Chapter 3

The effect of the first NP:
Processing Dutch main clauses

1 Introduction

1.1 Overview

In this chapter, the on-line processing of main clauses declaratives and \textit{wh}-
questions is investigated using a self-paced reading paradigm. The aim of the experiment is to see whether the discourse-related information introduced by the first NP (definite NP or \textit{wh}-phrase) affects order preferences. I will first briefly discuss how the type of the first NP may affect order preferences in main clauses. Next, the Syntactic and the Discourse Hypothesis, introduced in Chapter 2, are discussed and their predictions specified. In Section 2, the experimental procedures and results are described. The results are summarized and discussed in Section 3.

1.2 Dutch main clauses

In Chapter 2 it was shown that main clause declaratives and \textit{wh}-questions in Dutch are temporarily ambiguous between a subject-object and an object-subject reading. Consider for instance the declaratives in (1) and \textit{wh}-questions in (2). The sentence-initial NP can either be the subject or the object of the clause, exemplified by the (a) and (b) versions, respectively.

\begin{enumerate}
    \item a. De assistenten \textbf{hadden} de professor niet geholpen. [SO]
        the assistants had-PL the professor not helped
        ‘The assistants didn’t help the professor.’
    \item b. De assistenten \textbf{had} de professor niet geholpen. [OS]
        the assistants had-SG the professor not helped
        ‘The assistants, the professor didn’t help.’
\end{enumerate}
a. Welke assistenten hadden de professor niet geholpen? [SO]
   ‘Which assistants didn’t help the professor?’

b. Welke assistenten had de professor niet geholpen? [OS]
   ‘Which assistants didn’t the professor help?’

The sentences above are disambiguated by number information: in the object-initial sentences (1b, 2b) the first NP is plural, but the subsequent auxiliary is singular, indicating that this first NP cannot be the subject of the clause. In the subject-object clauses (1a, 2a), the auxiliary agrees in number with the first NP, but not with the second. Strictly speaking, the subject-initial sentences (1a, 2a) are disambiguated not at the auxiliary, but at the noun of the second NP: an object-subject reading is only excluded by the number features of the second NP.

Previous research, discussed in Chapter 2, has shown that Dutch speakers have a strong preference to assign a subject-object interpretation to a (temporarily) ambiguous clause. This subject-object preference is syntactic in nature, that is, based on generalizations and parsing principles that abstract away from the context and lexical content of the NPs. It is thus likely that the sentence-initial NPs in both (1) and (2) are assigned the role of subject even before the clause is syntactically disambiguated.

The aim of Experiment 1 is to investigate to what extent the nature of the first NP may affect the strength of this subject-object preference. Object-initial declaratives differ from subject-initial declaratives in more respects than just the order of subject and object (cf. Chapter 2, Section 5.2). A sentence-initial object refers to an entity that either has just been mentioned, or is contrasted with another entity in the context. Object-initial declaratives can thus be licitly used only in restricted contexts. Subject-initial declaratives do not impose such restrictions on the discourse. In this sense object-initial declaratives are more complex than subject-initial declaratives from a discourse point of view. Additionally, this discourse difference may be reflected in the syntactic representation of the clauses. If the first NP of a main clause is a non-deictic definite NP, the syntactic bias for a subject-initial order may therefore be enhanced by a discourse-related bias for this order.

If the first NP is a wh-phrase, on the other hand, subject-object and object-subject clauses are equal in terms of discourse requirements: in both cases, a set of N-referents, assistants in the example in (2), is presupposed. One can thus assume that the only difference between subject-object and object-subject wh-questions is a syntactic difference in word order. In contrast to the declaratives, then, the syntactically non-preferred object-subject reading may be easier to obtain when the first NP is a wh-phrase than when it is a definite NP.
1.3 The two hypotheses

In Chapter 2 two hypotheses were formulated for expository purposes: the Syntactic Hypothesis and the Discourse Hypothesis. According to the Syntactic Hypothesis, syntactic biases based on abstract categories alone take precedence over biases mediated by other information. The Discourse Hypothesis represents the view that (non-syntactic) biases triggered by more detailed lexical information are stronger than purely structural biases. The two hypotheses are repeated below:

(3)  
Syntactic Hypothesis
Syntactic information takes precedence; other information may only have a relatively late effect on ambiguity resolution.

(4)  
Discourse Hypothesis
If available, discourse-related information takes precedence over syntactic preferences in ambiguity resolution and does so immediately.

What do the two hypotheses predict concerning processing of main clauses like the ones given in (1) and (2)?

The Syntactic Hypothesis predicts that a temporarily ambiguous main clause will initially be assigned a subject-object reading on the basis of the syntactic bias. Other information is too weak to affect this preference. This means that at the point of disambiguation, the object-subject sentences are harder to process than the subject-object ones, irrespective of whether the first NP is a \(\text{wh}\)-phrase or a definite NP.

According to the Discourse Hypothesis, the strength of the subject-object preference is immediately modulated depending on the type of NP. If this first NP is definite, as in (1), a strong subject-object preference is expected on both syntactic and discourse grounds. If the first NP is a \(\text{wh}\)-phrase as in (2), no subject-object preference is expected on discourse grounds: both subject-object and object-subject conditions impose the same restrictions on the context. Hence, for the \(\text{wh}\)-questions only the syntactic bias for the subject-object reading should affect ambiguity resolution, yielding a weaker subject-object preference than in the declarative cases.

