(4) How can the accentuation of adpositions and particles be regulated automatically in a Dutch text-to-speech system?

I stated above that "the same words used as adpositions are often not accented", which implies that there are cases where adpositions are accented. In order to answer the question given in (4), a subquestion (5) will be answered.

(5) When are adpositions and particles accented in Dutch human speech?

In the next section I discuss when adpositions and particles are accented. In section 3 I present my accentuation algorithm. Section 4 concludes this paper.

[2] In most literature, the notion *preposition* is used instead of *adposition*. But in strict terms, a preposition is a word that precedes its complement. In this paper I also distinguish circumpositions, intransitive adpositions, stranded prepositions, and adpositions that are part of a pronominal PP (in Dutch a pronominal PP is called *voornaamwoordelijk bijwoord* and an example is *erop* in the sentence *ik plak het erop* ('I stick it on it')) and therefore I use the notion *adpositions* as a general term.

2 Accent placement on adpositions and particles

In my MA thesis (Grégoire 2004) a special chapter is devoted to the different uses of adpositions and adpositional phrases in Dutch. For each P[3] it was empirically tested whether it is accented in Dutch. To this end, the Corpus Gesproken Nederlands (CGN, Spoken Dutch Corpus)[4] was used as empirical material. The CGN contains approximately 125,000 prosodically annotated words. Besides prosodic information, part-of-speech (PoS) as well as syntactic information of each word is accessible. Within the syntactic information not only category labels are available, but also dependency labels. These dependency labels play an important role in the determination of accents on adpositions and particles.

As a starting point for this empirical investigation I used, amongst others, hypotheses formulated by Jan Odijk (2003 and personal communication) and adapted in such a way that they could be tested empirically using the data in the CGN. I formulated my findings by means of a set of claims that state that a P is accented under certain circumstances. The proposed accentuation algorithm is based on these claims. Because the main topic of this paper is to present the algorithm, I will not go into detail on how the empirical research was carried out, but just state the formulated claims in (6).

(6) a. The second part of a circumposition is accented if and only if its complement is not accented.

b. An intransitive adposition is always accented.

c. A particle is accented if and only if it is not directly adjacent to a focused argument.

d. A stranded preposition in an LD PP is accented if and only if it is not adjacent to a focused constituent.

e. A preposition in a pronominal LD PP is accented if and only if it is not adjacent to a focused constituent.

With LD PP is meant that the PP is a locative or directional complement, which can be recognized by the dependency label LD in the CGN. In the next section I will elaborate on these claims.

3 Accentuation of Ps in a TTS system for Dutch

3.1 Introduction

A TTS system generally deals with input text in two stages. In the first stage the input is linguistically analysed. The result is a phonetic representation of the utterance, which serves as input of the second stage, the speech synthesis, which involves

[3] I use the notion *Ps* to refer to all adpostions and particles.

[4] The *Spoken Dutch Corpus* is a database of contemporary Dutch as spoken by adults in the Netherlands and Flanders. The project is funded by the Flemish and Dutch governments and the Netherlands Organization for Scientific Research NWO. Its homepage is http://lands.let.kun.nl/cgn/ehome.htm.

converting this representation into a synthetic speech signal. In this paper I focus on converting an input text consisting of words into the same text in which the accents are marked, ignoring processes such as grapheme-to-morpheme conversion and speech synthesis.

The process I propose that generates an accented text from an unaccented text includes three tasks, viz.

1. part of speech tagging
2. syntactic parsing
3. accent placement

Merely PoS and syntactic information is not sufficient as input for accent placement, as predicting accent locations requires semantic and discourse information as well. Syntactic parsing in the CGN project involves — besides the assignment of category labels to each mother node — the assignment of dependency labels that denote the relation of a certain constituent with respect to another constituent dominated by the same mother node. This means that in the output of the syntactic annotation semantic information is visible to a certain extend. Because of this and because I assume that PoS tagging and syntactic annotation can be done automatically, I suggest that the applications used by the CGN project for PoS tagging and syntactic annotation should be used to perform task 1 and 2.

