CHAPTER 5. SENTENCE COMPREHENSION: AN INTEGRATION PROBLEM

Abstract
The goal of this study was to analyze the influence of word order and case information on auditory sentence comprehension in Turkish agrammatic patients with Broca’s aphasia. A test was developed to examine the comprehension of sentences in base and derived word order that varied in their use of case for agents and themes. Sentences with base case assignment (subject=nominative; object=accusative) and non-base case assignment were included. The results show that both word order and case influence the performance of the Turkish Broca patients. A clause is comprehended best when there is both base case and base order information (active base order clauses). The performance of the patients drops when there is base case information but the theme is not in the base position (sentences with object scrambling and subject relative clauses). Clauses lacking base case information, where the theme is not in its base position (object relatives and passives), are understood the poorest. These data suggest that the sentence comprehension deficit in Turkish Broca’s aphasia is due to a problem in assigning thematic roles to the noun phrases by integrating syntactic information (word order) and morphological information (case). Such an integration problem is in keeping with previous findings on sentence production in Turkish.
5.1. Introduction

In a couple of recent studies it was shown that Turkish agrammatic speakers with Broca’s aphasia have more problems producing sentences in derived order than sentences in base order (Yarbay Duman et al., 2007: see Chapter 2; Yarbay Duman et al., 2008: see Chapter 3). Word order errors and morphological errors were produced in sentences in derived order. Word order and morphology are closely related in Turkish. For example, in object relative sentences, the word order changes but so does the case of the subject: it changes from nominative to genitive. The data of Yarbay Duman et al. (2008; see Chapter 3) on the production of clauses with base and derived word order show that when Turkish agrammatic speakers fail to produce the right order, they adapt case to the order they produce. Apparently, there is an interaction between word order and case that Turkish agrammatic speakers are aware of when producing sentences.

Word order problems have often been mentioned as one of the key features of sentence comprehension in Broca’s aphasia for languages without overt case marking (e.g., Grodzinsky, 1995; Bastiaanse & Edwards, 2004). On the basis of the production data in Turkish, the question arises whether an interaction between word order and case similar to the one found in production can be observed in sentence comprehension. This point is addressed in the present study. Agrammatic patients with Broca’s aphasia were tested with a comprehension test where sentences with base and derived order varied in their use of case. Both sentences with base case assignment (base order clauses, object scrambling and subject relatives: subject=nominative; object=accusative) and sentences with non-base case assignment (object relatives: subject=genitive; object=nominative and passives=two nominatives) were included to evaluate the interplay between word order and case separately. Although a few sentence comprehension studies have been performed in languages where case information is decisive (Turkish by McWhinney et al., 1991; German by Burchert et al., 2003; Hebrew by Friedmann & Shapiro, 2003; Serbo-Croatian by Smith & Mimica, 1984; Lukatela et al., 1995), their results show that word order influences sentence comprehension. One of the questions these studies raised was about the interaction between word order and case in sentence comprehension. In sentences where the agent and theme thematic roles are not in their base positions, performance

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58 In most production studies, the aphasia type under investigation is referred to as ‘agrammatic aphasia’, whereas in comprehension studies, usually the term ‘Broca’s aphasia’ is used, since not all patients produce speech. The patients included in the present study all used telegraphic speech and were all diagnosed as suffering from Broca’s aphasia. Since in comprehension studies the term ‘Broca’s aphasia’ is more common, this term will be used from now on.
drops: the patients do not use case information to understand the sentences, although the performance of Broca patients from these languages is usually not as poor as the performance of patients from languages that do not have overt case marking. Aydin (2007) compared the comprehension of four subject relatives to four object relatives in five Turkish Broca’s aphasia patients. Unfortunately, no comparison of simple active sentences was performed. No difference was found between the sentence types, but the patients performed poorly overall. The use of case information was not mentioned. Finally, comprehension of sentences with moved elements is impaired in Italian (Luzzatti et al., 2001). Italian has no cases on nouns, but sentences with pronouns in base and derived positions were also tested. Italian pronouns are like English pronouns – they carry the case. Interestingly, the impairment was also observed in sentences with a clitic pronoun, which have overt case (Luzzatti et al., 2001).

In the next section two current theories of sentence comprehension will be discussed, followed by a description of the Turkish grammar in relation to the sentence types tested. Finally the predictions for Turkish made by both theories will be formulated.

5.1.1. Linguistic theories on sentence comprehension in Broca’s aphasia
The most influential theory of sentence comprehension in Broca’s aphasia was provided by Grodzinsky, for the first time in 1984. Many variants of this theory have been formulated, both by Grodzinsky himself (1995; Drai & Grodzinsky, 2006) and by others (for example, Double Dependencies Hypothesis by Mauner et al., 1993; and the Derived Order Problem Hypothesis by Bastiaanse & Van Zonneveld, 2005, 2006). Here, Grodzinsky’s Trace Deletion Hypothesis (TDH) and the related Derived Order Problem Hypothesis (DOP-H) will be discussed.