1.4 Self-paced reading

Results from previous experiments support the view that the type of NP has an effect. In the end-of-sentence grammaticality judgment task reported by Frazier and Flores d’Arcais (1989), performance was more accurate for the object-subject \(\text{wh}\)-questions than for the object-subject declaratives. Furthermore, the subject-object advantage for German \(\text{wh}\)-questions has up to now been somewhat controversial (cf. Chapter 2, Section 3), whereas a fairly robust subject-object preference has been found for declarative main clauses in this language. However,
declaratives and \textit{wh}-questions have not yet been compared on-line within one experiment. In the present experiment, the on-line processing of \textit{wh}-questions and declarative main clauses is directly compared. The experimental technique used is a word-by-word self-paced reading paradigm (Just, Carpenter and Woolley, 1982; Kennedy and Murray, 1984). In this task, subjects read a sentence word-by-word at their own pace: after they have read a word, they press a response key and the next word is displayed. Reading times for each word are recorded. Reading time is defined as the time interval between the presentation of the word and the button press. Differences in reading times are assumed to reflect differences in processing difficulty: reading times will be longer for words that cannot be easily integrated into the preceding context than for words that can.

Both the Syntactic and the Discourse Hypothesis predict that people assign a subject interpretation to the first NP. Reaction times will therefore be longer when number information at the verb is incompatible with this interpretation. An increase in reading times is expected starting at the disambiguating auxiliary (\textit{had}) for the object-initial clauses in (1b) and (2b) relative to the subject-initial equivalents in (1a) and (2a). The Syntactic Hypothesis predicts that the increase in reading times is the same for both declaratives (1) and \textit{wh}-questions (2). The Discourse Hypothesis, on the other hand, predicts that the increase in reading times for object-subject clauses is immediately modulated by the type of the first NP. At the point where the reading times for the object-subject condition get longer relative to the subject-object condition, the difference is predicted to be larger for the declaratives (1b versus 1a) than for the \textit{wh}-questions (2b versus 2a).

\section{Experiment 1: Dutch main clauses}

\subsection{Methods}

\subsubsection{Materials}

\paragraph{The structure of the experimental items}

Thirty-two sentence sets were created of the form NP1-auxiliary-NP2-\textit{niet}-past participle-PP. Examples of the experimental stimuli are given in Table 3.1. Each sentence set contained four versions of the sentence, corresponding to the four conditions: a subject-object declarative, an object-subject declarative, a subject-object \textit{wh}-question and an object-subject \textit{wh}-question. In the subject-object versions, the auxiliary agreed in number with NP1; in the object-subject versions the auxiliary agreed with NP2. The auxiliary was either \textit{had} or \textit{hadden}, the singular and plural past tense forms of \textit{hebben} ‘to have’. I chose to use the past tense forms rather than the present tense forms \textit{heeft} and \textit{hebben} to exclude a potentially confounding infinitival reading of the plural verb (cf. Frazier and Flores d’Arcais, 1989). \textit{Wh}-questions were derived from declaratives by replacing...
the first word, the determiner *de* (‘the’), by *welke* (‘which’). To balance the number features of the disambiguating auxiliary across conditions, sixteen sentence sets contained a singular NP1 and a plural NP2; in the remaining sixteen sets, NP1 was plural and NP2 singular.

Recall from the discussion in Chapter 2, Section 5.2, that object-initial declaratives are pragmatically odd when presented in isolation and the first NP is not contrastively stressed or repeated by a *die*-word. In order to render the object-subject declaratives pragmatically somewhat more acceptable, the experimental sentences always included the negation *niet*, which allowed a contrastive interpretation of the first NP. Since the negation only comes after the second NP, it was not expected to have much effect on the order preference at the disambiguating auxiliary and two following positions.

### 2.1.1.2 Comprehension questions

To encourage the subjects in the experiment to keep reading attentively, and to test whether the sentences were understood correctly, each sentence was followed by a comprehension question of the form: *Wie werd(en) niet V? NP1 NP2* (‘Who was/were not *V*? NP1 NP2’) with *V* corresponding to the participle of the preceding sentence, and the answers NP1 and NP2 corresponding to NP1 and NP2 in the experimental sentence. The order of the alternative answers always was the same as the order of the NPs in the experimental sentence. Thus, the correct answer was NP1 in half of the conditions and NP2 in the other half. Examples of comprehension questions are given in Table 3.1.

### 2.1.1.3 Plausibility and reversibility

Care was taken that the predicates used were reversible: a sentence with NP1 as the subject and NP2 as the object was semantically as plausible as a sentence with NP1 as object and NP2 as the subject.

Reversibility was tested by means of two paper-and-pencil rating tasks. In the first rating 40 potential experimental items were tested. Items were presented in two versions. One corresponding to the declarative subject-object version in Table 3.1 and another version in which the order of the two NPs was reversed and the number of the auxiliary changed to match the sentence-initial NP. In the first half of the test, half of the materials was presented in the original format, half in the reversed format. In the second half of the test, the same items were repeated but with the order of the two NPs reversed and verb agreement changed accordingly. Experimental items were pseudorandomly interspersed among twice as many fillers. Half of the fillers, too, were repeated in a reversed format in the second half of the test. Fillers were all more or less plausible sentences in at least one version. For instance *De jagers kwamen terug met een grote buit*. ‘The hunters returned with a large catch’ is plausible, but becomes anomalous when the two NPs are reversed. Two subject lists were created by varying the order between the test halves.
### TABLE 3.1
*Experimental conditions used in Experiment 1.*

1. **First NP = singular**

**Declarative**
- **s-o:** De filmster had de fotografen niet verwacht op het feest.
  the movie star had-SG the photographers not expected at the party
- **o-s:** De filmster hadden de fotografen niet verwacht op het feest.
  the movie star had-PL the photographers not expected at the party

**Wh-question**
- **s-o:** Welke filmster had de fotografen niet verwacht op het feest?
  which movie star had-SG the photographers not expected at the party
- **o-s:** Welke filmster hadden de fotografen niet verwacht op het feest?
  which movie star had-PL the photographers not expected at the party.

**Comprehension question:** Wie werd(en) niet verwacht?
who was (were) not expected

<table>
<thead>
<tr>
<th>FILMSTER</th>
<th>FOTOGRAFEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>movie star</td>
<td>photographers</td>
</tr>
</tbody>
</table>

2. **First NP = plural**

**Declarative**
- **s-o:** De assistenten hadden de professor niet geholpen met het rapport.
  the assistants had-PL the professor not helped with the report
- **o-s:** De assistenten had de professor niet geholpen met het rapport.
  the assistants had-SG the professor not helped with the report

**Wh-question**
- **s-o:** Welke assistenten hadden de professor niet geholpen met het rapport?
  which assistants had-PL the professor not helped with the report
- **o-s:** Welke assistenten had de professor niet geholpen met het rapport?
  which assistants had-SG the professor not helped with the report.

