1. SYNTACTIC MOVEMENT

1.1. Introduction

This chapter describes verb movement, a language-specific characteristic of verbs in the type of Dutch sentences that will be used in most of the experiments described in this chapter. After an introduction on linguistic movement (section 1), a short overview will be given of the literature on the consequences of movement during on-line sentence processing (section 2). Whereas *wh*-movement has been studied intensively in psycholinguistic research, and NP-movement has received attention as well, no studies have been published on the on-line processing effects of verb movement. In the remainder of the chapter, two experiments are presented that aim to capture the on-line consequences of verb movement as it occurs in Dutch matrix clauses (section 3 and 4). The implications of both experiments are discussed in the general discussion (section 5).

1.2. Movement

The greater the complexity of a sentence, the more operations are needed to process it. For example, *The man reads the book in the morning* is less complex than *It is the book that the man reads in the morning*. The latter sentence is more complex from a linguistic point of view, because the Object (*the book*) has been topicalized or ‘moved’. An important characteristic of movement is that a moved constituent leaves behind a phonologically ‘silent’ copy of itself (a trace) at its base position. In sentence (1), the verb *kiss* assigns thematic roles to both the Subject *Julia* and the Direct Object *the boy*. In English, the internal argument(s) (*the boy* in this example) typically appear(s) after the verb. Now consider sentence (2), where the same persons play the same roles.

(1) Julia kisses the boy.
(2) I see the boy who Julia kisses __.

In this example, it is assumed that the verb still assigns a semantic role rightwards, but in this case, the argument and its role are topicalized, leaving behind a copy at the trace

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1 For an explanation of *argument structure*, *subcategorization frames* and *thematic roles* see Chapter 4, section 1.2
position. When processing this sentence, the moved constituent is associated with the verb at the trace position (directly after the verb), in order to understand the relations between the different constituents in a sentence and to reach the correct interpretation of the sentence. This relation between the verb and its arguments appears in virtually all linguistic theories, including non-transformational lexical theories, like Head-driven Phrase Structure Grammar (Pollard & Sag, 1994).

One of the main assumptions in generative linguistics is that each language has one base or underlying (canonical) word order. Sentences with different (noncanonical) word orders are thought to be derived from this base word order by syntactic movement (see e.g., Chomsky’s Principles and Parameters theory: Chomsky, 1981; Chomsky & Lasnik, 1993; Chomsky, 1995). Three main types of movement are distinguished (wh-movement, NP-movement, and verb movement) and will be discussed next.

1.3. Wh-movement and NP-movement

Wh-movement occurs in wh-questions (3), relative clauses (4), and cleft constructions (5) and entails movement of a wh-constituent from its base Object position directly after the verb to a position in front of the clause. Following the traditions in linguistics, a t is used to refer to the trace and co-indexation indicates the relation between the moved constituent and its base position.

(3) Who did Julia kiss t?
(4) I see the boy, who Julia kisses t.
(5) It is the boy who Julia kisses t.

NP-movement (noun phrase movement) occurs in passives (6) and in raising (7).

(6) The boy was kissed t by Julia.
(7) Julia is likely t to kiss the boy.

1.4. Verb movement

Whereas in wh- and NP-movement whole sentence constituents (XPs) are moved, in verb movement it is only the verb itself that moves. In English, (overt) verb movement

\[2\] In sentences (4) to (5) the indexation at the NP the boy is used to indicate a direct co-reference between the wh-element who and this NP.

\[3\] In syntactical terms: verb movement is head movement (X^0).
only occurs in negative inversion structures (8) and in questions (9), where it is the auxiliary that moves.

(8) Never will Julia \( t \) kiss the boy.
(9) Has Julia \( t \) kissed the boy?

In Dutch, however, verb movement is an omnipresent phenomenon, occurring in all matrix clauses. In the standard analysis, Dutch is a Subject-Object-Verb (SOV) language (Koster, 1975, see also: Bennis, 1992; Sybesma, 2002; Wijnen & Verrips, 1998). All non-finite verbs, and in embedded clauses both finite and non-finite verbs, occur in clause-final position:

(10) Julia wil het boek lezen.
    *Julia wants the book *(to) read.*
    *(Julia wants to read the book.)*

In Dutch matrix clauses the verb appears in second position, after the first constituent (11). The word order in the matrix clause is derived from the word order in the embedded clause (Koster, 1975; Zwart, 1993). The finite verb, therefore, is said to be ‘moved’ from its base position at the end of the clause to second position. This rule is called *Verb Second (V2).*

(11) a. Julia leest, het boek \( t \).
    *Julia reads, the book \( t \).*

b. Gisteren las, Julia het boek \( t \).
    *Yesterday read, Julia the book \( t \).*
    *(Yesterday, Julia read the book.)*

c. Het liefst leest, Julia het boek in bed \( t \).
    *Preferably reads, Julia the book in bed \( t \).*
    *(Preferably, Julia reads the book in bed.)*

d. Waar leest, Julia het boek \( t \) ?

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4 Zwart (1993) and Koster (1975) agree on the fact that the SVO word order as it occurs in matrix clauses is derived from the SOV word order in embedded clauses. However, Zwart (1993) argues that this SOV word order in embedded clauses is in itself derived from a deep structure which has a VP with word order VO, so: external argument [verb, internal argument]. Therefore, whereas the analysis of Koster results in a matrix
Where reads Julia the book?
(Where does Julia read the book?)

Linguistic evidence for the SOV character of Dutch comes from particle verbs. For uninflected particle verbs (12a), as well as for finite particle verbs in embedded clauses (12b), the particle is attached to the verb. However, in matrix clauses, where the finite verb occurs in second position, the particle remains in its (presumed) original, sentence final position (13).

\begin{enumerate}
\item[12] a. Julia wil haar boek uitlezen.
   \textit{Julia wants her book out-read.}
   \textit{(Julia wants to finish her book.)}

\item[12] b. Ik weet, dat Julia haar boek uitleest.
   \textit{I know, that Julia her book out-reads.}
   \textit{(I know, that Julia will finish her book.)}
\end{enumerate}

\begin{enumerate}
\item[13] Julia leest haar boek uit.
   \textit{Julia reads her book out.}
   \textit{(Julia finishes her book.)}
\end{enumerate}

Other evidence comes from psycho- and neurolinguistic data suggesting that SOV is the ‘unmarked’ order. During the early stage of language acquisition in Dutch the child uses infinitival verbs only and places them in final position (‘infinitival stage’: compare koekje eten in Dutch and eat cookie in English). Only at a later stage, when the verb is inflected, it moves to the second position; in this stage the child still uses root infinitives, it is therefore called the “optional infinitive stage” (Wijnen & Verrips, 1998; Wexler, 1994). Dutch-speaking individuals with Broca’s aphasia make more errors and more often omit the verb when they have to produce finite verbs in second position as compared to clause-final position (Bastiaanse & Van Zonneveld, 1998; Bastiaanse, Hugen, Kos, & Van Zonneveld, 2002). The same holds for children with language impairments (Bastiaanse, Bol, Van Mol, & Zuckerman, 2002; De Jong, 1999; De Jong, 2002; for comparable findings on problems with V2 in German children with SLI, see Clahsen & Hansen, 1997). These findings support the idea that the clause-final position is the basic position of the verb, and that the word order in matrix clauses is more complex.

clause with surface structure $SV_{\text{[fin]}}$, in Zwarts analysis the surface structure of the embedded clause is $SO_{\text{[i]}}[V_{\text{[i]}}]$ and therefore the surface structure of the matrix clause is $SV_{\text{[fin]}}[O_{\text{[i]}}[V_{\text{[i]}}]]$. 

2. **PROCESSING CONSEQUENCES OF MOVEMENT**

2.1. **Processing consequences of Wh-movement**

In the psycholinguistic literature, the base position of the moved constituent is called the *gap* and the constituent that has been moved the *filler*. The dependency between the moved constituent and the trace that is proposed in linguistic literature is translated into *gap-filling effects* in psycholinguistic literature. An experiment supporting the psychological reality of gaps was reported by Swinney et al. (1988), who tested sentences like (14).

(14) The policeman saw the boy who, the crowd at the party accused of the crime.

Since *boy* is the direct Object of *accused* in base structure\(^5\), and English is an SVO language, the base position of *boy* is to the right of the verb *accused*. Therefore, it is assumed that a gap is postulated after *accused*. Swinney et al. (1988) used the Cross-Modal Lexical Priming (CMLP) paradigm to demonstrate reactivation of the filler (*boy*) at the place of the gap. Priming effects were found for targets related to the antecedent *boy* when the probe was presented at the gap position. Importantly, no priming was found at a control position before the verb. In other words, it seems that listeners reactivate the meaning of a moved constituent when they encounter the gap.