The TDH is based on Chomsky’s (1995) Government and Binding theory. According to this theory, every language has a base order, with other orders being derived by so-called ‘movement’. An element that moves leaves a trace behind, which is coindexed with the antecedent, as illustrated in (1), where i indicates the coindexation.

(1) the boy_i who_i the girl chases i

In order to interpret a sentence, the thematic roles have to be assigned correctly. The verb assigns thematic roles to the arguments, but when an argument is moved, the thematic role is assigned to the trace and then, by virtue of the coindexation, to the moved
argument. According to the TDH, in Broca’s aphasia the traces are removed from the sentence representation and therefore, no thematic role can be assigned to ‘the boy’ in (1).

Broca patients then use the so-called ‘default strategy’, which specifies that if an argument has no role, it is assigned the role that belongs to its position in the sentence, meaning in (1) that ‘the boy’ receives an agent role following this strategy. Now there are two agent roles, one for ‘the girl’, which receives this role from the finite verb, and one for ‘the boy’, which receives this role following the default strategy. Two agent roles will result in chance level performance, which is usually observed for this kind of sentence.

The TDH states that the traces are deleted from the sentence representation, meaning that it assumes that sentence comprehension is a representational deficit, i.e. that the patient is no longer able to reconstruct sentences with traces. Therefore, s/he will no longer understand any sentence with a trace. The default strategy allows him/her to make a choice in a sentence comprehension test. This assumption allows the researcher to work with performance based on the chance level.

The TDH has been revised twice. In Grodzinsky (1995) it was restricted to apply to A-chains (argument movement) only: verb movement, for example, should present no difficulties. Later, the TDH was said to be irrelevant to SOV languages, such as Dutch and German (Drai & Grodzinsky, 2006). In Dutch and German passives, the internal argument does not cross the verb and therefore, the verb can correctly assign the theme role.

However, Bastiaanse & Van Zonneveld (2006) disputed both of the revisions Grodzinsky made: (1) Dutch Broca patients perform at chance level when they have to judge the ungrammaticality of a sentence with illegal verb movement or without obligatory verb movement; and (2) an analysis of the complete set of the Dutch and German data shows that Broca patients, as a group, perform at chance level on passive sentences. They claim that the data obtained so far are better described by their DOP-H, which was developed for production but is also intended for comprehension, positing that sentences in derived word order are difficult. The advantage of this hypothesis is that it is relatively ‘theory free’. It does not rely on Government and Binding or any other linguistic theory prone to changes as theoretical insights develop over time. The DOP-H simply states that every language has a base order, for example SVO for English and SOV for Dutch and German, and that sentences in which the order is derived – whether or not this is by movement, merge or whatever – are more difficult to produce and comprehend than sentences in base order. Bastiaanse, Bouma and Post (2009) speculate on why this should be the case. In base order, according to them, constituents belonging together (heads and
their complements) are adjacent. In head-initial languages, such as English, the head immediately precedes its complement; in head final languages, the head immediately follows its complements. When these phrases become discontinuous, agrammatic performance drops. For example, in Dutch base order the verb (head) follows the object (complement): when the verb is in second sentence position, such as in Dutch matrix clauses, the complement-head chain is broken. Agrammatic speakers make more errors in these sentences than in sentences in which the complement-head chain is intact.

Notice that the DOP-H assumes that Broca’s aphasia is a processing rather than a representational deficit. It just states that some sentence types are more difficult to comprehend and produce than others due to processing problems. The DOP-H does not characterize the nature of this processing deficit any further. Assuming a processing disorder that affects some sentence types more than others requires statistical analysis of the data rather than analysis in terms of chance level. In addition, the DOP-H says nothing about default strategy and makes no claims about chance levels. It could very well be that the default strategy is applied by English and Dutch speaking Broca patients, which explains their chance level performance but not, or to a lesser extent by speakers of languages that are overtly marked for case. So far, the DOP-H seems to describe adequately the word order problems in production in various languages (English: Bastiaanse & Thompson, 2003; Dutch: Bastiaanse & Van Zonneveld, 2005; Turkish: Yarbay Duman et al., 2007; see Chapter 2).

In sum, both the TDH and the DOP-H predict sentence comprehension problems based on word order. The TDH is far more restricted, though. It only applies to argument movement and the default strategy is used to explain above and at chance performance. Furthermore, it is restricted to sentence comprehension. The DOP-H is an overarching theory and simply states that sentences with derived order are more difficult because derived word order dissociates constituents that naturally belong to each other.

In the next section, the relevant properties of Turkish grammar will be presented. This will be followed by the predictions made by the TDH and the DOP-H.