**Comprehension question:** Wie werd(en) niet geholpen?
who was (were) not helped

<table>
<thead>
<tr>
<th>ASSISTENTEN</th>
<th>PROFESSOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>assistants</td>
<td>professor</td>
</tr>
</tbody>
</table>

*s-o: subject-object order; o-s: object-subject order.*
Sentences were rated on plausibility by twenty subjects, ten for each list. Subjects were all students at the University of Groningen and native speakers of Dutch. Subjects were asked to rate the sentences for pragmatic plausibility on a scale from 1 to 5, with "most plausible" corresponding to "5". The score for reversibility was defined as the mean difference in rating scores between the reversed and the non-reversed version of a sentence. On the basis of the results of the rating task some experimental sentences were revised, and additional items were created. These new and revised sentences were again tested in the same way with a different group of 20 subjects. On the basis of these ratings, the 32 most reversible and plausible sentence sets were chosen to be used in the reading experiment. The versions corresponding to the subject-object version to be used in the reading experiment had a mean plausibility rating of 4.5 (standard deviation: .28). Mean plausibility score for the reversed versions was 4.4 (SD .32). The differences between the two versions is not significant [t(31) = 1.09, p = .285]. The complete set of experimental materials is given in Appendix 1.

2.1.1.4 Assignment to groups and lists
The 32 sentence sets were divided into four item groups of eight sets each. Each item group contained four sets in which the first NP was singular, and four in which the first NP was plural. On the basis of these four item groups, four subject lists were created, using a Latin Square design. Sentences in item group 1 appeared in the declarative subject-object version in list 1, in the declarative object-subject version in list 2, in the wh-subject-object version in list 3 and in the wh-object-subject version in list 4. Sentences in group 2 appeared in the declarative object-subject version in list 1, in the wh-subject-object version in list 2, and so on. In this way, each list contained an equal number of sentences in each condition, and no list contained more than one version of each sentence.

To avoid the possibility that all relatively implausible sentences or ones containing relatively long and infrequent words would cluster in the same condition on the subject lists, the item groups were matched on (i) mean plausibility and reversibility scores, and (ii) length (in number of characters) of the past participle and first, second and sentence-final noun; and (iii) raw and logarithmic (form) frequency of these open class words (source: CELEX, Nijmegen).

2.1.1.5 Fillers
In addition to the experimental items each list contained 64 fillers, yielding a total of 96 stimulus items. Fillers were the same for each list, and included a number of constructions: sentences with relative clauses containing object or subject gaps, sentences starting with a temporal clause and main clauses with a locative or temporal expression preceding the finite verb. Each of the filler sentences was followed by a comprehension question with two alternative answers corresponding to two NPs used in the sentence. In half of the cases, this question was posed in the active form (e.g. ‘Who had V?’), in half of the cases the question was in the
passive mode (e.g. 'Who was/were V?'). Care was taken that the correct answer was on the right hand side in half of the questions, and on the left in the remaining questions.

2.1.1.6 Order of presentation
The order of the experimental items and fillers was pseudorandomized in the following way. The stimulus sentences on a list were divided into eight blocks of 12 sentences: four experimental items (one of each condition) and eight fillers of various types. The order of the blocks and the order of items within the blocks was scrambled automatically and separately for each subject. For each subject the presentation of the actual materials was preceded by the dummy trial Let op: de eerste zin begint nu. ('Attention: the first sentence starts now.').

2.1.2 Subjects
Forty-eight subjects (8 left-handed, 11 male) participated. All were students at the University of Groningen, native speakers of Dutch and had normal or corrected to normal vision. None of them had taken part in the plausibility ratings described above. Subjects were pseudorandomly assigned to the subject lists such that each list was read by an equal number of subjects, and the number of males and left-handers was more or less balanced across the experimental lists. Subjects were paid $7.50 for participation.

2.1.3 Procedure
The task was a self-paced reading paradigm with a word-by-word moving window display (Just, Carpenter and Woolley, 1982; Kennedy and Murray, 1984). Stimulus presentation and data-acquisition in this and following experiments was controlled by the DMASTR software developed by K.I. and J.C. Forster.

Subjects were individually tested. They were seated in a sound-attenuating room. In front of them was a computer screen and a button box with a bar and a left and right response key. One of these keys was the "Go"-key. For half of the right-handed and half of the left-handed subjects the "Go"-key was the right hand key; for the remaining subjects, the "Go"-key was the left hand key.

A trial was initiated by pressing the bar on the button box. A sentence was preceded by five hashes presented on the middle line, close to the left edge of the screen. When the subject pressed the "Go"-key on the button box, the first word appeared at the position where the hashes had been. When the subject again pressed the "Go"-key, the first word disappeared and the second word was presented immediately to the right of where the first word had been, and so on. Sentences were short enough to fit on one line. The use of capital letters and punctuation was normal. When the last word of a sentence had been read, the comprehension question was presented entirely, together with the two alternative answers. The answers appeared on the next line; one on the left hand side of the
The effect of the first NP

screen and one on the right, corresponding to the position of the response keys on the button box. After the subject had answered the question, the screen turned blank. The next trial could then be initiated by pressing the bar.

Subjects were told that the experiment was about language processing, and were instructed to read for comprehension. They were asked to read at their normal speed, or even faster, so long as it did not affect their comprehension. Before the actual experiment, a practice session with 16 trials was run. This session also included a few sentences with an object-verb-subject structure. Feedback and explanation was given by the experimenter if the subject responded incorrectly. When it was clear that the subject understood all sentences and could properly operate the button box, the actual experiment was started. During the experimental session, subjects were given no feedback concerning the correctness of their responses. Most subjects completed the task within 20 minutes.