Although gap-filling effects (reactivation of the meaning of the target word at the site of the gap) in these types of sentences have been demonstrated by many researchers, using different paradigms (e.g., CMLP: Love & Swinney, 1996; Nagel et al., 1994; Nicol & Swinney, 1989; Swinney et al., 1988; self-paced reading: Stowe, 1986; Tanenhaus, Boland, Garnsey, & Carlson, 1989; probe recognition: Bever & McElree, 1988); ERP: (Felser, Clahsen, & Münte, 2003; Fiebach, Schlesewsky, & Friederici, 2001), not all researchers agree on the explanation of the results. Whereas the findings seem to provide good evidence for a Trace Reactivation Account (TRA: Nicol & Swinney, 1989; Swinney et al., 1988), alternative explanations have been proposed. These proposals share a lexical (instead of structural) approach, and are more closely related to non-transformational linguistic theories such as Head-driven Phrase Structure Grammar (HPSG, Pollard & Sag, 1994). These theories do not assume a difference between deep and surface structure, and co-indexing takes place directly between the verb and its arguments.

The Direct Association Hypothesis (DAH), raised in 1991 by Pickering and Barry (see also Pickering, 199), connects with these kinds of grammars in proposing that the priming

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\(^5\) Strictly speaking, the direct object of *accused* is *who*, but the authors assume that *who*, because of its co-reference with *boy*, has inherited the semantic characteristics of *boy*. 

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effects previously found at gap locations are not due to trace reactivation but to direct associations between the extracted element (argument) and its subcategorizer (verb). Thus, it involves identifying a verb and associating the filler directly with an unsaturated position in the argument structure of the verb. So in example (10) the DAH predicts activation of the boy after the verb accused, because it is an argument of the verb and the verb is supposed to be directly linked to its arguments. Two other lexical accounts were raised by Fodor (1989, 1995) and are called the Semantic Processing Account (SPA, after Featherston, 2001) and the Depth of Processing Account (DOP). The SPA assumes that the effects are “merely a result of a semantic computation of a sentence” (Featherston, 2001, p. 100). In case of a topicalized Direct Object this account predicts priming at the location of the subcategorizer (the verb) as well as sentence-final. The DOP is based on the fact that gaps are frequently predicted at (potential) clause boundaries and is in line with previous findings to the extent that the base positions are located at a (potential) clause boundary (for a thorough discussion on these three accounts and the predictions they make for gap-filling data see Clahsen & Featherston, 1999; Featherston, 2001).

The Swinney et al. (1988) data can be explained by each of these accounts. To reiterate the findings: for sentence (14) priming of the Direct Object the boy was found at the gap (directly after the verb) and not at a control position before the verb. The DAH predicts activation of the boy after the verb accused, because it is an argument of the verb and the verb is thought to be directly linked to all of its (internal) arguments. Featherston (2001) links the SPA to HPSG and argues that the SPA predicts reactivation of an argument wherever HPSG locates a semantic feature referring to the argument. As the semantic features of a topicalized Direct Object are available at the subcategorizer, the SPA also predicts priming at the verb. The DOP, finally, predicts priming because the sentence could end after the verb accused. Thus, the four accounts (TRA, DAH, SPA, and DOP) are indistinguishable here. However, in languages that have other word orders, the explanations can be teased apart.

For this reason, the focus in gap-filling research has shifted from English to head-final languages like German (Clahsen & Featherston, 1999; Featherston, 2001; Felser et al., 2003; Fiebach et al., 2001; Muckel & Pechmann, 2002) and Japanese (e.g., Aoshima, Phillips, & Weinberg, 2004; Nakano, Felser, & Clahsen, 2002). In these languages, reactivation of a moved noun constituent before the sentence-final verb has been encountered cannot be accounted for by the lexical hypotheses, which share a verb-centered approach, assuming that a (moved) constituent and the verb (as a subcategorizer) can only be linked at the verb itself.

To date, no published studies on German wh-movement employing the CMLP paradigm are available in the literature. However, in an ERP experiment by Fiebach,
Schlesewsky, and Friederici (2002), a sustained negativity was found starting at the onset of the \textit{wh}-filler and spanning the complete embedded question in Object \textit{wh}-questions like (15) compared to Subject \textit{wh}-questions such as (16). This is taken to indicate that the displaced element is activated and maintained in working memory before the subcategorizing verb is encountered (see also Felser et al., 2003).

(15) Thomas fragt sich, wen, am Mittwoch nachmittag nach dem Unfall der Doktor \textit{i} verständigt hat.
_Thomas asks himself who (ACC) on Wednesday after the accident the doctor (NOM) called has._
_(Thomas wonders who the doctor has called on Wednesday after the accident.)_

(16) Thomas fragt sich, wer am Mittwoch nachmittag nach dem Unfall den Doktor verständigt hat.
_Thomas asks himself who (NOM) on Wednesday after the accident the doctor (ACC) called has._
_(Thomas wonders who has called the doctor on Wednesday after the accident.)_

Other studies of German sentence processing have focused mainly on scrambling. Unfortunately, there is no consensus in the literature as to whether scrambling entails a movement operation or not (for a discussion see Friederici, Schlesewsky, & Fiebach, 2003). Friederici et al. (2003) found evidence that \textit{wh}-movement and scrambling elicit different brain responses in an ERP paradigm. Nevertheless, the CMLP studies on this topic converge on the main finding that reactivation of a scrambled constituent occurs immediately, so before the actual occurrence of the verb (Claßen & Featherston, 1999; Muckel & Pechmann, 2002; Nakano et al., 2002). Muckel and Pechmann (2002) studied sentences with topicalized Direct Objects:

(17) Der Krug \textit{i} ist einem jungen Richter des Berliner \textit{[1]} Gerichts \textit{[2]} zerbrochen.
_The jug \textit{i} is by a young judge of the Berlin \textit{[1]} court \textit{[2]} broken._
_(The jug is broken by a young judge of the Berlin court.)_

They presented probes identical to the Direct Object as well as matched controls at two positions, namely at the gap in [2], and at a control position directly before the last word preceding the gap, in [1]. A significant interaction was found between probe position and probe type, indicating reactivation of the Direct Object at the gap.

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\footnote{This negativity was similar in distribution to the LAN (left anterior negativity) reported by Friederici, Hahne, and Mecklinger (1996), but differed in temporal and functional characteristics.}
Similarly, Clahsen and Featherston (1999) tested double Object constructions where the Indirect Object preceded the Direct Object. The base order is Subject – Indirect Object – Direct Object (or: NOM – DAT – ACC). Object scrambling entails movement of the Indirect Object from its base position directly after the Direct Object to a position in front of it:


*After two days dispute awarded the judge (NOM) the business, (ACC) the rather surprised [1] Andreas (DAT) [2] to.*

*(After two days of dispute the judge awarded the business to the rather surprised Andreas.)*

Again, a significant interaction was found between probe position and probe type, indicating faster responses to identical targets at gap position [2], but not at control position [1], 400 ms earlier.

Similar to German, the base word order for a sentence with a ditransitive verb in Japanese is Subject – Indirect Object – Direct Object – verb. The activation pattern of the Direct Object in long distance Object scrambling (in which a Direct Object is moved from inside an embedded clause across the matrix clause Subject) was tested in a Japanese CMLP experiment with sentences such as (19).


*And then lemon (ACC) [CP/IP the second person (NOM) the master of ceremonies (DAT) [CP that child (NOM) [1] female person (DAT) [2] asking COMP] answered].*

*(And then, a lemon, the second person answered to the master of ceremonies that that child was asking the woman for.)*

Identical and control probes were presented at the gap [2] and 500 ms earlier, at position [1]. A significant interaction was found for participants with a high verbal working memory span but not for those with a low verbal working span memory. The low-span group also had much longer overall reaction times. The authors assume that the sentence complexity was such that the memory span of the low-spanners was exceeded, resulting in a breakdown of normal automatic processing (Nakano et al., 2002).

The results of these and other German and Japanese experiments are interpreted as supporting the Trace Reactivation Account. The results are not in line with the DAH, which would predict effects only at the verb, nor with the DOP, as the effects are not found at (potential) clause boundaries. The predictions of the SPA are unclear. Featherston
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(2001) interprets this account to predict activation of a Direct Object at least sentence-finally and at the verb. However, since in the experiments discussed above other sentence positions were involved, it seems safe to conclude that the data are not consistent with the SPA either.

2.2. Processing consequences of NP-movement

Whereas the majority of gap-filling studies have focused on *wh*-movement and the results have been replicated many times (Love & Swinney, 1996; Nagel et al., 1994; Nicol & Swinney, 1989; Swinney et al., 1988; Stowe, 1986; Tanenhaus et al., 1989; Bever & McElree, 1988; Felser et al., 2003; Fiebach et al., 2001), NP-movement has been studied less extensively and results have been less clear-cut. For example, Walenski and Fodor (1995, discussed in Featherston, 2001) found no gap-filling effects in passive sentences. They compared passives sentences (20) with active transitive control sentences (21) and found no differences in cross-modal naming times at test position [2], placed slightly after the NP-trace.

(20) Several clever monkeys that had been [1] caged at the zoo were squeezed [2] through the bars.

(21) Several clever monkeys that had been [1] caged at the zoo have squeezed the bananas [2] through the bars.