It must be taken into account that since both the PoS tags and the syntactic annotations were manually checked, we cannot just rely on the automatic output and that improvement of these applications is needed. I will discuss this point in the next section. In this section I assume that the output of automatic PoS tagging and syntactic annotation is 100% consistent and reliable.

The output of the CGN PoS tagger and syntactic annotator, which serves as the input for the accent placement task is a dependency tree such as Figure 1.
As was stated above, each mother node is assigned a category label (*c*-label: in the cylinder-boxes). Dependency labels (*d*-labels, in the square boxes) denote the relation of a certain constituent with respect to another constituent dominated by the same mother node. Each mother node contains at least the *d*-label HD (head).

In the remainder of this section I discuss the assignment of accents to a dependency tree such as Figure 1. I propose an algorithm for accent placement on adpositions and particles for the use in Dutch TTS systems. This algorithm is intended to be a refinement of the basic rule that simply assigns an accent to every content word.

The approach adopted to attain this goal starts from the focus and accentuation proposals in Marsi (2001). Although Marsi's rules are implemented in a concept-to-speech system,[5] whereas my proposals are for a text-to-speech system, I will show that using a dependency tree such as Figure 1 as input for the accentuation rules, Marsi's proposals can be adapted in such a way that they can predict the accent locations of adpositions and particles in a TTS system.

[5] In concept-to-speech systems, spoken output is generated on the basis of a text that has been produced by the system itself.

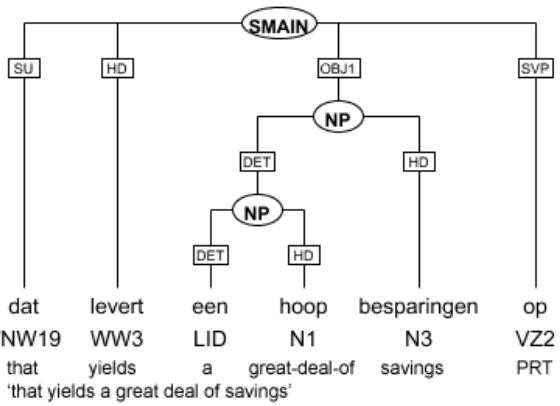

Figure 1: A dependency tree.

3.2 Accentuation algorithm

In this section I adapt Marsi's proposals so that it can take a dependency tree with part-of-speech information, such as Figure 1, as its input. In addition I propose a set of rules that locate accents on those Ps that are to be accented according to the claims formulated in the previous section. The accentuation algorithm I propose is presented in (7).

(7) **Accentuation algorithm**

1. Assign focus
2. Apply the Focus Projection Rules
3. Apply the Rules for Focusing Adpositions and Particles
4. Apply the Sentence Accent Assignment Rule

The input of the accentuation algorithm is restricted to a dependency tree that contains at least one verbal domain. A verbal domain is a constituent the head (HD) of which is a (finite or infinite) verb. Six verbal domains are distinguished in the CGN. The category label and a description of each verbal domain are given in Table 1. A verbal domain may be embedded in another verbal domain. The accentuation rules I propose are to be applied to each verbal domain.

3.2.1 Focus assignment

The first task of the accentuation algorithm is to assign focus (the feature FOC) to every content word. Since it is not so clear whether adverbs are content words or function words (Marsi 2001, 232), I follow Marsi in his decision not to focus adverbs. The part-of-speech tags — used in the CGN — in Table 2 are content words:

Table 1: Category labels of verbal domains in the CGN.

c-label	description
SMAIN	declarative sentence (verb second)
SSUB	subordinate clause (verb final)
SV1	verb first sentence
INF	infinitive clause
PPART	past participle clause
PPRESS	present participle clause

Table 2: Parts-of-speech distinguished in the CGN that are content words.

part-of-speech	abbreviation for	translation
ADJ	*adjectief*	adjective
N	*nomen*	noun
TW	*telwoord*	numeral
WW	*werkwoord*	verb

The focus assignment rule has no access to the given-new information of the sentence constituents. This means that every content word is focused, even if it conveys 'old' information. In Figure 1 the words *levert*, *hoop* and *besparingen* are content words according to their part-of-speech labels. In the dependency tree shown in Figure 2 the feature FOC is assigned to each content word.