2.2 Analysis and results

Analysis and results will be discussed separately for sentence reading times and comprehension data.

2.2.1 Reading times

2.2.1.1 Analysis
Response times faster than 90 ms or slower than 3000 ms were treated as missing data. Analysis was done on raw data and residual reading times. Generally, raw reading times show some amount of variability due to the overall differences in reading rate among subjects. Furthermore, differences in word length within conditions may introduce some noise. For instance, in the present experiment, the disambiguating auxiliary could either be singular had or plural hadden. Although verb number was balanced across the subject-object and object-subject conditions, the differences in length between the singular and plural auxiliary may have increased the variance. Differences in individual reading rate and word length may thus obscure factual differences between conditions. A better understanding of the data is therefore gained if differences in overall reading rate and word length are corrected for. One way to do so is to calculate residual reading times (cf. Ferreira and Clifton, 1986; Trueswell, Tanenhaus and Garnsey, 1994).

For the present data, residual reading times were obtained in the following way. First, on the basis of the reading times of all except final words of the experimental sentences, a linear regression was estimated for each subject with reading time as the dependent variable and length in number of characters as the explanatory variable. A single-group t-test on the coefficients for all subjects showed that both the intercept and the linear component were significantly different from zero (cf. Lorch and Myers, 1990). For each subject residual reading times were calculated by subtracting the reading times predicted by the individual linear regression from the actual reading times. A positive number therefore
indicates that the reading time is slower than predicted on the basis of the length of the word; a negative number indicates that the reading time is faster than expected. Next, for each word position and condition, data exceeding the mean plus or minus 2.5 times standard deviation over all subjects for that position and condition were trimmed to the mean plus or minus 2.5 times standard deviation. This affected 2.7% of the data.

For analysis on the raw reading times, reading times were trimmed for each subject individually. Reading times exceeding the subject mean plus (minus) 2.5 times the standard deviation for all conditions taken together were reduced to the mean value plus (minus) 2.5 times the standard deviation. This procedure was carried out jointly for word positions 1 through 9 but separately for the sentence-final word. This procedure affected around 3.0% of the data.

On both residual reading times and raw data, an SPSS/PC+ MANOVA for repeated measurements were conducted for each word position separately. In the analysis by subjects ($F_1$), order (subject-object, object-subject), type (declarative, wh-question) and number of the wh-phrase (singular, plural) were within subject factors; subject list (4 levels) was the between subject factor. In the analysis by items ($F_2$), order and type were the within item factors; between item factors were item group (4 levels) and number of the wh-phrase. In this experiment and the experiments reported in the next chapters, results were regarded as significant if the $p$-value was less than .05, although effects with a $p$-value of less than .1 are reported when they are of particular theoretical interest.

The analysis presented below includes all responses, that is, irrespective of the performance on the comprehension questions. An additional analysis was carried out, excluding trials in which the comprehension questions were responded incorrectly. Since errors were not distributed equally across conditions, the exclusion of erroneous trials violated the assumption of homogeneity of variance, thus increasing the likelihood of a type I error, that is, rejecting the null hypothesis when in fact it is true. Results did not differ much from the analysis of the full data set, however, cf. Table 3.3. In the main text below, I will report $F$- and $p$-values for the analysis on the complete data set for residual reading times only.

### 2.2.1.2 Results

Raw and residual means for each word position in each of the four main conditions (declarative subject-object, declarative object-subject, wh-question subject-object and wh-question object-subject) are given in Table 3.2. Figure 3.1 depicts the residual reading times for each word position and condition, collapsed over number of the first NP. An overview of the significant effects is given in Table 3.3.

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1. The factors subject list and items group were included to control for variability due to differences between lists and groups (cf. Pollatsek and Well, 1995).
TABLE 3.2
Mean residual and raw reading times in ms for all word positions
as a function of the four main conditions, collapsed over number (Experiment 1).

<table>
<thead>
<tr>
<th>data set</th>
<th>condition</th>
<th>DET1 De/Welke ‘The/Which’</th>
<th>N1 assistenten ‘assistants’</th>
<th>AUX haden ‘had’-SG/PL</th>
<th>DET2 de ‘the’</th>
<th>N2 professor ‘professor’</th>
<th>NEG niet ‘not’</th>
<th>V geholpen ‘helped’</th>
<th>P met ‘with’</th>
<th>DET3 het ‘the’</th>
<th>N3 rapport ‘report’</th>
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<tr>
<td>Res.</td>
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<td>-56</td>
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<td>451</td>
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</tr>
</tbody>
</table>

*De-so*: subject-object declarative; *De-os*: object-subject declarative; *Wh-so*: subject-object wh-question; *Wh-os*: object-subject wh-questions.
*Res. RTs*: residual reading times.
Chapter 3

Significant effects for residual and raw reading times in the subjects (F1) and items analysis (F2) in Experiment 1.

<table>
<thead>
<tr>
<th>word position</th>
<th>effect</th>
<th>residual RTs</th>
<th>raw RTs</th>
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<td></td>
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<td>***</td>
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<td>order x type</td>
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</tr>
<tr>
<td></td>
<td>order x type</td>
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</tr>
</tbody>
</table>

The symbols in the word position column correspond to the ones in Table 3.2. Order: subject-object vs object-subject order; type: declarative vs wh-question; number: singular vs plural NP. *** $p < .001$; ** $p < .01$; * $p < .025$; + $p < .05$.

* These effects were not significant when the data set was restricted to those trials for which the comprehension question was answered correctly.

No significant effects were found at word positions preceding the disambiguating auxiliary. At the auxiliary, subject-object sentences were read faster than object-subject sentences. The effect of order just failed to reach significance in the subjects analysis [ $F(1,44) = 4.00$, $p = .052$; $F(2,1.24) = 8.35$, $p < .01$]. No interaction between order and type was found [ all F’s < 1], although order did
The effect of the first NP.

interact with number at the auxiliary for the raw reading times. This effect is presumably related to the length of the word forms used. We will return to this effect later.