An experiment by Osterhout and Swinney (1993) on passives shed further light on this issue. In a CMLP paradigm, they compared lexical decision times for targets related to the Subject head noun and for matched controls at three positions in verbal passive sentences (22) as well as active sentences (23). The probes were presented directly after the verb and 500 and 1000 ms later. No priming effect was found in the active sentences, whereas a main effect of probe type indicated that RTs to the related probes were faster in general in the passive sentences. This effect was marginally significant at the first two probe positions, becoming statistically significant only at the third probe position, 1000 ms after the NP gap. This suggests that gap-filling in NP-movement is less immediate than in *wh*-movement. Apparently, the parser needs some time to process the construction, resulting in delayed gap-filling effects increasing in strength until at least 1000 ms after the actual point where the linguistic operation formally took place.

(22) The dentist from the new medical center in town was invited [1] by the [2] actress [3] to go to the party.

In conclusion, gap-filling effects have been found for NP-movement, but were delayed and less robust (for a review see Featherston, 2001). Fodor (1989, 1993; see also Featherston, 2001) discusses two possible explanations for the different effects found for *wh*-traces and NP-traces (see also Osterhout & Swinney, 1993). One refers to linguistic theory and the assumptions about movement and traces. In *wh*-extraction, all linguistic theories accept some kind of relation between the *wh*-constituent and the verb (or preposition) later in the sentence. However, non-transformational linguistic theories (e.g., HPSG) acknowledge only *wh*-traces, and do not assume movement mechanisms for passive and raising constructions (the ones that result in NP-traces according to transformational linguistics). Therefore, the differences in results can be argued to be in line with non-transformational grammars, although the presence of NP-reactivation, albeit delayed (Osterhout & Swinney, 1993), is not explained by this account.

The other tack that can be taken to explain the differences between on-line activation patterns for *wh*-movement versus NP-movement is more psycholinguistically oriented and suggests that a *wh*-trace may be easier to recognize than an NP-trace. In relative clause constructions the moved constituents ‘land’ in a non-argument position, clearly indicating the existence of an upcoming gap. The delay in reactivation of the moved constituent in NP-movement as compared to *wh*-movement might reflect the processor’s sensitivity to this ‘visibility of movement’ (Fodor, 1989).

2.3. Processing consequences of Verb movement

It is unknown whether a verb that is not in its base position is reactivated at its original position, because there have been very few gap-filling studies in languages where verb movement is a common phenomenon, and no study to date has examined the processing of verb movement during auditory sentence processing. If the same pattern of results were found for moved verbs in Dutch as has been found for moved noun constituents in English, this would open up new paths for a theory of gap-filling independent of language and movement-type.

It is, however, not inconceivable that movement of verbs is not reflected in psychological reality. First of all, the assumption of verb movement is strictly theory-internal to generative linguistics (Chomsky, 1995). Secondly, it is unclear what hypotheses should be formulated based on the ‘visibility’ account (Fodor, 1989). For a syntactically oriented parser, encountering a matrix verb in second position in Dutch should be a clear cue that a verb gap is forthcoming. However, in *wh*- and NP-movement, gap-filling is
necessary in order to assign thematic roles to constituents that are detached from their subcategorizer. Where verb-movement is concerned, gap-filling is not necessary for sentence interpretation but only for structural, syntactic reasons: to fulfill requirements formulated by formal syntactic theory.

A short neurolinguistic ‘excursion’ might give some initial clues as to whether any processing consequences of verb movement can be expected. Studies conducted over the past few decades have shown that agrammatic speakers encounter no problems in comprehending simple active sentences, Subject-relatives, Subject-clefts and Subject questions. However, they fail to understand sentences where movement of a certain constituent results in a word order in which the Object occurs before the Subject: e.g., verbal passives, Object-relatives, Object-clefts, and topicalization structures (for a review see Grodzinsky, Pinango, Zurif, & Drai, 1999).

An interesting question is how these patients perform on sentences where verb movement has taken place. Although significant difficulties have been found in the production of sentences with verb movement (Bastiaanse & Van Zonneveld, 1998; Bastiaanse et al., 2002; Bastiaanse & Thompson, 2003; Friedmann, 2000), no problems seem to occur in comprehension. The majority of agrammatic patients in two different studies showed good performance on grammaticality judgments of verb (auxiliary) movement structures in English (Linebarger, Schwartz, & Saffran, 1983; Grodzinsky & Finkel, 1998). In a Dutch grammaticality judgement experiment, patients with agrammatism performed well on grammatical SVO and XSVO sentences, where the verb has been moved from its base sentence-final position, and demonstrated chance-level performance on ungrammatical sentences (Wiegers, 1998).

Since the grammaticality judgment task is an indirect measure to tap into sentence comprehension, Friedmann and Gil (2001, reported in Friedmann, Gvion, Biran, & Novogrodsky, 2005) tried to replicate these effects using more direct comprehension tests. They found that agrammatic patients performed at ceiling level in plausibility judgments and a sentence-picture matching task with Hebrew verb movement structures: the patients were found to understand simple XVSO sentences in which verb movement had taken place.

However, an interesting manipulation in these Hebrew sentence materials resulted in comprehension problems, suggesting that the patients might have used non-syntactic compensation strategies to understand the sentences presented in previous studies. It has been suggested that the difference in comprehension success between, for example, Subject-relatives and Object-relatives can be attributed to a strategy which involves a

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7 In Hebrew, verb movement to second position is optional, allowing for a direct comparison of sentences with and without verb movement.
default assignment of thematic roles to NPs in non-base position (Grodzinsky, 2000). In this view, it is assumed that if an NP is moved, its trace is deleted. Therefore, no role can be assigned to the NP. An NP without a role automatically gets assigned the role ‘matching’ to the sentence position in which it occurs. Thus, in the case of Subject- or Object-relatives, the role of Agent is assigned to the first NP in the sentence. This results in good comprehension of sentences where the Subject appears before the Object, as is the case in Subject-relatives, but in chance performance for sentences where the Object is followed by the Subject, as for example in Object-relatives⁸. As the Subject preceded the Object in the tested structures with verb movement, this same strategy might have obscured ‘real’ comprehension problems.

To investigate this hypothesis, Friedmann et al. (2005) used XVSO sentences with one major change: the Direct Object was ambiguous in word meaning and could either be a noun or a verb (as in (24)). This change resulted in significant comprehension problems if these sentences had undergone verb movement: The agrammatic patients paraphrased or read aloud the sentences with verb movement correctly in only approximately half of the cases, the other times taking the Object to be the verb or indicating that the sentences did not make sense. Their performance on similar sentences where the verb had not been moved (25) was significantly better.

(24) Maxar tekashet ha-isha tikra ba-moadon.
    Tomorrow will-decorate the-woman ceiling (OR; will-read FEM) in-the-club.
    (Tomorrow the woman will decorate a ceiling in the club.)

(25) Maxar ha-isha tekashet tikra ba-moadon.
    Tomorrow the-woman will-decorate ceiling (OR; will-read FEM) in-the-club.
    (Tomorrow the woman will decorate a ceiling in the club.)

The conclusion from this neurolinguistic evidence is that verb movement might have processing consequences similar to wh-movement and NP-movement.

Another issue that could affect the way verb movement manifests itself during on-line sentence comprehension is the inherent difference between verbs and nouns. The verb is the core of a sentence and ‘manages’ both the semantic and syntactic information available in a sentence (see Chapter 1, section 2, and Chapters 4 and 5). Psycholinguistic studies suggest that these differences between nouns and verbs matter in sentence processing: many studies have revealed that verbs take longer to process in isolation (reaction times to

⁸ Chance performance arises because there are two Agents in Object-relatives: the first NP receives the Agent role based on the default strategy, whereas the second NP receives the Agent role via the normal syntactic
verbs are longer than to nouns: Gomes, Ritter, Tartter, Vaughan, & Rosen, 1997; Haan et al., 2000; Rösler et al., 2001) and influences of argument structure have been found at very early stages in sentence processing (e.g., Shapiro et al., 1987, 1989, 1991; Trueswell & Kim, 1998; see Chapter 4).

It is unknown what role these characteristics of verbs play in on-line processing of moved verbs. Will similar reactivation effects be found for verbs that are displaced from their base positions? One clue comes from work investigating VP-ellipsis in English. In a series of experiments, Shapiro, Hestvik, and colleagues (Shapiro & Hestvik, 1995; Shapiro et al., 2003) found reactivation of an NP (a tie) that is part of a verb phrase (bought a tie for Easter) at an elided position in an ellipsis structure.

In (26) there is an elided VP in the coordinate clause, signalled by the bare auxiliary did, that receives its reference from the VP in the matrix clause. Using CMLP, Shapiro et al. found that the Object from the matrix clause (a tie) was reactivated at the elided position [2] in the coordinate clause (no activation was observed at the pre-ellipsis position [1]).

(26) The mailman [bought a tie for Easter], and his brother, who was playing volleyball, did <buy a tie for Easter> too, according to the sales clerk.

(27) The mailman bought a tie for Easter, and his brother, who was play[1]ing volleyball, did [2] too, according to the sales clerk.

Though only activation of the NP was tested in this case, it was assumed that the verb from the matrix clause was also reactivated, given that the entire VP is copied.

More recently, a study examining verb gapping (where only the verb itself is elided in the second clause, and not the entire VP as in the ellipsis constructions investigated by Shapiro et al. described above), revealed some evidence suggesting that the missing verb itself is indeed active at the gap (Kaan, Wijnen, & Swaab, 2004). Kaan et al. used event-related potentials while manipulating plausibility. Consider the following examples:

(28) Ron took the planks for the bookcase, and Bill ___ the hammer with the big head.
(29) Ron sanded the planks for the bookcase, and Bill ___ the hammer with the big head.