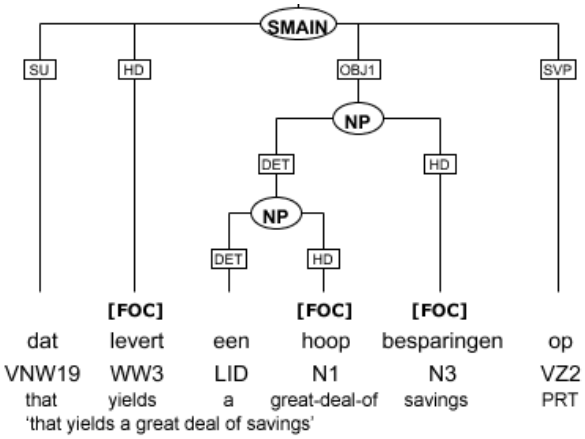

Figure 2: Assigning the [FOC]-feature to each content word.

3.2.2 Focus Projection Rules

The accentuation algorithm employs a set of Focus Projection Rules proposed by Marsi (2001, 217), based on Selkirk (1984, 1995):

(8) **Focus Projection Rules**

a. If the head of an NP is focused, then the NP is focused as well.

b. If the head of an AP is focused, then the AP is focused as well.

c. If the NP argument of a P is focused, then the PP is focused as well.

d. If the main verb in an S is focused, then the S is focused as well.

e. If all the conjuncts of a coordination are focused, then the coordination is focused as well.

According to these rules it is not sufficient if only the modifier of an NP, AP or S is focused. If, for example, only the N *London* but not the N *train* in the NP *the train to London* is focused, rule (8c) will project focus on the PP *to London*, but there is no rule in (8) that licences any further projection. This means that the NP is not focused, according to FPR. However, if the N *train* is focused, rule (8a) will project focus onto the whole NP.

Applying the Focus Projection Rules to the output of the focus assignment task results in Figure 3.

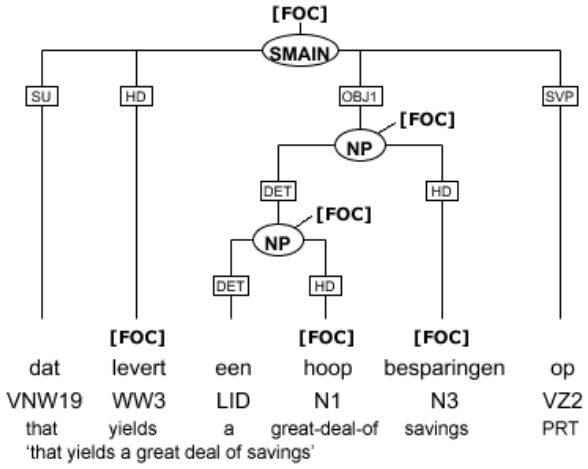

Figure 3: Applying the Focus Projection Rules.

3.2.3 Rules for Focusing Adpositions and Particles

In this section rules for focusing adpositions and particles are proposed. Not all Ps are to be focused. The claims that state that a P is accented under certain circumstances

are repeated in (9).

(9) a. The second part of a circumposition is accented if and only if its complement is not accented.

b. An intransitive adposition is always accented.

c. A particle is accented if and only if it is not directly adjacent to a focused argument.

d. A stranded preposition in an LD PP is accented if and only if it is not adjacent to a focused constituent.

e. A preposition in a pronominal LD PP is accented if and only if it is not adjacent to a focused constituent.