5.2. Turkish Grammar

5.2.1. Word Order
Turkish is a subject-object-verb (SOV) language (see 2), but word order is free, so alternations to this basic order are possible. These alternations are exemplified in (3).
(2) polis hırsızlar›-ı vur-uyor
   policeman-nom thief-plr-acc shoot-aspect/3sg
   'the policeman shoots the thieves'

(3) a. hırsızlar› polis vuruyor OSV
   b. polis vuruyor hırsızlar› SVO
   c. hırsızlar› vuruyor polis OVS
   d. vuruyor polis hırsızlar› VSO
   e. vuruyor hırsızlar› polis VOS

The sentences in (3) are derived from the base order through the movement of constituents as a result of syntactic processes such as topicalization, focusing and backgrounding (Erguvanlı, 1984). Word order variation in Turkish is thus assumed to be a result of a syntactic phenomenon. The variation is constrained. For example, indefinite objects (unlike definite objects, as in 3a above) are generally required to occupy the immediate preverbal position and when they are moved to the clause initial position, the string results in an unacceptable (*) sentence for the intended interpretation *the policeman shoots the thieves* (see 4 below).

(4) * hırsızlar polis vur-uyor

Turkish nouns are marked for number (singular – plural). The plural suffix –lEr, which immediately follows the noun before any other suffix, can be used with nouns and third person verbs. However, Turkish uses third person singular verbs inflected with a zero agreement morpheme with plural nouns in daily speech. Therefore, number inflection in the examples above has no effect on identifying the subject and the object of the sentence.

Because of the free word order, the distinction between a subject and an object cannot be maintained solely on the basis of word order. Case inflection on the nouns signals the thematic roles, e.g., the agent and the theme of the clause.

5.2.2. Grammatical Case
In Turkish grammatical case (hereafter, case) is expressed through a specific suffix on the noun phrase. There are six cases in Turkish: nominative, accusative, genitive, dative,

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59 There is no definite article in Turkish. Definiteness is marked by the accusative case on objects and by sentence initial position in subjects.
locative and ablative. Each case has a specific inflection (–i for accusative, –in for genitive, –e for dative, –de for locative, –den for ablative and zero morpheme for nominative).

In main clauses, the subject is generally inflected in the nominative case and the (definite) object is inflected in the accusative case. Therefore, we refer to this combination (subject = nominative, object = accusative) as ‘base case assignment’ since the case information unambiguously signals the agent and theme roles of the noun phrase. Examples 2 and 3a above are repeated below as 5 and 6 respectively. In 6 the object precedes the subject, as illustrated by ti, which shows the base position of the object coindexed with the object in the sentence initial position. However, movement of the object in object scrambling (also known as topicalization, Erguvanlı, 1984) does not have an effect on case. Therefore, base case assignment points to polis (policeman) as the subject and hırsızlar as the object of the clause. This means that the theme/object precedes the agent/subject.

5. Base Order (SOV)

polisagent hırsız-lar-theme vur-uyor
policeman-nom thief-plr-acc shoot-aspect/3sg
‘the policeman shoots the thieves’

6. Object Scrambling (OSV)

hırsız-lar-ı-theme polisagent ti vur-uyor
thief-plr-acc policeman-nom shoot-aspect/3sg
‘the thieves, the policeman shoots’

In Turkish subject relative clauses (see 7), the subject, which is inflected in the nominative case, is moved from its clause initial position to the end of the clause as indicated by the t position. The clause initial object is inflected in the accusative case. In these sentences, the theme precedes the agent.

In Turkish the case of a noun phrase which embodies a relative clause depends on the external syntax of the clause (see the brackets in examples 7 and 8). However, the

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60 The case on the extracted subject in subject relative clauses is dependent on the external syntax of the relative clause. Specifically, if the subject relative clause is the subject of a main clause, then it is in the nominative (e.g., polisi vuran hırsız burada ‘the thief who has shot/shot the policeman is here’). If it is the object of a main clause, then it is in the accusative (i.e. polisi vuran hırsız gördüm, ‘I saw the thief who has shot/shot the policeman’). The case on the extracted object in object relative clauses is also dependent on the
relative clauses in the present study are tested as NPs (i.e. in the absence of a higher main clause verb) in which the subject of the subject relative and the object of the object relative are unmarked for case. In this respect, they appear nominative at the surface level since nominative is also deprived of overt case morphology. Accordingly, we will refer to unmarked case (also see passives, below) as nominative case to emphasize the surface similarity for the purposes of this study.

7. **Subject relatives**

\[ t_i \ hırsız-lar-1_{theme} \ vur-an \ polis_i_{agent} \ [burada \ yaşıyor] \]

the thief-plr-acc shoot-aspect the policeman-nom [here lives]

‘the policeman who has shot the thieves [lives here]’

However, case information does not always signal thematic roles unambiguously. In other words, some sentences have non-base case assignment, to which base case assignment (subject = nominative, object = accusative) cannot be applied. Object relative clauses and passives are such structures. Example 8 below is an object relative clause in which the object has been moved from its pre-verbal position to the right of the verb, as shown by the \( t \) position. Although overt movement as such does not change the order of agent – theme, it changes the case of the nouns: the subject is inflected in the genitive and the object in the nominative case.