Note that the verb in the first clause (took in (28) and sanded in (29)), which is missing in the second clause, renders the Direct Object in the second clause either plausible (28) or

route.
implausible (29). Kaan et al. found evidence for an N400 effect\(^9\) in the vicinity of the Direct Object, suggesting that participants attempt to semantically integrate the Direct Object with the missing verb. However, because the sentences were presented visually in a word-by-word fashion with 300 ms per word and 200 ms between words, and the participants were required to make a plausibility judgment on the entire sentence, it could be argued that the technique is particularly conducive to finding such N400 effects. Also, unlike the Shapiro et al. studies, no conclusions can be reached about reactivation since there was no analysis point prior to the gap.

Wijnen and Kaan (2001) conducted a CMLP experiment with Dutch gapped sentences. They tested with related (geld/money) and control probes (klok/clock) that were matched for baseline RT at four probe positions in the coordinate clause:

\[(30)\]  


Probe position [2] is the position of the gap, probe position [3] is the position where the absence of the verb, given structural constraints (V2), can be detected from the input (when an adjunct is encountered). Reaction times were faster for related than for control probes at all four probe positions (differences in RTs were [1]: 24 ms, [2]: 25 ms, [3]: 41 ms, [4]: 27 ms), but only significantly so from probe position [2] onwards. The authors interpret the data to be suggestive of reactivation of the verb at the point where the input clearly signals the presence of a verb gap (probe position [3]). An alternative interpretation is that continued activation of the meaning of the verb is found (apparently just failing the standard significance level at probe position [1]), combined with a gap-filling effect at position [3].\(^{10}\)

In a study on moved verbs in Spanish, an SVO language, declarative sentences with two different word orders (VSO and VOS) were compared (Basilico, Pinar, & Anton-Mendez, 1995). Possible activation of the meaning of the verb was tested between the Subject and the Object in the VSO sentences and between the Object and the Subject in the VOS sentences. Thus, probes were presented at the position of the verb gap in the

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\(^9\) The N400 effect has been shown to reflect difficulties with semantic integration of a word in a wider context (e.g., sentence).

\(^{10}\) Unfortunately, ANOVA interaction effects between the first and second probe position are not reported. If these were not found (which would not be surprising considering the raw difference scores of 24 vs. 25 ms), this would mean that the difference in RTs at probe position [1] does not differ significantly from the difference at [2], and thus the maintained verb activation hypothesis would gain in plausibility.
VSO sentences, whereas at the probe position in the VOS sentences no verb gap was postulated. Priming of the verb was found in the VSO sentences, and not in the VOS sentences. It was concluded that the verb was activated at the gap. Conclusions about reactivation cannot be drawn, however, because no pre-gap control probe position was included in the design.

A final result comes from a German study examining SVO sentences in which the matrix verb has been moved to V2 and the particle remained in $V^0$, the base position of the verb (Muckel, Urban, & Heartl, personal communication, 2003). The study failed to show reactivation for the verb stem of split particle verbs at the base position of the verb, directly after the particle that followed the Direct Object. Sentences were of the following type:

(31) Wir heizen, in den nächsten Stunden die [1] Sauna vor t_i [2] und ...

We heat, in the next hours the [1] sauna PARTICLE: $t_i$ [2] and ...

Identical and unrelated targets were presented in a control position [1] and in the base position of the verb in [2]. Reaction times to identical probes were faster than reaction times to control probes at the control probe position as well as at the experimental probe position. However, as no interaction between probe position and probe type was found, there was no evidence for reactivation. Because the authors did not test for priming directly after the verb and do not present baseline reaction times for the two probe types, it cannot be concluded which pattern was found: the results are suggestive of either continued activation of the verb stem or no activation at all (in this case, the priming effects can be explained by the materials used: identical probes are generally more sensitive to priming than associatively related primes).

2.4. Summary

Three types of movement are distinguished: $wh$-movement, NP-movement and verb-movement. Processing studies on $wh$-movement consistently show reactivation of the moved Direct Object at the gap position, whereas delayed gap-filling effects are reported for NP-movement. Clear data on the psychological reality of verb movement are lacking. In certain verb movement studies, agrammatic patients show good comprehension, but when compensation strategies cannot be used, deficits are revealed. Psycholinguistic evidence is contradictory: a suggestion for re-activation of moved verbs can be tentatively deduced from the ellipsis studies of Shapiro et al. (1995, 2003) and from Wijnen and Kaan (2001). Activation (but no reactivation) is found by Kaan et al. (2004) and Basilico et al. (1995); maintained activation of the verb is probable in the Wijnen and Kaan (2001) study.
and cannot be rejected in Kaan et al. (2004), Basilico et al. (1995) and Muckel et al. (p.c., 2003). Clearly, there is a great need for more studies on the activation pattern of the moved verb during on-line sentence processing, which will contribute to our current understanding of sentence processing and the psychological reality of movement.

2.5. Implications for the present study

In the second half of this chapter, two CMLP experiments are presented, exploring the question whether or not verb movement has processing consequences similar to movement where nouns are involved. The experimental sentences in the present experiments consist of matrix clauses in which the verb has been moved from its clause-final base position to V2 position (leaving behind a gap) followed by a second clause. If verb movement, like \(wh\)-movement, is reflected in psychological reality (i.e., has consequences for the parser) activation of the meaning of the verb is expected to occur directly after the verb (direct priming), with deactivation between the overt verb position and the gap, and reactivation at the gap (gap-filling). A delayed gap-filling effect would be in line with findings on NP-movement.

If moved verbs show reactivation at their base position, then a strong case can be made for the possibility that listeners attempt to recover base word order whenever they encounter a structure that is non-canonical. However, at least two alternative outcomes are possible. First, it is possible that there is no (re)activation at the gap (e.g., because head movement is not reflected in psychological reality). Second, the meaning of the verb could remain activated once the verb has been encountered (e.g., because verbs play a binding role in the sentence).

3. EXPERIMENT 1

3.1. Introduction

The initial experiment investigates the activation pattern of V2 positioned verbs in Dutch declarative matrix clauses in three critical test positions in order to determine whether re-activation of the verb occurs in its base position. Consider the following Dutch sentence (provided with English gloss) in which the verb \textit{imiteren (imitate)} resides in V2 position, and its putative base position is marked by a blank underline:

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\(^{11}\) This experiment was run in collaboration with Femke Wester.

NADOEN (COPY) – FILMEN (FILM)

A design is used where probes related to the matrix verb (e.g., *nadoen/copy*) and unrelated control probes (e.g., *filmen/film*) are momentarily presented at one of three positions throughout the sentence. Faster RTs to related than to control probes are predicted at position [1], shortly after the verb is encountered. This forms a baseline to demonstrate that the target probes are initially primed by the verb, and that the verb has been fully processed when encountered. The issue of whether the verb is reactivated at its base position at the end of the matrix clause will be reflected by the pattern of activation at positions [2] and [3]. Probe position [2] provides a key intermediate test position to examine the continued activation versus reactivation issue: if no priming for probe targets related to the verb *imiteren* (*imitate*) is found at test position [2], any later evidence for activation of the meaning of the verb can be interpreted as reactivation (and, hence, verb gap-filling in V2 languages). Test position [3] is placed following the end of the matrix clause (specifically, after the conjunction indicating initiation of the embedded clause). The reasoning for this decision is two-fold: First, there is the visibility issue, namely the possibility that despite the fact that the base position of the verb theoretically resides after the noun *voetbaltrainer* (*soccer coach*), it might not be recognized as the true verb base position until some subsequent information signaling the end of the clause is processed. Relatedly, some studies examining NP-based gaps have noted a short delay in reactivation at gap positions (Fodor, 1989, 1993; Nagel et al., 1994; Osterhout & Swinney, 1993). (To anticipate, Experiment 2, was specifically designed to provide a probe directly at the base position without a delay).

3.2. Methods

3.2.1 Participants

In total, 51 undergraduate and graduate students from the University of Groningen participated in the experiment. Half were volunteers and half were given course credit for participation. Of these 51 participants, 7 had to be excluded because they did not take part in both experimental sessions, 1 participant failed the preset criterion of 67% correct answers on the comprehension questions (see section 3.2.2), and 2 participants were excluded from the analysis because the mean or standard deviation (SD) of their reaction times (RTs) deviated more than 2.5 SD from the other participants.
All remaining 41 participants (12 male, 29 female) were native speakers of Dutch. All had self-reported normal or corrected-to-normal vision and hearing, no dyslexia or other reading problems and no history of neurological disorders or long periods of unconsciousness. Two persons were ambidextrous, the others were right-handed. The mean age was 22.4 years (range 18-30). The 51 original participants were randomly assigned to one of three groups (the number of participants per group for the remaining 41 participants was 14, 14 and 13 for the three groups).