On the basis of these claims I propose the following sets of focus rules:

(10) **Focus Rules for Adpositions** (FRA)
Assign the feature [FOC] to each 'VZ2'[6] word if,

(i) it carries the *d*-label HDF and if the OBJ1 within the PP does not have the FOC-feature, or

(ii) 1. it is directly attached to the verbal domain without an intervening PP *c*-label, and
2. does not have the *d*-label SVP, or

(iii) it carries the *d*-label OBJ1 within a PP, or

(iv) 1. it carries the *d*-label HD within a PP, and
2. the OBJ1 within the PP has the PoS label 'VNW20' [7] or 'VNW15'[8].
3. this PP has the *d*-label LD, and
4. there is no constituent that is marked with the FOC-feature adjacent.

(11) **Focus Rule for Particles** (FRP)
Assign the feature [FOC] to a 'VZ2' word that has the *d*-label SVP, if there is no argument that is marked with the FOC-feature adjacent.

In addition I propose a rule for defocusing the verbal part of a particle verb.[9]

(12) **Defocusing Rule for Verbal parts of particle verbs** (DRV)
Delete the FOC-feature from the head of the verbal domain in which a word that has the PoS label 'VZ2' and the *d*-label SVP occurs.

[6]The PoS tag 'VZ2' is used in the CGN for final Ps.
[7]The PoS tag 'VNW20' is used for the R-pronouns *er*, *d'r*, *daar* and *hier*.
[8]The PoS tag 'VNW15' refers to the R-pronoun *waar* ('where'), which is attached to the PP by a secondary edge.
[9]In Grégoire (2004), no conclusions were drawn regarding the accentuation of the verbal parts of particle verbs. Therefore, I follow Marsi (2001) in his assumption that if a particle verb is accented, the accent goes to the particle.

As claimed, a preposition in a pronominal LD PP is accented if and only if it is not adjacent to a focused constituent. Pronominal PPs in the CGN do not belong to the adposition set, but are PoS tagged as 'BW' (abbreviation of *bijwoord* ('adverb')). Since there are many types of adverbs, which are not further subdivided in the CGN, a more refined classification is needed in order to distinguish the pronominal PPs from other adverbs. This problem can be solved by assuming that pronominal PPs can be recognised in the CGN by the lexicon and that they are split into two separate words that are PoS tagged and syntactically annotated as stranded prepositions. An example is given in Figure 4: the left tree shows how pronominal PPs are dealt with in the CGN and the right tree shows my suggestion on how the CGN should deal with pronominal PPs. Since the preposition in a pronominal PP is to be focused under the same circumstances a stranded preposition is focused under, no extra focus rule for pronominal PPs is needed.

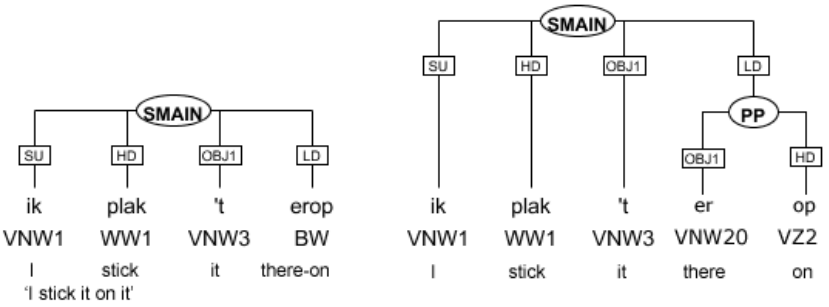

Figure 4: Pronominal PPs.

The output of FRA (i) is given in Figure 5 and 6. In Figure 5 the *heen* is assigned the

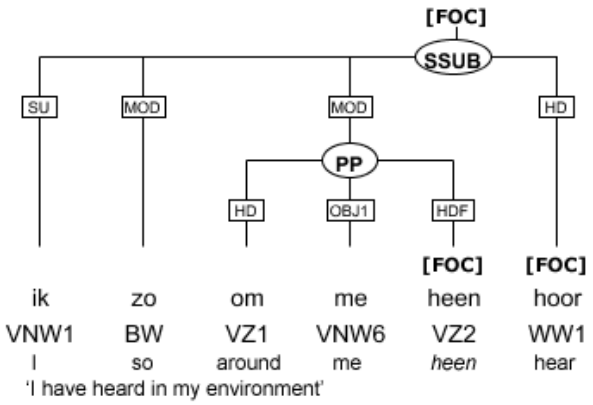

Figure 5: Output of FRA (i): *heen* is focused.

feature [FOC], because it has the PoS tag 'VZ2' and the *d*-label HDF, and the OBJ1 within the PP does not have the FOC-feature. Although *toe* in Figure 6 has the PoS tag 'VZ2' and the *d*-label HDF, FRA does not assign the FOC-feature to it, because the OBJ1 within the PP is focused.