8. **Object relatives**

\[ \text{polis-in}_{agent} \ t_i \ vur-duğ-u \ hırsızlar-1_{theme} \ [sarhoştu] \]

the policeman -gen shoot-aspect-agr the thief-plr-nom [were drunk]

‘the thieves whom the policeman has shot [were drunk]’

In passives (pass) the theme inflected in the nominative case is the subject and the agent is also in the unmarked case. Hence, neither the theme nor the agent are overtly marked for case, although the theme is in the subject position and is in the nominative case and the agent is the object of the by-phrase (see example 9).
CHAPTER 5

9. Passives

horesiz-lar theme polis agent tarafindan vur-ul-uyor

‘the thieves are shot by the policeman’

Table 5.1. Summary of all the clause types with respect to thematic structure (agent=A; theme=Th), movement (‘moved’ constituents are in italics) and case morphology (nom=nominative; acc=accusative; gen=genitive).

<table>
<thead>
<tr>
<th>Thematic Structure</th>
<th>Case Agent</th>
<th>Case Theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Order</td>
<td>A-Th</td>
<td>nom</td>
</tr>
<tr>
<td>Scrambling</td>
<td>Th-A</td>
<td>nom</td>
</tr>
<tr>
<td>Subject Relative</td>
<td>[NP Th-A]</td>
<td>nom</td>
</tr>
<tr>
<td>Object Relative</td>
<td>[NP A-Th]</td>
<td>gen</td>
</tr>
<tr>
<td>Passives</td>
<td>Th-A</td>
<td>nom</td>
</tr>
</tbody>
</table>

The present study focuses on the comprehension of base order clauses, object scrambled clauses, relative clauses and passives. Table 5.1 provides a summary of these clause types with respect to grammatical and thematic structure, movement and case morphology. As can be inferred from the Table, (1) base order clauses have base case assignment; (2) object scrambled and subject relative clauses also have base case assignment, though both these clauses have derived word order; and (3) object relatives and passives do not have base case assignment while both of them have derived word order.61

5.3. The predictions of TDH and DOP-H for Turkish

Neither the TDH nor the DOP-H make specific predictions for Turkish. However, from previous studies of sentence comprehension in languages with overt case marking it is clear that case does not play a decisive role and does not assist sentence comprehension much. However, in some of these languages (German, Hebrew), word order is relatively free, though there are not as many word order variants as in Turkish. Moreover, case marking does not change according to sentence type as in Turkish. Because of the word

61 We assume that passives are derived because the theme is the subject.
order and case variation, Turkish is an interesting language for distinguishing their separate influence on sentence comprehension.

**Table 5.2.** Predictions made by the old TDH (Grodzinsky, 1995), the latest TDH (Drai & Grodzinsky, 2007) and the DOP-H (Bastiaanse & Van Zonneveld, 2005; 2007). The constituents in *italics* are not in their base positions (byP.=by phrase).

<table>
<thead>
<tr>
<th>Grammatical &amp; Thematic Structure</th>
<th>Old TDH</th>
<th>New TDH</th>
<th>DOP-H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Order subj.=agent – obj.=theme – V</td>
<td>above chance</td>
<td>above chance</td>
<td>+</td>
</tr>
<tr>
<td>Object Scrambling obj.=theme – subj.=agent – V</td>
<td>at chance</td>
<td>above chance</td>
<td>-</td>
</tr>
<tr>
<td>Subject Relative obj.=theme – V – subject=agent</td>
<td>at chance</td>
<td>above chance</td>
<td>-</td>
</tr>
<tr>
<td>Object relative subj.=agent – V – obj.=theme</td>
<td>above chance</td>
<td>above chance</td>
<td>-</td>
</tr>
<tr>
<td>Passives subj.=theme– byP.=agent – V</td>
<td>at chance</td>
<td>above chance</td>
<td>-</td>
</tr>
</tbody>
</table>

An important difference between the TDH and the DOP-H is the way in which their predictions are formulated. The TDH and its related default strategy make predictions in terms of chance level: patients score above or at chance level (or, in a very few cases below chance level). Typically, no statistical comparison is performed. The DOP-H predicts that sentences in base order will be better understood than sentences in derived order. To test the DOP-H, statistical comparisons between the different sentence types should be performed.

In Table 5.2 the predictions made by the classic and the latest version of the TDH and the DOP-H are given. Notice that this is purely based on word order, since neither theory includes case as a relevant factor. The latest version of the TDH predicts that performance is above chance in SOV languages as long as the internal argument does not cross the verb. The only Turkish sentence type in which such crossing occurs is the object relative. In this sentence type the object ‘moves’ over the verb and therefore no thematic role can be assigned. Applying the default strategy (‘assign the thematic role appropriate to the sentence position’) assigns a theme role to the second NP and results in the object relatives being correctly understood. Drai & Grodzinsky (2006) do not consider the possibility that the external subject crosses the verb, as it does in Turkish subject relatives for example, because they do not include rightward movement. Here, the literal interpretation of their
restriction is used to describe their prediction, but it could be that they mean crossing of internal or external arguments. In that case the default strategy assigns the theme role to the traceless subject according to its position in the sentence. There are then two themes and hence the patients perform at chance level.

The old TDH predicts chance level performance for all sentences where the traceless NPs receive, following the default strategy, the same role as the other NP. This occurs in (1) the object scrambled sentences, where the object receives an agent role because it is in the sentence initial position; (2) the subject relatives where the traceless subject receives a theme role because it is the second NP; and (3) in the passives where the traceless subject receives an agent role because it is sentence initial.