At the word following the disambiguating auxiliary (the determiner of the second NP), subject-object sentences were read faster than object-subject sentences for both declaratives and wh-questions \( F(1,44) = 23.95, p < .001; F(2,1,24) = 72.34, p < .001 \). This effect remained significant at the next word position (the second noun) \( F(1,44) = 5.67, p < .025; F(2,1,24) = 6.66, p < .025 \). This confirms the data reported in Chapter 2 showing a general preference for a subject-object interpretation. The difference between the two orders was larger for the declaratives than for the wh-questions: 55 and 24 ms, respectively, in the raw reading times. This resulted in an interaction of order and type at the word following the disambiguating auxiliary \( F(1,44) = 13.27, p < .001; F(2,1,24) = 11.61, p < .01 \). This is what would be expected if the processor is sensitive to the properties of the first NP. Pairwise comparisons for declaratives and wh-questions separately show a significant effect of order within each sentence type \( F(1,44) = 24.47, p < .001; F(2,1,24) = 41.05, p < .001; F(1,44) = 8.91, p < .05; F(2,1,24) = 17.07, p < .001 \).
This interaction of order and type remained significant at the next word position, the N of the second NP \[ F(1,44) = 7.95, \ p < .01; \ F(2,124) = 6.34, \ p < .025 \]. Pairwise comparisons showed that the effect was significant for declaratives only [declaratives: \( F(1,44) = 11.22, \ p < .01; \ F(2,124) = 14.34, \ p < .001 \). wh-questions: \( F, F < 1, \ N.S. \)].

Starting at the participle, wh-questions were read more slowly than declaratives, resulting in a main effect of type at the participle and sentence-final word [Participle: \( F(1,44) = 10.86, \ p < .01; \ F(2,124) = 9.70, \ p < .01 \). Final noun: \( F(1,44) = 14.81, \ p < .001; \ F(2,124) = 15.87, \ p < .001 \)]. At the preposition following the participle, reading times for the declarative object-subject condition became as long as for the wh-conditions. The subject-object declaratives were still read fastest. This resulted in a significant interaction of order and type \[ F(1,44) = 6.90, \ p < .025; \ F(2,124) = 6.21, \ p < .025 \]. Pairwise comparisons showed that the difference between object-subject and subject-object order was significant for the declaratives only [declaratives: \( F(1,44) = 8.28, \ p < .01; \ F(2,124) = 8.97, \ p < .01 \). wh-questions: \( F's < 1, \ N.S. \)]. In addition, a main effect of order was seen at this word position: subject-object clauses were read faster than object-subject clauses \[ F(1,44) = 4.43, \ p < .05; \ F(2,124) = 5.21, \ p < .05 \]. At the sentence-final noun the effect was reversed: the object-subject sentences were read faster than the subject-object sentences \[ F(1,44) = 3.91, \ p = .054; \ F(2,124) = 5.69, \ p < .025 \].

Let us now turn to the effects of number of the first NP. As has already been mentioned, raw reading times showed a significant interaction of order and number of the first NP at the disambiguating auxiliary. At the two word positions following the disambiguating auxiliary, the interaction was significant also for residual times: subject-object sentences were read faster when the first NP was singular than when it was plural; the reverse held for object-subject sentences \[ Aux+1: \ F(1,44) = 16.06, \ p < .001; \ F(2,124) = 20.95, \ p < .001. \ Aux+2: \ F(1,44) = 9.20, \ p < .01; \ F(2,124) = 6.62, \ p < .025 \]. Probably, this effect is due to the number of the auxiliary: conditions were read faster when the auxiliary was the singular \textit{had} than when it was the plural \textit{hadden}. Table 3.4 gives the mean residual and raw reading times for the auxiliary and two following positions as a function of the number of the first NP. The conditions in which the auxiliary is plural are underscored.

The effect of auxiliary number was not significantly different for the two order conditions: an analysis with number of the auxiliary instead of number of the first NP as a within subjects factor showed no interaction of this factor with the factor order at the auxiliary and following positions [all \( p's > .2 \)].

The effect of number in the raw reading times at the auxiliary itself is probably due to the difference in length between singular \textit{had} and plural \textit{hadden}. However the effects of number found for residual reading times at the following...
The effect of the first NP

Mean residual and raw reading times in ms for the auxiliary and two following positions as a function of the number of the first NP, collapsed over clause type (Experiment 1).

<table>
<thead>
<tr>
<th></th>
<th>AUX</th>
<th>DET2</th>
<th>N2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NP1=SG</td>
<td>NP1=PL</td>
<td>NP1=SG</td>
</tr>
<tr>
<td>Res. RTs</td>
<td>subject-object</td>
<td>-22</td>
<td>-21</td>
</tr>
<tr>
<td></td>
<td>object-subject</td>
<td>-6</td>
<td>-5</td>
</tr>
<tr>
<td>Raw RTs</td>
<td>subject-object</td>
<td>362</td>
<td>382</td>
</tr>
<tr>
<td></td>
<td>object-subject</td>
<td>395</td>
<td>377</td>
</tr>
</tbody>
</table>

Symbols for word positions correspond to those in Table 3.2. The conditions in which the auxiliary is plural are underscored. sg: singular; pl: plural.

two word positions are unlikely to be caused by the physical differences between the two verb forms. In general, factors such as length only affect reading times at the word itself (Just, Carpenter and Woolley, 1982). It is therefore more likely that the effect of number at these later positions is due to higher level differences between singular and plural forms. I will come back to this in Section 3.4.

The analysis also included the factors subject list and item group. At the auxiliary, the participle and the three following word positions, these factors interacted with one or more of the factors order, type, and number. These effects are generally due to one item group being read more slowly than the other groups, or to subjects in one list reacting more slowly than subjects in the remaining lists. The factors subject list and item group were mainly included to control for the variance due to group and list differences. I will therefore not further discuss these effects.