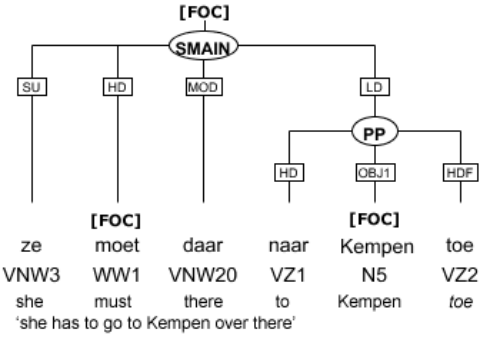

Figure 6: Output of FRA (i): *toe* remains unfocused.

An illustration of the output of FRA (ii) is shown in Figure 7.

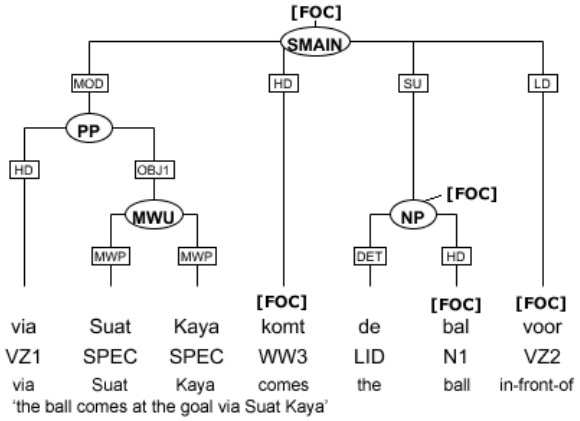

Figure 7: Output of FRA (ii): *voor* is focused.

An example of the output of FRA (iii) is given in Figure 8.

FRA (iv) is illustrated in Figure 9–11. In Figure 9 *bij* is PoS tagged as 'VZ2', it is the head of the PP, the OBJ1 within that PP is a 'VNW20', and this PP had the *d*-label LD. However, *bij* is not focused, because there is an adjacent focused constituent, in this case the subject NP *zo'n vragenlijst*. In Figure 10 the stranded preposition *in* is focused, because no focused constituent is adjacent. In Figure 11 the pronominal PP is annotated as proposed and since no focused constituent is adjacent to the LD PP, the

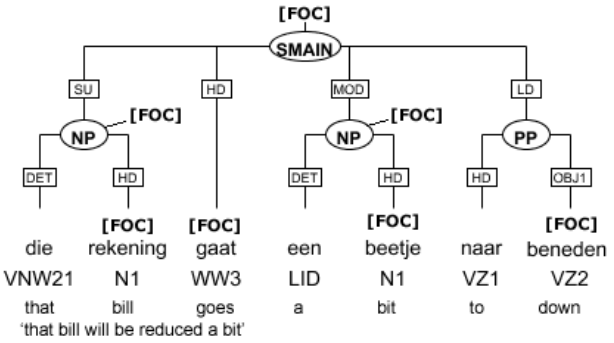

Figure 8: Output of FRA (iii): *beneden* is focused.

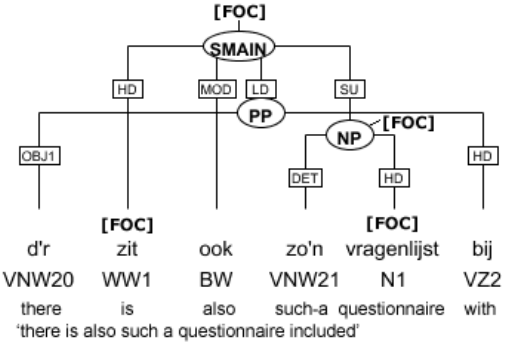

Figure 9: Output of FRA (iv): *bij* remains unfocused.