The DOP-H predicts poor performance for all sentences in derived order compared to sentences in base order. It does not make predictions in terms of chance level because important differences between sentence types could be missed when only chance level is taken into consideration. Statistics are used to determine whether differences at performance level are reliable.

For the present study, we will first describe performance levels at chance and above. It will be demonstrated that restriction to such an analysis fails to reveal important differences between sentence types. Therefore, statistical analyses were performed to understand the exact influence of word order and case on sentence comprehension in Turkish Broca patients.

The goal of this study is to evaluate whether word order accounts such as the TDH and the DOP-H are sufficient to describe the sentence comprehension deficits in a language where case plays as important a role as word order. It will be shown that case influences performance both at the group and at the individual level, but that it is less decisive than word order, even in a language where word order seems to be free.

5.4. Method

5.4.1. Subjects
Seventeen Turkish speakers with Broca’s aphasia (seven female/ten male) with a mean age of 49.8 years participated in the study. All the patients were right-handed and had normal or corrected to normal auditory and visual acuity. All patients but one (B12) were at least four months post-onset and had a single lesion in the left hemisphere – except for B4 and B7 who had had two strokes in their left hemispheres. Of the seventeen patients, fifteen suffered from a left CVA, and the others from a brain trauma due to a gunshot (B15)
and a brain tumor (B16). All but one (B7) suffered from right hemiplegia at the time of testing, indicating left frontal damage.

The aphasia type was established with the Gülhane Aphasia Test (Tanrıdağ, 1993) and confirmed by a speech therapist. Based on spontaneous speech production, the speech therapist confirmed that all the patients had non-fluent (i.e. slower than normal) speech. They were able to produce simple and short utterances but had difficulty with the production of complex utterances. It was also confirmed that the patients’ comprehension was relatively good compared to their production. Relevant patient data are provided in Appendix 5A. Ten native speakers of Turkish with no language or speech impairment history served as the control group. All were right-handed. This group was matched for age and education with the Broca’s aphasia group. They performed at ceiling. Therefore, their data will be ignored further.

5.4.2. Materials
A spoken-sentence-to-picture-matching task was developed with five semantically reversible sentence types. There were twenty items in each condition. A total of 100 reversible sentences were tested for each participant.

![Figure 5.1. Example stimuli for ‘the policeman shoots / has shot the thieves’.

A semantically reversible sentence was read aloud by the experimenter. The participants were asked to point to the picture that matched the spoken sentence. There were four pictures: (1) target picture; (2) picture with role reversals; (3) picture in which...
the roles are correct but the number of agents/themes was wrong (hereafter, number); and (4) picture in which both the roles and the number of agents/themes were incorrect (hereafter, role reversal + number). Figure 5.1 shows an example of the test stimuli. For the sentence ‘the policeman shoots / has shot the thieves’ the target is at the left upper corner and next to it is the role reversal. Number is at the left bottom corner and next to it is the role reversal + number.

Half the sentences in each condition were presented with singular agent/plural theme and the other half were presented with singular theme/plural agent to manipulate number. Number manipulation did not have an effect on the verb form, which was always singular. The plural morpheme on the NP was always the same (-1Ar). We manipulated ‘number’ in order to discriminate errors mainly at the syntactic level (role reversals) from the errors mainly at the morphological level (number). The order of the pictures was pseudo-randomized.

The task was administered individually. It started with two practice trials, each consisting of five items. The practice trials were repeated until it was clear that the patient understood the task. Once the test started, the experimenter only repeated the target sentence on request, not more than once. No time limit was imposed.

5.5. Results

5.5.1. Qualitative Analysis
The mean numbers (proportions in brackets) of the correctly interpreted sentences are given in Table 5.3 (individual scores are given in Appendix 5B).

<table>
<thead>
<tr>
<th></th>
<th>Base Order</th>
<th>Object Scrambling</th>
<th>Subject Relative</th>
<th>Object Relative</th>
<th>Passive</th>
</tr>
</thead>
<tbody>
<tr>
<td>mean</td>
<td>15.06</td>
<td>12.00</td>
<td>12.06</td>
<td>10.23</td>
<td>9.29</td>
</tr>
<tr>
<td>proportion</td>
<td>0.75</td>
<td>0.60</td>
<td>0.60</td>
<td>0.51</td>
<td>0.46</td>
</tr>
<tr>
<td>chance level</td>
<td>above chance</td>
<td>at chance</td>
<td>at chance</td>
<td>at chance</td>
<td>at chance</td>
</tr>
</tbody>
</table>

62 Turkish uses singular verbs with plural subjects in colloquial speech.
Table 5.3 also includes a presentation of whether the score was at chance level or above. Considering that the majority of the errors included word order errors (628 out of 703 errors: 89.33%), chance level was set at 33.3–67.7% correct. As a group, the Broca patients scored at chance level for all sentence types, except for the base order sentences where they scored above chance.