3.2.2 Materials

Forty-two experimental sentences as in (32) were created (see Appendix for the full set). In order to examine for verb activation beyond the matrix clause and in order to avoid end-of-sentence effects which might obscure gap-filling effects (see, e.g., Balogh et al., 1998), an embedded clause was added to the matrix clause. All sentences were matched for syntactic structure and composed according to the following criteria: the matrix verb was in the third person plural, the Object noun phrase was at least nine syllables in length, and the conjunctions were all subordinating. All sentences were recorded with a natural intonation pattern, with the only restriction that a fall-rise intonation was used at the Object head noun, which, in Dutch, signals that the clause has ended, but that another clause will follow and continue the sentence. This fall-rise pattern was further accompanied by a lengthening of the vowel of the stressed syllable of the Object head noun and followed by a relatively long pause in all sentences.

Each experimental sentence was paired with a related and an unrelated, control probe word. The related probe was a verb which was an associate of the matrix verb, and the control probe had no associated relationship to any words in the sentence. The related probe words were chosen on the basis of an off-line Association Task (Pretest 1) involving 80 native Dutch speakers (undergraduate students from the University of Groningen, mean age 19.9 years, none of whom participated in the on-line experiment). The participants were presented with a list of 104 verbs and were instructed to write down the first one or two verbs that came to mind for each item on the list. From the associated verbs provided, related verb probes were chosen based on having an association quotient\textsuperscript{12} of 40% or higher across all participants.

Next, independent lexical decision responses were collected to 64 highly related probes, 191 possible control probes and 255 non-words in an Unprimed List Lexical Decision Task (Pretest 2: Baseline LDT) involving 25 right-handed native Dutch speakers (mean age 20.7 years), none of whom participated in the on-line experiment.

\textsuperscript{12} The association quotient was calculated per item by counting the number of participants that wrote down the same verb (first or second choice) and dividing this number through the total amount of participants.
The final 42 related and 42 control probes were matched per pair as closely as possible on reaction time (RT), frequency (CELEX; Burnage, 1990), number of letters, number of syllables and transitivity (see Table 1). For each pair of probes, any difference in baseline RT was always in a direction opposite to that which might be found in priming, so in favor of the control probe. As a result of this, the baseline RTs for control probes were significantly faster than those for related probes (difference = 4.1 ms, t (41) = 5.9, p < .001).

Table 1. Characteristics of related and unrelated control probes in Experiment 1

<table>
<thead>
<tr>
<th></th>
<th>Related probes (n=42)</th>
<th>Unrelated control probes (n=42)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Baseline RT</td>
<td>585.7</td>
<td>34.5</td>
</tr>
<tr>
<td>Frequency (logarithmic)</td>
<td>1.80</td>
<td>0.64</td>
</tr>
<tr>
<td>Number of letters</td>
<td>6.8</td>
<td>1.6</td>
</tr>
<tr>
<td>Number of syllables</td>
<td>2.3</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Activation of the verb was tested at three probe positions as described above. Probe position [1] occurred at the offset of the matrix verb, probe position [2] was placed 700 ms after the first probe position and probe position [3] occurred immediately at the offset of the conjunction, a point that was on average 456 ms after the offset of the Object NP in the matrix clause.

As discussed in Chapter 2, visual target words are not integrated into an ongoing auditory sentence in a CMLP paradigm (e.g., see Love & Swinney, 1998; Nicol et al., 2006; Nicol et al., 1994, in response to McKoon et al., 1994; McKoon & Ratcliff, 1994). However, in order to fully establish the case that priming for targets related to the verb is caused by activation of the verb itself, a Goodness-of-fit Test (Pretest 3) was conducted to verify that spurious priming was not mediated by easier integration of the ‘related’ probe than the control probe into the ongoing sentence. In a paper-and-pencil test, participants were presented with parts of the sentences (more specifically: with 3 possible parts; the sentence up to each of the three probe positions) and were asked to rate the goodness of fit of the related and control probe with the presented sentence part.

In Table 2 it can be seen that only very few probes were scored as possible continuations of the sentence at any of the probe positions, resulting in a mean ‘goodness-of-fit score’ of 1.65 (SD = .91) for the related probes and 1.49 (SD = .70) for the control probes on a 7-point scale, where 1 means: ‘this word is absolutely not a good continuation of the sentence fragment’. The difference in continuation scores was significant at probe positions [2] and [3] (probe position [2]: difference = .33, t (40) = 2.0, p < .05; probe
position [3]: difference = .19, t (40) = 5.27, p < .001), but not at probe position [1] (difference = -.05, t (40) = -.25, p = .81).

Table 2. Off-line Goodness-of-fit Test scores for related and unrelated control probes in Experiment 1 (scale 0-7).

<table>
<thead>
<tr>
<th>Probe Position</th>
<th>Related probes</th>
<th>Control probes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Probe Position [1]</td>
<td>1.78</td>
<td>1.00</td>
</tr>
<tr>
<td>Probe Position [2]</td>
<td>1.84</td>
<td>1.13</td>
</tr>
<tr>
<td>Probe Position [3]</td>
<td>1.32</td>
<td>0.29</td>
</tr>
</tbody>
</table>

Forty-two filler sentences with a structure similar to the experimental sentences were constructed and paired with non-word target probes. This resulted in an equal number of *word* versus *non-word* lexical decisions for sentences with this particular structure. In addition, 20 filler sentences containing a variety of structures (all different from the experimental sentences, but of approximately the same length) were constructed. Ten of these were paired with word target probes and ten with non-word target probes, to ensure equal proportions of word and non-word probes. The probe positions in the filler sentences were chosen randomly to prevent participants from building expectations about the place of the probe positions. The non-words were created by changing two letters in existing Dutch verbs (no verbs that were used as prime in the sentences or as related or control verb probe targets appeared in any form in these non-word probes). All non-words were orthographically and phonologically legal Dutch words. In Dutch, all regular infinitive verbs end with –*en*. This ending of the verbs was never changed, which means that the non-words were, more specifically, non-verbs.

The 110 resulting experimental and filler sentences were pseudo-randomly combined (such that no more than three sentences in a row were either experimental or filler sentences). In addition, it was ensured that there were no semantic relations between successive sentences and/or probes in the final ordering. Finally, six practice sentences

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13 In anticipation of the results, please note here that there is no parallel between the off-line continuation ratings and the on-line CMLP findings; thus there is no concern here over pre-existing ‘easy integration’ of probes causing priming effects. The priming pattern predicted by these data would show no priming at the first probe position and priming at the other probe points ([2] and [3]). This is not what was found. Also, correlations between differences in RT and differences in continuation score per probe position were not significant, indicating that the items with larger priming effects (differences in RTs between related and control probes), were not the items with larger continuation differences: pp [1]: \( r = .114, p > .4 \); pp [2]: \( r = .029, p > .8 \); pp [3]: \( -.055, p > .7 \) (\( r = \) Pearson’s R).
with various syntactic structures were created and paired with three non-word and three word target probes.

To ensure that participants paid attention to the sentences, yes/no comprehension questions were formulated for 15 sentences throughout the entire experiment (14% of all sentences). The questions focused on factual aspects of different parts of the sentences. Questions were presented aurally in a different voice (female instead of male) and asked about both experimental and filler sentences. A comprehension question was never directly followed by an experimental sentence.

3.2.3 Design

Probe position and probe type were both within-subject factors. A completely counterbalanced design was created. Because each experimental sentence was combined with two pairs of probes at three different probe positions, three pairs of lists were extracted from the basic pseudorandom list. The same experimental and filler sentences were used in both lists of a pair. Lists were counterbalanced such that each participant was presented with probes at all three probe positions and with both related and control probes. If an experimental sentence was paired with its related probe in list 1, it was paired with the control probe in list 2. The two lists of one pair were presented to each participant in two different sessions at least two weeks apart (see Table 3).

3.2.4 Procedure

Participants were tested individually in a sound-attenuated room with no visual distractions. The sentences were presented over headphones with an inter-trial interval of 1500 ms. The probes were presented on a standard computer screen in lower-case Arial 16 point characters (white on black background). A white piece of paper was attached to the screen with a 4 x 10 cm rectangle left open, to help the participants focus on the location of the screen where the probes would appear. The experimental software Tempo (University of California, San Diego), combined with a response box with two response buttons, was used to present the auditory sentence and the visual target probes and to register the accuracy (word/non-word response) and RTs of the responses. Each target probe was presented for 300 ms and a response was accepted up to 2000 ms from target probe onset. Importantly, the auditory sentences continued without interruption during visual presentation of the probe.

Participants were instructed to listen carefully to the sentences and to expect comprehension questions about some sentences, immediately after their occurrence. It was emphasized that they should not memorize the sentences; merely listening to and comprehending the sentences would be sufficient to answer the questions correctly.
Questions had to be answered by pressing the left button with their left index finger for ‘no’ or the right button with their right index finger for ‘yes’. Participants were told that at some point during each auditory sentence they would see a string of letters on the screen. They were asked to decide for each of these letter strings (probes) whether it formed an existing Dutch word or not. Participants pressed the right button with their right index finger when they saw a word, and the left button with their left index finger when they saw a non-word. Participants were encouraged to respond as quickly and accurately as possible.