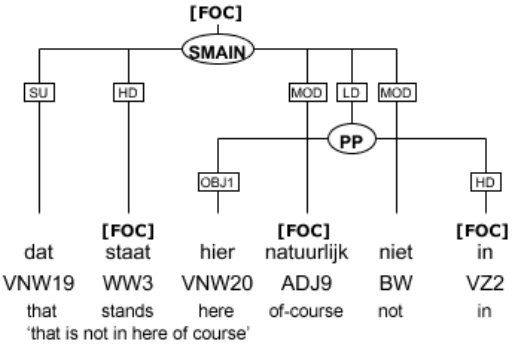

Figure 10: Output of FRA (iv): *in* is focused.

preposition *op* in this PP is assigned the FOC-feature.

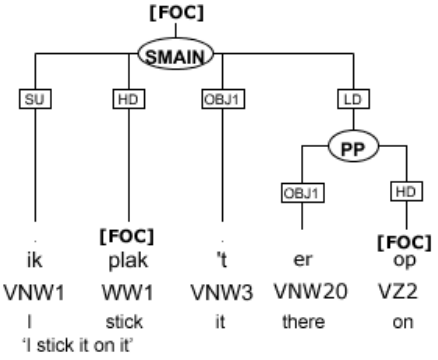

Figure 11: Output of FRA (iv): *op* is focused.

The output of FRP and DRV is illustrated in Figure 12 and 13. In both Figure 12 and 13 DRV deletes the FOC-feature on the head of the verbal domain, because a word — in Figure 12 *op* and in Figure 13 *uit* — that has the PoS label 'VZ2' and the *d*-label SVP occurs in the same domain. In Figure 12 the particle *op* remains unfocused, because a focused argument — the OBJ1 NP *een hoop besparingen* — is adjacent, whereas in Figure 13 the FOC-feature is assigned to the particle *uit*, since no focused argument is adjacent.

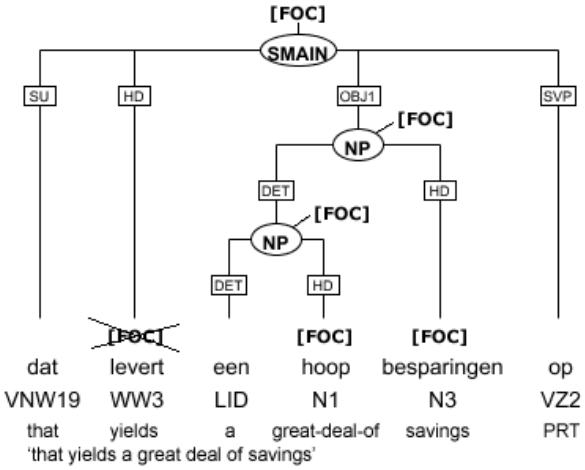

Figure 12: Output of FRP and DRV: The [FOC]-feature on *levert* is deleted and *op* remains unfocused.

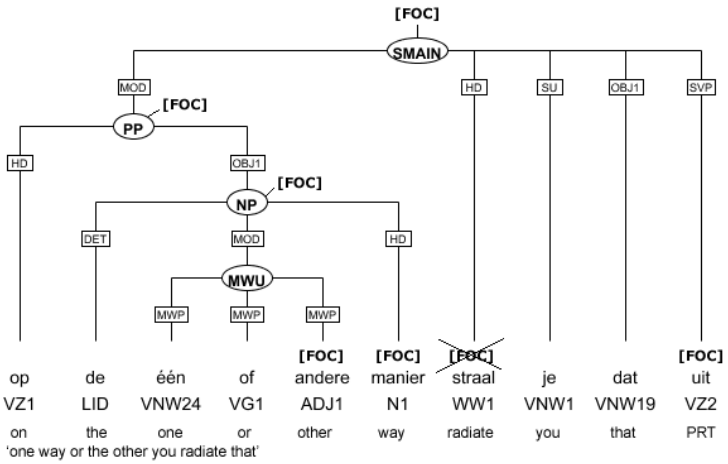

Figure 13: Output of FRP and DRV: The [FOC]-feature on *straal* is deleted and *uit* is focused.