A Repeated Measures analysis of variance was performed to investigate whether and how order (base and derived order) affects sentence comprehension in Broca’s aphasia in sentences with base case assignment (agent=nominative case, theme=accusative case) or non-base case assignment. Both order and case were treated as within-participants factors. For agent-theme base order with base case assignment, we used Base Order (BO); for theme-agent derived order with base case assignment, we used the average of Scrambling and Subject Relative (SCR-SR); for agent-theme derived order without base case assignment, we used Object Relative (OR); and for theme-agent derived order without base case assignment, we used the Passive (PASS).

The Repeated Measures ANOVA showed a statistically significant effect for order: F(1.16)=19.3, p<.000. An inspection of the mean scores indicated that sentences with agent-theme order (BO+OR) (M=0.63, SD=0.02) were comprehended better than sentences with theme-agent order (SCR-SR+PASS) (M=0.53, SD=0.02). There was also a statistically significant main effect of case F(1.16)=192, p<.000. That is, based on the mean scores, sentences with base case information (BO+SCR-SR) (M=0.67, SD=0.02) were comprehended better than sentences where this type of information was absent (OR+PASS) (M=0.48, SD=0.01).

These main effects were qualified by a significant interaction between order and case: F(1.16)=5.75, p<.029. Although there was an effect of order when two clauses had normal case information (F(1.16)=18.1, p<.046), this effect was lost when the normal case information was absent (F(1.16)=3.13, p<.096). In other words, according to the mean scores, a sentence in agent-theme order (BO; M=0.752, SD=0.12) is easier to comprehend than a sentence in theme-agent order (SCR-SR; M=0.60, SD=0.11) only when both have base case information. However, when base case information is lacking, the sentences in agent-theme order (OR; M=0.51, SD=0.08) are as difficult as the sentences in theme-agent order (PASS; M=0.46, SD=0.09), implying that syntactic movement had a negative effect on performance even when it did not result in a theme-agent order, and that case information, which changed as a consequence of movement, was confusing for the patients. In sum, the following order of difficulty was observed:
5.5.2. Quantitative Analysis

In Table 5.4 the mean numbers (proportions in round brackets) of the error types per condition are given. Individual scores are given in Appendix 5C. There were three types of distracters: role reversal (RR), number (N) and [role reversal+number] (RR+N). The patients made significantly more errors with distracters with role reversals (i.e. role reversal and role reversal + number) compared to single number errors in all conditions (for base order t=4.06, df=16, p=0.001; object scrambling t=12.2, df=16, p=0.000, subject relatives t=7.5, df=16, p=0.000, object relatives t=16.9, df=16, p=0.000, passives t=19.3, df=16, p=0.000).

A one-way analysis of variance (ANOVA) revealed that there was a statistically significant difference in the test conditions [F (4,80)=25.4, p=0.000). According to the post-hoc comparisons with Bonferroni corrections, (corrected p value is <0.005 since there are overall ten comparisons between conditions), role reversals were statistically the least frequent for the base order (m=3.5, sd=1.90) compared to object scrambling (m=7.2, sd=1.98, p=0.000), subject relatives (m=6.8, sd=2.7, p=0.000), object relatives (m=9.1, sd=1.81, p=0.000) and passives (m=10.17, sd=1.84, p=0.000). No significant difference however was found between role reversals for object scrambling (m=7.2, sd=1.98) and subject relatives (m=6.8, sd=2.7, p=1.000), and object relatives (m=9.1, sd=1.81) and passives (m=10.17, sd=1.84, p=1.000).

Table 5.4. The mean number (max.=20; proportions in round brackets) of the error types per condition.

<table>
<thead>
<tr>
<th></th>
<th>Role Reversal</th>
<th>Number</th>
<th>Role Reversal + Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Order</td>
<td>2.7 (13.5)</td>
<td>1.4 (7)</td>
<td>0.8 (4.1)</td>
</tr>
<tr>
<td>Object Scrambling</td>
<td>5.6 (28.2)</td>
<td>0.8 (3.8)</td>
<td>1.6 (7.9)</td>
</tr>
<tr>
<td>Subject Relative</td>
<td>4.6 (23.2)</td>
<td>1.1 (5.5)</td>
<td>2.1 (10.8)</td>
</tr>
<tr>
<td>Object Relative</td>
<td>7.2 (36.1)</td>
<td>0.6 (2.9)</td>
<td>1.9 (9.7)</td>
</tr>
<tr>
<td>Passive</td>
<td>8.1 (40.8)</td>
<td>0.5 (2.6)</td>
<td>2 (10)</td>
</tr>
</tbody>
</table>
5.5.3. **Summary of the results**

(a) Qualitatively

Base order clauses were the easiest to comprehend. The performance of the Broca patients dropped significantly for sentences with object scrambling and subject relatives. Object relatives and passives were the most difficult to comprehend.

(b) Quantitatively

The patients predominantly made role reversal errors but this type of error was less frequent for base order clauses than for the others. They made role reversal errors regardless of whether a clause followed the theme-agent order or not. In other words, these errors were made not only when the clause had a theme-agent order (object scrambling, subject relatives) but also when it has an agent-theme order (base order, object relatives).