Both test sessions in the experiment was divided into three blocks: a practice block (consisting of six filler sentences and two comprehension questions) and two experimental blocks (consisting of 52 sentences and six or seven comprehension questions each). The length of the experimental blocks was approximately eight minutes, with a break in between; duration of the break was determined by the participant. Each experimental session (instructions and breaks included) lasted approximately 30 minutes. The second session was administered at least two weeks after the first one.

Table 3. Overview of the sentence types and probe types in each session and block for Experiment 1

<table>
<thead>
<tr>
<th>SESSION 1</th>
<th>SESSION 2 (&gt;2 weeks later)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>sentences</strong></td>
<td><strong>probes</strong></td>
</tr>
<tr>
<td>Practice block</td>
<td>6 filler</td>
</tr>
<tr>
<td></td>
<td>3 non-word</td>
</tr>
<tr>
<td>Exp. block A</td>
<td>21 exp A</td>
</tr>
<tr>
<td></td>
<td>11 control</td>
</tr>
<tr>
<td></td>
<td>21 quasi-exp A</td>
</tr>
<tr>
<td></td>
<td>10 filler A</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Exp. block B</td>
<td>21 exp B</td>
</tr>
<tr>
<td></td>
<td>10 control</td>
</tr>
<tr>
<td></td>
<td>21 quasi-exp B</td>
</tr>
<tr>
<td></td>
<td>10 filler B</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.3. Results

Response times (RTs) for experimental items were collapsed across items and across subjects and repeated-measures analyses of variance were performed on means calculated for each. In the subject-analysis ($F_1$), RTs are collapsed over items, with subjects as the random factor; in the item-analysis ($F_2$), RTs are collapsed over subjects, with items as the random factor. Probe position ([1],[2], [3]) and probe type (related and control) were
within-subjects factors. *A priori* planned comparisons were made between related and control probes at each probe position (paired samples t-tests, one-tailed) and differences in RTs were compared between the probe positions ($F_1$ and $F_2$ interaction effects).

Error rates were low (1.8%). The exclusion of errors and outliers (all values deviating from the subject and item mean for the particular data point with more than 2.5 SD were excluded) resulted in 2.7% data loss.

The mean RTs for all probe positions and probe types are presented in Table 4 (the values that are presented here and in following tables are derived from the subject-analyses; the item-analyses revealed very similar data). As can be seen in Table 4, overall, the RTs to related target probes were faster than to control probes. This priming effect reached significance in the subject-based ANOVA ($F_1 (1,40) = 7.91, p = .008$) and marginal significance in the item-based analysis ($F_2 (1,41) = 3.43, p = .071$). There was no significant interaction between probe position and probe type overall ($F_1 (2,80) = .83, p > .4; F_2 (2,82) = .46, p > .6$). Planned comparisons for differences in RTs between the probe positions were performed to obtain insight into the pattern during the unfolding sentence, and thus compared interaction effects for probe positions [1] and [2] separately and [2] and [3] separately. No significant interactions were found for the first two test positions ($F_1 (1,40) = .12, p > .7; F_2 (1,41) = .03, p > .8$) nor for the last two positions ($F_1 (1,40) = .87, p > .3; F_2 (1,41) = .55, p > .4$).

**Table 4.** Mean (and SD) reaction times (in ms) to related and control probes for each probe position in Experiment 1.

<table>
<thead>
<tr>
<th>Probe Type</th>
<th>Probe Position</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[1]</td>
<td>[2]</td>
<td>[3]</td>
</tr>
<tr>
<td>Control</td>
<td>633 (68)</td>
<td>635 (61)</td>
<td>626 (72)</td>
</tr>
<tr>
<td>Related</td>
<td>617 (65)</td>
<td>621 (66)</td>
<td>620 (73)</td>
</tr>
<tr>
<td>Difference</td>
<td>16 **</td>
<td>14 **</td>
<td>6</td>
</tr>
</tbody>
</table>

** p<.01 (paired samples t-test, subject-analyses, 1-tailed)


Most importantly, however, *a priori* planned paired t-tests examining for priming related to the verb at each of the individual probe positions revealed significantly shorter RTs for related than for control probes (priming for probes related to the matrix verb) at test position [1] ($t_1 (40) = 2.53, p = .008; t_2 (41) = 1.75, p = .044$) and at position [2]
(although only marginally significant in the item-analyses at this place: \( t_1 (40) = 2.64, p = .006; t_2 (41) = 1.40, p = .085 \)). Finally, planned comparisons at probe position [3] revealed a lack of priming for related versus control probes \( t_1 (40) = .81 p > .2; t_2 (41) = .82, p > .2 \).

3.4. Discussion

This initial examination of the on-line activation of moved verbs in Dutch matrix clauses reveals an interesting pattern. Activation of the verb once it is first encountered appears to be maintained at least up to the point of the second, intermediate test position. However, the priming effect is dampened at the third test position, in the subordinate clause. At first glance these results do not support the view that the verb is reactivated after the end-of-clause base position. However, this initial experiment only examined for verb activation at a few select positions.

The position of the control probe position (700 ms after the verb) was based upon the literature on gap-filling effects with nouns as the constituents being moved: studies on anaphora and \( wh \)-movement have repeatedly demonstrated that activation of anaphors and \( wh \)-traces rapidly degrades. According to Featherston (2001), the existing data converge on a figure of about 500 ms. However, it might be the case that this figure is different for verbs. As a considerable amount of evidence is available indicating that verbs are more complex and take longer to process than nouns (see Chapter 1, section 2.2 and Chapter 5), it is not implausible that verbs remain activated longer than nouns and, thus, that the control position was placed too early.

In addition, the initial choice of placement of probe position [3] is not sufficient to determine that the verb was not reactivated exactly at the base verb position, as the current probe position was well after the presumed verb gap, for reasons discussed above (section 3.1). In the experimental sentences, the putative gap is situated immediately following the Object head noun (\( voetbaltrainer = soccer coach \)). However, probe position [3] was placed at the offset of the conjunction, the first word following this Object head noun. Given that the sentence was purposefully recorded with strong prosodic cues indicating the end of the matrix clause, it may be that the parser did not encounter any ambiguities in recognizing the end of the clause, but clearly realized that probe position [3] was in a position well into the next clause. As such, the parser, even if it did reactivate the verb at the gap, may have rapidly suppressed this activation in anticipation of processing the subsequent clause. In addition, it needs to be noted that a matrix verb that is not in sentence final position (rather, in V2) may be a strong signal to the parser that movement has taken place. Fodor (1989, 1993) calls this visibility of movement: the stronger the indications that movement has taken place, the more likely it is that the parser 'predicts' the gap, and that it is filled immediately.
The next experiment was conducted to address the issues raised above.

4. EXPERIMENT 2

4.1. Introduction

The aim of the second experiment was to further investigate the possibility that the linguistic concept of verb movement has implications for sentence processing. An additional control probe position 1500 ms after the occurrence of the verb (intended to allow the activation of the verb to dissipate) and a probe position at the exact gap position (end of the clause) were inserted as a final test for verb reactivation. Furthermore, some small changes were introduced to minimize the chances that gap-filling would be delayed.

The sentences used were largely similar to the sentences in Experiment 1, with three differences. First, the sentential materials immediately following the matrix verb were extended by several syllables with a temporal Adverbial Phrase so that probes could be presented 1500 ms after the onset of the verb (in contrast to the 700 ms offset employed in Experiment 1). Second, a coordinate clause rather than a subordinate clause followed the matrix clause in order to reduce any potentially delayed gap filling effects introduced because of the subordinating conjunction (Shapiro & Hestvik, 1995). Third, the prosody at the clause boundary was altered. Whereas in the first experiment prosody indicated that a gap was to be expected, this cue can be made even more salient by employing a falling prosody combined with a lengthening of the Object head noun and followed by a pause, indicating that the clause has ended. This latter prosody was employed in Experiment 2, providing an even stronger cue that the base position of the verb occurs immediately after the Object head noun, thus allowing for a test of gap-filling in a more constrained condition. The probes and design were identical to Experiment 1.

Example (33) displays a sentence and the probe positions employed for this experiment (note that because has two Dutch counterparts, namely want and omdat; when omdat is used, the second clause is subordinating, when want is used it is coordinating).


The refined men imitate [1] regularly their hysterically [2] scolding wives ___ [3], because (coordinating) [4] in-this-way can they expression give to their frustration without violent to get.

NADOEN (COPY) – FILMEN (FILM)

14 This experiment was run in collaboration with Femke Wester.
According to the gap-filling hypothesis, significant priming effects are expected directly after the verb (probe position [1]) and at its base position (probe position [3]), but not at the intermediate probe position [2] and the coordinate clause probe position [4].

4.2. Methods

4.2.1 Participants

Seventy students from the University of Groningen took part in the experiment, and were paid for their participation. None of these participants took part in Experiment 1 or any of the pretests. Ten of the participants were excluded from the analysis for not meeting the preset criteria on background characteristics or for not taking part in both test sessions. Three participants were excluded because their mean and/or SD reaction time exceeded those of the overall group by more than 2.5 SD.

The remaining 57 participants (12 male, 45 female) were all right-handed (1 ambidextrous) native Dutch speakers with self-reported normal or corrected-to-normal vision and hearing, no dyslexia or other reading problems and no history of neurological disorders or long periods of unconsciousness. Their mean age was 20.7 years (range 18-28 years). The 70 participants were originally randomly assigned to four groups (the numbers of participants per group for the remaining 57 participants were 14, 15, 13 and 15 respectively).