2.2.2 Comprehension questions

Comprehension questions were included in the materials to make subjects read more attentively and to check whether the sentences were understood correctly. Performance on the comprehension questions may provide additional data concerning processing difficulty: when a sentence is hard to process, it is generally also hard to understand. Responses will therefore be slower and less accurate on comprehension questions probing difficult sentences than on those probing easy sentences.
Analyses were done on both reaction times and accuracy rates. Some questions showed very short response times. Subjects often reported that they automatically pressed the response key at the end of the sentence and noticed too late that a comprehension question was displayed. Inspection of the response times showed that response times higher than 600 ms formed a continuum, with little difference in latency among the individual responses, whereas responses faster than 600 were rather scattered. For this reason responses faster than 600 ms were treated as missing data. This affected 0.8% of the data. Answers slower than 9000 ms (0.3%) were treated as errors in the analysis below.2

2.2.2.1 Reaction times
In the response time analysis, only correct responses were taken into consideration. Four subjects were dropped because their responses were all either missing or false in one condition.3 An SPSS/PC+ MANOVA was carried out on the raw response times; the factorial design was the same as for the sentence reading times.

Mean reaction times for correct responses in each condition are given in Table 3.5. Average response times were 175 ms longer for the *wh*-questions compared to the declaratives \( F1(1,40) = 4.79, p < .05; \) \( F2(1,24) = 5.44, p < .05 \). Furthermore, response times in the *wh*-questions were longer for the

<table>
<thead>
<tr>
<th>order</th>
<th>declaratives</th>
<th>wh-questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>subject-object</td>
<td>2092</td>
<td>2547</td>
</tr>
<tr>
<td>object-subject</td>
<td>2382</td>
<td>2276</td>
</tr>
</tbody>
</table>

2 The mean number of missing responses (out of eight responses) for each of the four main conditions were the following: declaratives: subject-object .02; object-subject: .1; wh-questions: subject-object .06; object-subject: .08. As can be seen from Table 3.6 the absolute number of errors patterns with the percentage of errors relative to the number of non-missing responses. Treating the short responses as missing therefore should not have substantially affected the results of the error analysis.

3 These empty cells concerned object-subject declaratives with a singular first NP (one subject) or object-subject declaratives with a plural first NP (three subjects).
subject-object than for the object-subject conditions; the reverse pattern was seen in the declaratives. This led to a significant interaction of order and type \( F(1,40) = 8.54, p < .01; F(1,24) = 6.96, p < .025 \). A comparison between the subject-object and object-subject order, conducted separately for declaratives and \( wh \)-questions showed significant effects for both clause types in the subject analyses only [declaratives: \( F(1,40) = 5.29, p < .05; F(1,24) = 3.41, p = .077 \); \( wh \)-questions: \( F(1,44) = 6.46, p < .025; F(1,24) = 2.74, p = .111 \)].

The long response times for the subject-object \( wh \)-condition are rather surprising given the short reading times for this condition immediately following the point of disambiguation. I will argue below that this effect is probably due to the use of negation, which rendered the comprehension questions pragmatically awkward in the subject-object \( wh \)-condition.

As in the sentence reading times, the factors subject list and items group were included in the factorial design for the analysis by subject and items, respectively. The factor item group showed significant interactions with type and with type and order. No effects of subject list were found.

### 2.2.2.2 Error rates

Mean absolute number of errors and percentage of errors for non-missing responses in the four conditions are given in Table 3.6.

<table>
<thead>
<tr>
<th>order</th>
<th>clause type</th>
<th>declaratives</th>
<th>( wh )-questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>subject-object</td>
<td>.9 (11%)</td>
<td>2.1 (26%)</td>
<td></td>
</tr>
<tr>
<td>object-subject</td>
<td>2.9 (37%)</td>
<td>1.8 (23%)</td>
<td></td>
</tr>
</tbody>
</table>

Note: Responses faster than 600 ms are excluded; responses longer than 9000 ms are treated as errors.

Analyses were performed on the absolute number of errors in each condition for subjects (subjects analysis) and items (items analysis). Since the number of errors was relatively small and the data consisted of positive, discrete numbers, analysis was done using the Poisson-distribution (Van Duijn, 1992; 1993). First, a model was fitted on the data including all factors: three subject lists (three item groups in the analysis by items), number of the \( wh \)-phrase, type, order and the interactions among these factors. In order to estimate the effect of a factor, a model was fitted in which this factor was dropped. Next, the difference in fit to the data
(i.e. deviance) was calculated relative to a model in which the factor was still present. $P$-values were obtained by testing this difference in deviance using a $\chi^2$ test with the degrees of freedom corresponding to difference in the number of factors between the two models. The factors number and subject lists (item groups) had no significant effects. The effects of type, order and the interaction of order and type were therefore evaluated relative to a model excluding the factors corresponding to number and lists (groups).

In the declaratives, performance was worse for the object-subject order; in the $wh$-questions, on the other hand, most errors were made in the subject-object condition. This resulted in a significant contribution of the interaction of order and type [difference in deviance $= 36.1$, $df. = 1$, $p < .0001$, for both subjects and items]. Overall, more errors were made in the object-subject than in the subject-object conditions. This led to a significant difference in deviance when both the factor order and the order by type interaction were dropped from the reference model [diff. dev. $= 55.5$, $df. = 2$, $p < .0001$, for both subjects and items]. The factor type hardly had any effect in addition to the order by type interaction. Dropping both type and order by type factors from the model yielded a significant difference in deviance [diff. dev. $= 36.9$, $df. = 2$, $p < .0001$, for both subjects and items]. However, the magnitude of the difference in deviance (36.9) was comparable to the effect of dropping the interaction alone (36.1).