5.6. **Discussion**

The structure of the discussion will be as follows. First, the results are discussed in relation to the theories of agrammatism mentioned in the introduction (the TDH and the DOP-H). Secondly, chance level performances will be compared to statistical data to determine whether the difference between sentence types are reliable when only chance levels are considered. Finally, we compare the present findings on comprehension to our earlier findings on production in Turkish agrammatic Broca patients.

5.6.1. **The TDH and DOP-H: word order accounts**

Earlier we introduced the TDH and DOP-H. Table 5.5 repeats Table 5.2 (summary of all the clause types with respect to grammatical and thematic structure, order and case morphology), combined with the summary of the predictions of the TDH, DOP-H and the present results.
Table 5.5. Summary of all the clause types with respect to grammatical and thematic structure: order (constituents in derived position are in *italics*) and case morphology (non-base case is in *italics*), and predictions made by the hypotheses and the results (byP.=by phrase).

<table>
<thead>
<tr>
<th></th>
<th>grammatical &amp; thematic structure</th>
<th>old TDH</th>
<th>new TDH</th>
<th>DOP-H</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Base Order</strong></td>
<td>subj.=agent – obj.=theme verb</td>
<td>above</td>
<td>above</td>
<td>+</td>
<td>(above chance)</td>
</tr>
<tr>
<td></td>
<td>nominative – accusative</td>
<td>chance</td>
<td>chance</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Object Scrambling</strong></td>
<td>obj.=theme – subj.=agent – V</td>
<td>at</td>
<td>above</td>
<td>-</td>
<td>(at chance)</td>
</tr>
<tr>
<td></td>
<td>accusative – nominative</td>
<td>chance</td>
<td>chance</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Subject Relative</strong></td>
<td>obj.=theme – V – subject=agent</td>
<td>at</td>
<td>above</td>
<td>-</td>
<td>(at chance)</td>
</tr>
<tr>
<td></td>
<td>accusative – nominative</td>
<td>chance</td>
<td>chance</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Object Relative</strong></td>
<td>subj.=agent – V – obj.=theme</td>
<td>above</td>
<td>above</td>
<td>-</td>
<td>(at chance)</td>
</tr>
<tr>
<td></td>
<td>genitive – nominative</td>
<td>chance</td>
<td>chance</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Passives</strong></td>
<td>subj.=theme – byP.=agent – V</td>
<td>at</td>
<td>above</td>
<td>-</td>
<td>(at chance)</td>
</tr>
<tr>
<td></td>
<td>nominative – nominative</td>
<td>chance</td>
<td>chance</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As mentioned earlier, the TDH and its related default strategy make predictions in terms of chance level. The old TDH predicted chance level performance for all sentences where the traceless NPs receive, through the default strategy, the same role as the other NP. Therefore, the TDH made correct predictions for object scrambled sentences (the object received an agent role because it was in sentence initial position); subject relatives (the traceless subject received a theme role because it was the second NP) and passives (the traceless subject received an agent role because it was sentence initial), since the patients were at chance on these clause types. The TDH predicted above chance performance for object relatives, however. In these clauses, the object had been ‘moved’ over the verb and no thematic role was thus assigned. The default strategy was then expected to assign a theme role to the second NP (the default strategy assigns the thematic role on the basis of the position in the sentence), leading to above chance performance. Nevertheless, this is not in line with the findings – the patients performed at chance. Overall, the old TDH is quite successful at predicting the performance levels but its predictions do not hold true for all sentence types.

The new TDH predicted above chance performance for all sentence types. This is because the internal argument did not cross the verb in any of the sentence types we tested except for the object relatives, for which the default strategy was expected to assign the
correct thematic role to the theme. However, though the patients performed ‘at chance’ on all clauses, it was with base order. Apparently, as Table 5.5 shows, the new TDH is not as successful as the old TDH in predicting performance levels.

The DOP-H predicted all clauses with derived order to be more difficult than clauses where the elements are in their base positions. In other words, this theory predicted more difficulties in clauses where phrases become discontinuous, i.e. derived orders. These predictions are supported by the data.

The TDH is concerned with scores based on guessing, whereas the DOP-H works with absolute scores. The question that arises is whether all clauses that were at chance level are equally difficult for the patients; or to put it differently, were all clauses with a derived order equally impaired? The answers to these questions are discussed below.

5.6.2. Chance level (TDH) versus absolute scores (DOP-H)
The patients performed above chance for base order clauses and at chance for the rest: object scrambling, subject relatives, object relatives and the passives. According to this finding based on a chance level analysis, (1) base order clauses were easier than the rest of the clauses and (2) all other constructions were equally difficult for the patients. However, when statistics are used to test whether the differences between the absolute scores on the different sentence types are reliable (see section 5.5.1), a more detailed pattern emerges: the sentences where the patients scored at chance were not equally impaired. Statistics revealed three patterns: (a) sentences with object scrambling were as difficult as subject relatives; (b) object relatives were as difficult as passives, and (c) object relatives and passives were more difficult than sentences with object scrambling and subject relatives. Therefore, there is quite some variation in the sentences where comprehension was at chance level for the Broca patients. This suggests that a chance level analysis is missing an important variation in performance differences between sentences types crucial to understanding agrammatic behaviour.