4.2.2 Materials and design

In this experiment, probe materials for the experimental sentences (related and control probes) were identical to those in Experiment 1, but the sentences themselves were different. Whereas in Experiment 1 the Object noun phrase in the experimental sentences consisted of at least nine syllables, in the present experiment an Adverbial Phrase was added; this phrase plus the Object noun phrase was at least 12 syllables in length. Also, the second clause always started with a coordinate conjunction; half of the sentences employed maar (but), the other half want (because). Finally, the exact words of the sentences (except for the verbs) were different as well. The materials from each of the four probe conditions were equally distributed (counterbalanced). To this end, 40 experimental sentences were selected from the 42 employed in Experiment 1. Two items were excluded on the basis of an off-line rating study in which participants were asked to create sentences for each prime verb. One verb that was excluded in the present experiment was used intransitively by all ten raters (studeren = study), the other verb is optionally ditransitive (zenden = send). The 40 remaining verb primes were all (optional) transitives. The number of similarly structured
filler sentences (which also had an adverbial phrase in front of the Object noun phrase, to match the experimental sentences) was reduced to 40 as well, and the same non-word probes were used as in Experiment 1.

The first probe position occurred at the offset of the matrix verb, and position [2] occurred 1500 ms later (but still at least 700 ms before the end-of-clause verb base position). Probe position [3] was placed at the offset of the Object head noun (immediately at the putative verb gap). Finally, the fourth probe position was inserted at the offset of the conjunction (i.e., in the coordinate clause), in order to evaluate whether the dissipation of matrix verb activation generalizes to other clause/conjunction types (see (33) above for an example of probe point locations).

As in Experiment 1, an off-line Goodness-of-fit Test was conducted to control for potential integration effects (easier integration of related probes than of control probes). The sentence fragment up to each probe position was tested, except for the final probe position, which was after the conjunction. Since this test position was structurally identical to test position [3] in Experiment 1 (Pretest 3), this position was not evaluated again.

In Table 5, it can be seen that, overall, the test revealed low scores (mean 1.76 for related probes and mean 1.68 for control probes on a 7-point scale). No significant difference were found between related and control probes at probe position [1] and [2] (related probes: 1.97 and 1.89, control probes 1.89 and 1.80; t’s < 1, p’s >.5), but the difference of .14 (1.40 versus 1.26) at probe position [3] reached significance (t (37) = 3.3, p = .002). Again, this pattern is not reflected in the priming data.

<table>
<thead>
<tr>
<th>Probe Position</th>
<th>Related probes</th>
<th>Control probes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Probe Position [1]</td>
<td>1.97</td>
<td>1.02</td>
</tr>
<tr>
<td>Probe Position [2]</td>
<td>1.89</td>
<td>1.02</td>
</tr>
<tr>
<td>Probe Position [3]</td>
<td>1.40</td>
<td>0.26</td>
</tr>
</tbody>
</table>

Filler sentences were the same as in Experiment 1, but, as there were 40 instead of 42 experimental sentences, two filler sentences with a structure similar to the experimental sentences were moved to the practice blocks. Thus, one experimental session contained 40 experimental sentences, 40 filler sentences with similar structures (combined with non-words), 20 filler sentences with varying structures (combined with 10 words and 10 non-words) and 15 comprehension questions.
4.2.3 Procedure

The procedure was similar to Experiment 1. Each of the two test sessions (conducted at least two weeks apart) consisted of four blocks. The practice block was extended with a simple LDT block where participants had to make lexical decisions to 5 words and 5 non-words. After this, a CMLP practice block was presented, consisting of ten filler sentences and three comprehension questions. The same lexical decision targets were used in the LDT block and the CMLP block. These two practice blocks were followed by two experimental blocks (consisting of 50 sentences and seven or eight comprehension questions each), with a short break in between.

4.3. Results

Like in Experiment 1, means for all conditions were calculated across subjects and across items (see Table 6). Subject-based and item-based ANOVAs and a priori planned comparisons (at each probe position) were performed on the resulting data. Errors and outliers (2.5 SD screen for both items and participants) were excluded from further analyses, resulting in 3.1% data loss.

Table 6. Mean (and SD) reaction times (in ms) to related and control probes for each probe position in Experiment 2.

<table>
<thead>
<tr>
<th>Probe Type</th>
<th>[1]</th>
<th>[2]</th>
<th>[3]</th>
<th>[4]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>663 (94)</td>
<td>671 (99)</td>
<td>668 (95)</td>
<td>666 (88)</td>
</tr>
<tr>
<td>Related</td>
<td>662 (91)</td>
<td>657 (84)</td>
<td>654 (101)</td>
<td>672 (103)</td>
</tr>
<tr>
<td>Difference</td>
<td>1</td>
<td>15 **</td>
<td>14 *</td>
<td>-5</td>
</tr>
</tbody>
</table>

** p<.01 (paired samples t-test, subject-analyses, 1-tailed)
* p<.05 (paired samples t-test, subject-analyses, 1-tailed)


Repeated measures ANOVAs revealed a main effect of probe type (priming for probes related to the matrix verb) in the subject-analysis (F₁ (1,56) = 4.61, p = .036) but not in the item-analysis (F₂ (1,39) = .98, p > .3). The overall interaction of probe type and probe position reached marginal significance (F₁ (3,168) = 2.46, p = .065; F₂ (3,117) = 2.40, p = .072).
Planned comparisons examining for priming at each probe position demonstrated no priming effect at probe position [1] ($t_1$ (56) = .15, $p > .4$; $t_2$ (39) = .29, $p > .3$). There was a significant effect of priming for related versus control probes at probe position [2] in the subject-based comparison ($t_1$ (56) = 2.49, $p = .008$); the item-analysis at this probe position revealed a trend for priming ($t_2$ (39) = 1.37, $p = .090$). Critically, a significant effect of priming for related versus control probes was also found at the gap probe position [3] for both subject- and item-analyses: $t_1$ (56) = 2.08, $p = .021$; $t_2$ (39) = 1.76, $p = .043$. Finally, examination at probe position [4], following the coordinating conjunction in the embedded clause, again failed to reveal any effect of priming ($t_1$ (56) = -.98, $p > .15$; $t_2$ (21) = -.95, $p > .15$). The interaction between probe position and probe type for the last two probe positions ([3] and [4]) was significant ($F_1$ (1,56) = 5.16, $p = .027$; $F_2$ (1,39) = 5.54, $p = .024$).

4.4. Discussion

The results of Experiment 2 allow important conclusions with regard to verb activation, reactivation, and the concept of gap-based verb activation. However, before discussion of these issues, the surprising null-effect at probe position [1] will be discussed. Post-hoc analysis reveals that this lack of effect was probably related to the exact timing of probe presentation. During the materials-design stage of the experiment, the exact moment of the offset of the verb was measured in order to put the probe at this position. In some cases (e.g., *buren nog = rent still*), assimilation processes made it impossible to distinguish between the end of the verb and the beginning of the next word. Also, sometimes the *n* of the *–en* ending is deleted in colloquial Dutch and the *e* is attached to the first phoneme of the next word (e.g., in *opereren regelmatig = operate regularly*). In these ambiguous cases, it was decided to place the probe at the beginning of the ambiguous region. A post-hoc analysis revealed that for the majority of items (16 out of 18) that involved a probe which was presented relatively early (just before or immediately at the offset of the verb) a negative difference between RTs for the control and related probe was found, suggesting that these particular items did not show a ‘priming effect’. For the majority of items (17 out of 22) for which the probes were placed relatively late, that is, slightly after the offset of the verb, a positive difference was found, suggesting a potential ‘priming effect’ for these particular items. This interaction between placement of the probe position and the ‘priming effect’ was significant ($\chi^2$ (1) = 17.4, $p < .001$). Thus, a tentative conclusion is that many of the probe positions in Experiment 2 occurred too early, probably before the verb was fully processed, resulting in an incomplete demonstration of priming at probe position [1].

The claim that the verb has not been fully processed at (or just before) its offset might seem to contradict findings from other cross-modal experiments where priming effects have been reported directly after the verb (e.g., Allen & Badecker, 2002; Marslen-Wilson &
Zwitserlood, 1989; Shapiro et al., 1991; Shapiro, Nagel, & Levine, 1993b). However, the experiments by Allen and Badecker and Marlsen-Wilson and Zwitserlood concerned word-level experiments. Results at the word level cannot be directly compared to results at the sentence level (see Chapter 5 for why this is the case especially for verbs). The experiments by Shapiro et al. involved the Cross-Modal Interference (CMI) Paradigm, where probes presented at the offset of the verb are unrelated to the verb itself and differences in RTs after different verbs are thought to reflect differences in processing costs. Although in these latter experiments effects were found for different types of verbs, these were only attributed to differences in argument structure. The fact that the verb has been processed at this level does not necessarily imply that its meaning has been fully accessed (which is necessary to cause associative priming effects in the CMLP paradigm). I am unaware of any studies where priming for verbs has been found immediately after its offset in a spoken sentence paradigm. This discussion will be continued in Chapter 4, where all probes were presented later, to test the relation between timing of probe placement and direct verb priming.