To sum up, more errors were made in the object-subject than in the subject-object condition. This again confirms the general subject-object preference which was also found in the on-line reading data: compared to subject-object sentences, object-subject sentences showed larger effects of processing effort after the point of disambiguation. However, this general pattern was seen only in the declaratives; in the $wh$-questions, more errors were made in the subject-object than in the object-subject condition. This result patterns with the response time data: recall that question answering latencies were longer for object-subject than for subject-object declaratives, but were shorter for object-subject than for subject-object $wh$-questions. The larger number of errors in the object-subject declarative and object-subject $wh$-conditions therefore cannot be due to a speed accuracy trade-off: if this were the case, conditions with the highest number of errors would also show the fastest response times.

3 Discussion

3.1 Summary of the results

Briefly put, the following effects were found:

- Subject-object main clauses were read faster than object-subject main clauses. This effect was present at the disambiguating auxiliary (although only weakly significant by subjects), and the two following word positions. The preference for a subject-object order was also reflected in
The effect of the first NP

The overall performance accuracy on the comprehension questions: overall fewer errors were made in the subject-object conditions.

- Reading time differences for object-subject and subject-object sentences were smaller for the wh-questions than for the declaratives. This effect only started at the word position following the disambiguating auxiliary.

- At the lexical verb and at the sentence-final word, reading times were longer for wh-questions than for declaratives. This effect was also seen for the comprehension questions: question answering times were slower for the wh-conditions than for the declaratives.

- Furthermore, at the sentence-final position, response times were longer for the subject-object wh-questions than for the remaining conditions, though the type by order interaction just failed to reach significance. This, too, corresponded to the question answering data. For the declaratives, responses were slower and less accurate in the object-subject conditions; for the wh-questions longer reaction times and more errors were recorded in the subject-object condition. However, the interaction was strongly significant only in the analysis of the comprehension questions.

- Finally, the number of the auxiliary had an effect: at two word positions following the disambiguating auxiliary, both subject-object and object-subject sentences were read faster when the auxiliary was singular than when it was plural.

3.2 The two hypotheses

The aim of the present experiment was to investigate to what extent and when the type of the first NP affects order preferences. Two hypotheses were formulated. According to the Syntactic Hypothesis, the syntactic bias for subject-object order takes precedence in ambiguity resolution. Other information does not affect ambiguity resolution, or at least, not immediately. The Discourse Hypothesis, on the other hand, predicts that the discourse-related properties of the NPs have a large and immediate effect on ambiguity resolution.

In accordance with both hypotheses, subject-object conditions were faster than object-subject conditions. This effect started at the disambiguating auxiliary. This result confirms the general finding that subject-object clauses are easier to process than object-subject ordered clauses (Frazier and Flores d'Arcais, 1989; Lamers, 1996; Hemforth, 1993; Bayer and Marslen-Wilson, 1992; and the number disambiguation conditions reported in Meng, 1995 and Schlesewsky et al., to
Furthermore, the type of the first NP has an effect on the strength of the subject-object preference. The difference between the object-subject and subject-object order was smaller when the first NP was a which-N phrase (wh-questions) than when it was a definite NP (declarative conditions). This confirms the pattern of grammaticality judgment errors reported by Frazier and Flores d’Arcais (1989), and the observation that the subject-object preference is less robust for German wh-questions than it is for declaratives. This effect, too, is compatible with both hypotheses. However, in accordance with the Syntactic Hypothesis and in contrast to the predictions of the Discourse Hypothesis, the effect of first NP on the order preference was somewhat delayed. Object-subject clauses took longer to read than subject-object clauses at the disambiguating auxiliary itself; however the interaction of type and order only started one word position later. Although these findings need to be replicated using experimental techniques with a better temporal resolution (eyetracking, ERPs) before any firm conclusions can be drawn, the present results do suggest that the information introduced by the properties of the first NP does not have an immediate effect on ambiguity resolution. The Syntactic Hypothesis is therefore supported by the data, the Discourse Hypothesis is not.

Note however, that the Syntactic and Discourse Hypotheses were formulated for expository reasons only, and represent rather extreme views of syntax-first and interactive approaches to processing, respectively. The results are therefore not incompatible with more sophisticated interactive approaches. In the general discussion, Chapter 6, I will sketch how several current sentence processing theories, including syntax-first and interactive models, may account for the results.

Turning now to the other effects mentioned in the summary, we see a rather unexpected result. At later word positions in the sentence and for the comprehension questions, the wh-questions appear to be rather difficult to process, especially the subject-object wh-questions. Below I will argue that the increase in reading times and the bad performance on subject-initial wh-questions may be caused by the use of a negation in the sentence. These results therefore do not affect the major findings of the experiment discussed above.

Another unexpected result was the interaction of order and the number of the first NP. Although it is not immediately relevant to the purpose of the present experiment, the effect is of methodological importance. I will discuss this effect in Section 3.4.

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4 There is some evidence in the literature that the subject-object preference for which-N questions is somewhat weaker and delayed relative to who-questions (cf. De Vincenzi, 1991a). The effects found immediately after the which-phrase in Experiment 1 suggests that the subject-object analysis is not delayed for such clauses in Dutch. However, since who-phrases were not tested, a processing difference between which-N and who-questions in Dutch may still not be excluded.
3.3 The effect of negation

The long response times and high error rates in the subject-object *wh*-questions may be due to an unforeseen effect of the negation used in the experimental sentences and the comprehension questions. The negation may have triggered some discourse inferences that may have rendered the comprehension question in the subject-object *wh*-conditions pragmatically odd. Consider for instance the comprehension question in (5).

(5) Wie werd(en) niet geholpen? Assistenten Professor
Who was/were not helped assistants professor

This question is pragmatically licit only if either the professor or the assistants were not helped. This condition is met if the question follows the subject-object declarative in (6a), the object-subject declarative in (b) and the object-subject *wh*-question in (c), but not if the question probes the subject-object *wh*-question in (d).