3.2.4 Sentence Accent Assignment Rule

The outputs of the preceding section constitute the input of the Sentence Accent Assignment Rule (Gussenhoven 1992):

(13) **Sentence Accent Assignment Rule** (SAAR)
If focused, every predicate, argument, and modifier must be accented, with the exception of a predicate that, discounting unfocused constituents, is adjacent to an argument.

The first part of SAAR requires every focused constituent to be accented. The second part makes an exception for predicates that meet the specified condition. From a practical point of view it is more convenient to apply SAAR in two steps (Marsi 2001): (1) accent all focused constituents; (2) deaccent the head of the verbal domain if a focused argument is adjacent, discounting unfocused constituents.[10]

The output of this step consists of a string of words marked with accents. The results for each example given in section 3.2.3 are presented in (14)-(17).

In (14a–b) and (16b–c), the verb is accented, because there is no adjacent focused argument.

In (15a) the head of the verbal domain *komt* is deaccented, because it is adjacent to the focused argument NP *de bal*.

In (15b) the head of the verbal domain *gaat* is deaccented, because it is adjacent to the focused argument NP *de rekening*.

In (16a) the modifier *ook* intervenes between the head of the verbal domain *zit* en the argument NP *zo'n vragenlijst*. Since this modifier is unfocused it is ignored, and

[10]Marsi discusses some exceptions for deaccenting the predicate if the adjacent focused argument is topicalised or extraposed. Discussing these issues is beyond the scope of this paper.

zit is deaccented by virtue of its focused argument.

Both verbs in (17a–b) are not accented, because they are the verbal part of a particle verb, which is never accented according to DRV.

(14) a. ik zo om me HEEN HOOR
b. ze MOET daar naar KEMPEN toe

(15) a. via Suat Kaya komt de BAL VOOR
b. de REKENING gaat een BEETJE naar BENEDEN

(16) a. d'r zit ook zo'n VRAGENLIJST bij
b. dat STAAT hier NATUURLIJK niet IN
c. ik PLAK het er OP

(17) a. dat levert een HOOP BESPARINGEN op
b. op de één of andere MANIER straal je dat UIT

3.3 Discussion

The accentuation algorithm has not been implemented and tested. It might turn out that there will be complications that are not foreseen. I want to make a few remarks on the accentuation algorithm that I encountered during its set up.

There is no Focus Projection Rule that projects the focus on a P to the PP. This means that a PP constituent without an NP complement — such as the PP *er op* in Figure 11 — is not recognised by SAAR as a focused argument that might cause the predicate to be deaccented. Further research is required in order to determine whether an extra Focus Projection Rule, such as (18), is necessary.

(18) If a 'VZ2' word within a PP is focused, then the PP is focused as well.

In Grégoire (2004) it was concluded that a particle is not accented if there is an accented adverb in the sentence that causes the rest of the sentence, as well as the particle, not to be accented. This conclusion is not taken into account in the accentuation algorithm since it is not obvious when an adverb is focused. Some adverbs are semantically richer than other adverbs and might be considered content words. With respect to the accentuation of adverbs Marsi (2001) concludes that "[it] is not is not simply a matter of correctly predicting their focus, but requires a semantically driven accentuation rule in the spirit of SAAR." (233)

It was stated before that the accentuation algorithm applies within each of the six discussed verbal domains. The verbal domain 'SSUB' can be dominated by a 'REL' category label of which the head is a pronominal PP — starting with the R-pronoun *waar* ('where') —, and both 'SSUB' and 'SV1' can be respectively dominated by a 'WHSUB' and 'WHQ' category label which head can be the pronominal PP *waarom* ('why'). An example of a 'REL' category is given in Figure 14.
Strictly speaking this means that the verbal domains the accentuation algorithm should apply to must be extended with the domains 'REL', 'WHSUB' and 'WHQ'. Because