Critically relevant to the question of verb (re)activation is the finding of verb priming at both the intermediate probe position [2] and probe position [3], the putative base position of the verb. These results, when combined with positions [1] and [2] from Experiment 1, demonstrate a clear case for continued activation of the verb in V2 position, once it is encountered and throughout the matrix clause until the base position of the verb is reached at the end of the clause. This finding strongly suggests that there is no reactivation of the verb at its gap position. Rather, the verb appears to be maintained in an active state until the clause ends.

Finally, the lack of priming at probe position [4] following the conjunction in the coordinate clause both replicates the findings from Experiment 1 for subordinating conjunctions (thus generalizing the effect across conjunction types) and supports the view that priming from the matrix verb is suppressed when a subsequent, well-marked, clause is encountered. The fact that the change in priming between probe positions [3] and [4] is a significant one (as demonstrated in the significant interaction) lends credence to the concept of suppression across the clause boundary. Activation of the verb encountered in the matrix clause appears to be bounded by the clause.

5. **General Discussion**

5.1. **Summary**

In two CMLP experiments, Dutch sentences consisting of a matrix clause (SVO) followed by an embedded clause were aurally presented to participants. In Dutch matrix
clauses, the verb is not in its base clause-final position, but has been moved to the second place in the sentence (V2; Koster, 1975). The aim of the experiments was to evaluate whether moved verbs (in Dutch) behave similarly to moved nouns\textsuperscript{15}. If the process of gap-filling is ‘universal’, similar results are expected for different types of movement and across different languages. The results of the present experiments show that, at least in Dutch, processing of moved verbs results in different behavior of the moved element than has been found before. Neither of the experiments provided evidence for reactivation of the verb at its base position. Instead, it was demonstrated that the verb was activated (almost) immediately and remained activated at positions 700 ms later, 1500 ms later, and throughout the offset of the clause-final Object head noun. No evidence for verb priming was found immediately following occurrence of the conjunction linking the matrix to the embedded clause. These experiments therefore suggest that in Dutch, a moved verb remains active until the end of the clause employing that verb.

5.2. Previous experiments on verb movement

The studies by Wijnen and Kaan (2001), Kaan et al. (2004), Basilico et al. (1995) and Muckel et al. (p.c., 2003) can be interpreted in different ways, but they do not contradict the current ones. The Dutch verb gapping study by Wijnen and Kaan (2001) showed a numerical advantage for the related probe at positions before and after the verb gap; however, this difference was only statistically significant at the gap position. Importantly, after this position, significant priming was found at two other positions as well, indicating that the verb either remained active during the complete sentence, or at least, that after reactivation, activation did not fade away soon, remaining for at least four words (or seven syllables), which approximates 1200-1400 ms if a normal speech rate was used\textsuperscript{16}.

The ERP study on English verb gapping by Kaan et al. (2004) does not add much information to this issue, as only one test position was used; because of this single test point, continued activation cannot be excluded. Muckel et al. (p.c., 2003) found activation of a split particle verb at a control probe position and at the particle. Since they did not test for priming directly after the verb and do not present baseline reaction times for the two probe types the results are suggestive of either continued activation of the verb or no activation at all\textsuperscript{17}. Finally, Basilico et al. (1995) found activation of the verb at the site of the assumed gap (VS*O) in Spanish sentences with non-canonical word order. However, they

\textsuperscript{15} In English wh-phrases, immediate reactivation of the moved constituent is found at the location of the gap, whereas NP-phrases are reactivated with a temporal delay.

\textsuperscript{16} For English, the standardized measure is six syllables per second (Nicol et al., 2006). In Experiment 1 the average speech rate was 5.2 syllables per second.
did not test directly after the verb, nor did they use a control probe position to determine whether the activation of the verb had subsided in between. It is possible, therefore, that a moved verb in Spanish also remains active.

5.3. A combination of maintained verb activation and gap-filling?

Basilico et al. (1995) did not find continued activation of the verb in their sentences where the verb had not been moved, suggesting that this pattern of maintained activation could be directly related to verb movement, and could be caused by the existence of a verb gap later in the sentence. Thus, perhaps the effect observed at the end of the clause in Experiment 2 reflects both sustained activation and a gap-filling effect. Note that a similar suggestion was made in section 2.3 to explain the CMLP data on Dutch verb gapping by Wijnen and Kaan (2001).

One interpretation of the data therefore is that, although no evidence was found for reactivation, a structural account can still hold for the data; the verb was indeed active at the gap. However, instead of being reactivated, moved verbs are maintained active until the gap, perhaps in order to fulfill a syntactic reordering requirement. If one adheres to this interpretation, the structural account as represented by the Trace Reactivation Account (Nicol & Swinney, 1989; Swinney et al., 1988) needs a thorough revision. In this broader account the different expressions of gap-filling in wh-movement, NP-movement and verb movement should be taken into account and explained.

5.4. No verb gap in psychological reality?

On the other hand, it is not inconceivable that the continued activation of the verb is not related to the gap at all. It is possible that movement of verbs is not reflected in psychological reality. In wh-extraction, all linguistic theories accept some kind of relation between the wh-constituent and the verb later in the sentence. In movement of noun constituents, gap-filling is necessary to assign thematic roles to constituents that are detached from their subcategorizer. In contrast, the assumption of verb movement is theory-internal to generative linguistics (Chomsky, 1995). Moreover, whereas gap-filling serves an interpretational purpose where wh-movement and NP-movement are concerned, the reasons for verbs to be reactivated at the gap are purely structural and theory-internal. In fact, it has been found that having the verb available early in the sentence facilitates the integration of the upcoming arguments in the sentence structure (Friederici & Frisch, 2000). It is suggested that the verb, when encountered before its internal arguments, sets

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17 In this case, the priming effects can be explained by the materials: identical probes are generally more
up a subcategorization frame to make sure that the theta roles can be assigned as soon as they are encountered. Indeed, the surface structure of matrix clauses in English, in which the assignment of theta roles is unproblematic, is exactly the same as the surface structure of Dutch matrix clauses.

A structural explanation of the data can be rejected if non-moved verbs are found to remain active as well. In English matrix clauses, the finite verb is in base position, so there is no verb gap at the end of the clause. If the verb does *not* remain active in English, the present results are most likely to be due to restoration of the base word order (gap-filling). If, however, the results for English are *similar* to the results of the experiments discussed in this paper, other accounts will gain credibility. Preliminary findings for English suggest that once the meaning of the verb is activated, it remains active for an extended period of time, even during adjuncts (L.P. Shapiro, personal communication, August 2006).

5.5. **Lexical accounts**

Apart from the structural account, lexical accounts have been put forward as an explanation for reactivation of extracted elements following their subcategorizer (e.g., Direct Association Hypothesis; Pickering & Barry, 1991), Semantic Processing Account, and Depth of Processing Account (Fodor, 1989, 1995). According to these types of accounts, there is no gap and thus no gap-filling. Instead, a verb is directly related to its arguments. The central role of the verb that emerges from the data seems to be in keeping with this idea. However, the lexical accounts were interpreted to predict verb activation in the vicinity of an argument. Unless the interpretation of these accounts is extended to assert activation *until* the final argument has been processed or *until* the clause boundary is reached, the data are inconsistent with these accounts. As the lexical accounts do not predict such ongoing activation until a critical point for other sentence elements (e.g., Direct Objects), a thorough revision will be needed if they aim to explain verb activation patterns.18

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18 'sensitive to priming' than associatively related primes.

18 Taking this issue somewhat further, a lexical theory such as Head-driven Phrase Structure Grammar (Pollard & Sag, 1994) could be interpreted to predict 'activation' of the subcategorization frame of the verb during sentence processing. This subcategorization frame defines the feature SLASH, which is meant to make sure that all constituents fit in the sentence structure correctly and that all arguments are assigned the accurate thematic role. When all arguments have been encountered SLASH is 'empty'. The current data, where activation is found until the final argument has been processed are in line with this interpretation of HPSG.
5.6. Argument Structure Hypothesis

Possible effects of argument structure on the activation pattern of the verb during sentence processing were discussed in section 2.3, where the special role of verbs (as opposed to nouns) was highlighted. A property of verbs that has been studied very intensely in the literature is the relation with arguments: verbs provide the number and type of possible persons or objects that are involved in the event (subcategorization), and assign thematic roles to these persons or objects. One possible reason for the pattern of maintained activation found in the present experiments is that verbs, whether encountered in second position in V2 constructions or in base position, are kept active until their argument structure is saturated and all arguments are encountered. As all verbs that were used in the present experiments were transitive verbs, the final argument was always the Direct Object, which occurred at the end of the matrix clause. Therefore, one possible reason for continued verb activation in the experimental sentences is that verbs remain active to ‘find’ their arguments in order to assign thematic roles. According to this hypothesis continued activation is predicted up until the final argument is encountered. This Argument Structure Hypothesis is tested in Chapter 4. Alternatively, it may be that verbs are simply maintained active throughout any clause in which they occur, in order to allow appropriate linkage to all arguments and adjuncts (and other levels of conceptual structure) during processing.