(6) a. De assistenten hadden de professor niet geholpen. [SO]
   ‘The assistants didn’t help the professor.’
 b. De assistenten had de professor niet geholpen. [OS]
   ‘The assistants, the professor didn’t help.’
 c. Welke assistenten had de professor niet geholpen? [OS]
   ‘Which assistants didn’t the professor help?’
 d. Welke assistenten hadden de professor niet geholpen? [SO]
   ‘Which assistants didn’t help the professor?’

The sentences in (6a-c) imply that either the assistants or the professor was not helped, or at least do not contradict this presupposition. First, consider the subject-object declarative in (a). This sentence states that the professor has not been helped by the assistants. It does not, or at least, does not strongly imply that the professor has been helped by people other than assistants. The comprehension question in (5) thus is pragmatically licit, as it is reasonable to assume that the one who is not helped is the professor. The object-subject declarative in (b) and *wh*-question in (c) imply that at least some assistants were not helped. A potential interpretation of the object-subject declarative in (b) is that the set of assistants is contrasted with a non-identified set of other people: whereas these other people were helped by the professor, the assistants were not. In (c), the negation will trigger a division of the set of assistants in those that were not helped by the
professor and those that were.\textsuperscript{5} Thus, in (6a-c), the presupposition of the comprehension question in (5) is met: all sentences imply that either the professor or some assistants were not helped.

Now consider the subject-object \textit{wh}-question in (6d). This question may trigger the inference that there is a set of assistants who did not help the professor and a set of ones who did. The \textit{wh}-question may thus imply that the professor had been helped by at least some assistants. The presupposition of the comprehension question in (5) is therefore not necessarily met. This may have caused the increase in response times and the higher error rates for the comprehension questions following subject-object \textit{wh}-questions.

The difficulty for the subject-object \textit{wh}-questions may therefore be due to the comprehension question rather than to the properties of the sentence itself. Response time and accuracy data for the comprehension questions therefore must be interpreted with caution: they may tell more about the discourse properties of the comprehension question than about the processing difficulty of the probed sentence.

3.4 The effect of verb number

Another rather unexpected result was that order interacted significantly with the number of the first NP. In Section 2.2.1.2, I have shown that this interaction is probably due to an advantage for the singular auxiliary over the plural. It was also discussed that this effect is probably due to higher level processes rather than physical differences between singular \textit{had} and plural \textit{hadden}. Physical differences between words generally affect reading times only at the relevant word position itself (cf. Just, \textit{et al.}, 1982). However, in the present data the effect did not appear until one word position later and was still visible at the second word position after the auxiliary. Furthermore, the effect remained present even when length was corrected for using a linear regression. Hence, the effect of number is most likely due to other factors. However, which factors is as of yet unclear.

Frazier and Flores d’Arcais (1989) also report an effect of number. In their end-of-sentence grammaticality judgment task, reaction times were longer to conditions with a plural finite verb. However, in their data this effect was present in object-subject conditions only. Frazier and Flores d’Arcais suggest that this is due to the fact that Dutch allows sentences to start with an infinitival complement, as in (7)

\hspace{1cm}

\textsuperscript{5} Somewhat speculatively, the increase in reading times after the negation for both subject-object and object-subject \textit{wh}-questions may reflect the inference and subdivision of a presupposed set.
In the Frazier and Flores d’Arcais materials, the plural verb following the first NP was always ambiguous between a plural past form and an infinitival form. Frazier and Flores d’Arcais’ explanation for the effect of number runs as follows. When the preferred syntactic structure (subject-object) is contradicted by the input, an infinitival analysis is proposed, if the verb form allows this. This competing analysis leads to an additional increase in processing effort in object-subject conditions with plural verb forms relative to singular ones.

The Frazier and Flores d’Arcais explanation does not capture the present facts, however. First, as opposed to the Frazier and Flores d’Arcais data, the effect of number of the auxiliary did not differ significantly for the preferred subject-object order and non-preferred object-subject order. And, more importantly: the plural verb form used, hadden, is not homonymous with an infinitival verb. An infinitival explanation for the number differences is therefore not tenable.

As we will see in the next chapter, verb number has a rather complex effect on response times. In embedded clauses, plural auxiliaries are responded to faster than singular auxiliaries. This is in contrast to the pattern in main clauses (cf. also Van Gompel (1995) for different effects of verb number). It is as yet unclear what could account for these data. The difference between singular and plural conditions may in some way be related to the saliency of plural features which has been attested in production studies (cf. Bock and Miller, 1991; Bock and Cutting, 1993). The data are rather complex, however, as the direction of the effects seems to depend on the position of the verb in the sentence. I will therefore not discuss this issue any further and leave it open for future research.

The effect of number does have some methodological consequences. Since non-pronominal NPs are not case-marked in Dutch, word order preferences are commonly investigated using clauses that are disambiguated by number information at the verb. However, since the effects of verb number may confound the effect of order, the number of the verb should always be balanced across conditions. This however may introduce a substantial amount of noise, which may obscure other effects. If verb number cannot be varied across conditions for some reason, as is the case in Experiments 6 and 7 in Chapter 4, a main effect of order should be interpreted with caution.

4 Summary

Experiment 1 was aimed at investigating to what extent discourse-related properties of the first NP could affect word order preferences. Dutch subject-object and object-subject main clauses were compared in a self-paced reading task. The first NP either was a definite NP (de ‘the’-N) or a welke-N (‘which’-N).
phrase. Sentences were disambiguated immediately after the first NP by number information at the verb. Starting at the point of disambiguation, object-subject clauses were read slower than subject-object clauses. This confirms the findings discussed in Chapter 2.

The strength of the subject-object preference was affected by the type of the first NP: the increase in reading times for the object-subject relative to the subject-object clauses was smaller for wh-questions than for declaratives. However, this effect was only visible at the two words following the point of disambiguation. This suggests that in addition to the syntactic bias for the subject-object order, biases triggered by the properties of the first NP play a role in determining order preferences. However, these effects appear to be somewhat delayed relative to the syntax-driven subject-object preference. This is in accordance with the predictions of the Syntactic Hypothesis and somewhat problematic for the Discourse Hypothesis as formulated in Chapter 2.