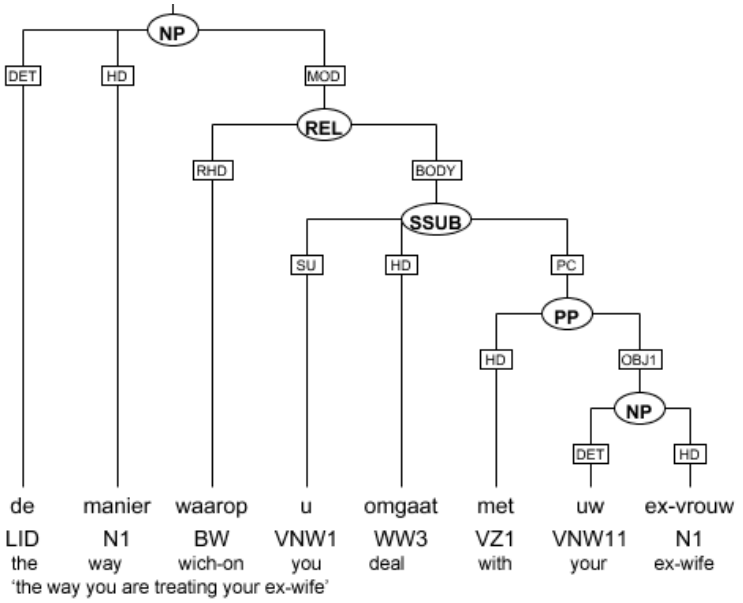

Figure 14: A dependency tree with a 'REL' category.

the pronominal PPs that are the head of these domains are all modifiers — secondary dependency labels are ignored — they are not dealt with by FRA and therefore I stay with the six verbal domains that are distinguished earlier in this chapter and will not add any other domain to them.

Finally it must be noted that the word *naartoe* ('to') that occurs as a stranded preposition is labelled with the PoS tag 'BW'. Although it carries the *d*-label HD within a PP that is an LD, the FRA overlooks it, since it does not have the PoS tag 'VZ2'. This means that either the word *naartoe* should be PoS tagged as a 'VZ2' or the first line of FRA "assign the feature [FOC] to each 'VZ2' word if", should be changed in "assign the feature [FOC] to each 'VZ2' or 'BW' word if".

3.4 Future work

What is left for future work is to evaluate whether the naturalness of synthetic speech improves using the proposed algorithm for accentuation. This can be tested by a listener's experiment. Ideally the algorithm should be implemented in a TTS system in which the PoS tagging and syntactic annotation tasks are performed by the PoS tagger and syntactic annotator used by the CGN project. Since subsequently we need other modules for pre-processing the input text and conversion of the algorithm's output into synthetic speech, this may be too demanding.

A more simple way to test the algorithm is not implement the algorithm exactly as proposed in the previous section, but to integrate the claims formulated in section 2 in

an existing TTS system in which adpositions and particles are never accented.

In the Speech Editor of Fluency (1999, version 1.3),[11] for example, it is possible to add the '\+' or '\-' tag to obtain/delete accent on the word that follows the tag. Without adding any tags, Fluency assigns the accents in a sentence such as *hij belt haar op* ('he called her') as in (19a). According to claim (6c) *op* should be accented, since it is a particle and no focused argument is adjacent. In addition *belt* should be unaccented because I assumed that a particle verb can only carry one accent and if a particle verb is accented the accent goes to the particle and not to the verbal part. Adding the '\+' tag before *op* and the '\-' tag before *belt* results in the accent pattern as in (19b).

(19) a. hij BELT haar op
b. hij belt haar OP

Using this function in Fluency the claims can be tested and subjects can be asked to rate the speech quality of the various sentences.

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[11] An online demo version of Fluency can be found at http://www.fluency.nl/