Note that the DOP-H takes absolute scores into account and thus allows for statistical comparisons. However, the DOP-H does not adequately predict the performance differences between sentence types either: some clauses with derived word order are more difficult than others, a finding that cannot be explained by a theory of word order alone. Apparently, there are many factors at stake, and word order is one of them. The next section uses statistical data to reconsider performance levels by looking at both case and order.
5.6.3. The interaction between case and order
As noted above, there are three performance levels. Each level seems to be shaped by an interaction between case and word order. These performance levels are:

1. base order clauses were the easiest to comprehend. In these clauses there is base case assignment (the agent=nominative; theme=accusative) and the agent and the theme are in their base position: i.e. the participants received unambiguous information both from case and order.

2. object scrambling sentences and subject relatives were more difficult to comprehend. In object scrambling and subject relatives there is base case assignment (agent=nominative; theme=accusative). However, the theme is not in its base position. Therefore, the participants received information only from case, since the word order is derived.

3. object relatives and passives were the most difficult to comprehend. In object relatives and passives there is non-base case assignment (agent=genitive; theme=nominative in object relatives: agent=nominative; theme=nominative in passives). Moreover, the theme is not in its base position. Consequently, there is neither base case information nor base word order.

In sum, a clause is comprehended best when there is both base (unambiguous) case and word order information (base order clauses). The patients performance drops if there is base case information but derived word order (object scrambling and subject relatives). A clause is comprehended the poorest when there is neither base case information nor base word order (object relatives and passives).

At the individual level, however, three patients (B12, B15 and B17; see Appendix 5B) scored above chance on sentences with derived word order and base case information, but at chance on sentences with derived order and non-base case information. They seemed to profit from the base case information in sentences with object scrambling and subject relatives. The difference in absolute scores is only reliable for one patient (B17: \( \chi^2 = 4.42, p=0.018 \)). For B12 and B15 the difference is not reliable (B12: \( \chi^2 = 2.01, p=0.156 \); B15: \( \chi^2 = 2.09; p=0.148 \)).

In sum, the predictions made by the new and old TDH are not supported by the Turkish data. The DOP-H correctly predicts that Turkish Broca patients have problems understanding all sentence types with derived word order. However, the DOP-H, which only takes word order into consideration, cannot account for the influence of case information observed in the group data. Apparently, there is an interaction between case
and word order information. When either of these is not in base form, comprehension diminishes. When neither is in the base form, performance drops even further.

The question is how the interaction between case and word order can be paired with the earlier reported Turkish production data.

5.6.4. Integrating information from different linguistic levels
The data in the present study demonstrate that Broca patients have more problems understanding sentences with derived order and non-base case assignment than simple active sentences. These findings seem to complement our earlier findings on speech production in Turkish agrammatic Broca patients: agrammatic Broca patients have more difficulties producing sentences with derived word order (sentences with object scrambling, subject and object relatives) than simple active sentences (Yarbay Duman et al., 2007; see Chapter 2, 2008; see Chapter 3). As mentioned previously, in sentences with derived order, the patients produced both word order and morphological errors. For example, in object relative clauses, when the object moves to postverbal position within the noun phrase, the constituent order changes but so does the case of the subject – it changes from nominative to genitive. The data of Yarbay Duman et al. (2008; see Chapter 3) on the production of relative clauses show that when Turkish agrammatic speakers fail to produce the right order, they adapt case to the order they produce. Apparently, there is an interaction between word order and case that Turkish agrammatic speakers are aware of when producing sentences. The present comprehension study also shows an interaction between order and case. The most common error in this comprehension study was pointing to the inappropriate picture where the thematic roles were reversed. Choosing a picture with reversed thematic roles can be taken as evidence of deleted traces (Grodzinsky, 1995). However, this explanation would mean that the default strategy of the TDH works well for all clause types except object relatives, which questions either the existence or the consistency of such a strategy. Furthermore, this explanation cannot account for why simple base order sentences that do not involve traces at theta positions are already difficult for the patients.

An alternative explanation of the comprehension problem, usually reflected in a task requiring the subject to choose a picture with reversed roles, is that Broca patients have problems integrating information from different linguistic levels. Generally, this could mean that if information from different sources (syntax, morphology or semantics) needs to be integrated, both production and comprehension decreases. For example, Yarbay
Duman & Bastiaanse (2009; see Chapter 4) show that integration of semantics (time reference) into morpho-syntax (verb inflection) is difficult for Broca patients. For the present study, this means that integrating word order information and case information to assign thematic roles to the NPs is difficult. When information from word order and case is basic, Broca patients perform quite well in production and comprehension, although they perform poorer than non-brain-damaged subjects. When either word order or case information is non-basic, problems arise. In a comprehension test like the one used in the present study, it stops being clear who the agent is and who the theme is. In production, sentences with derived order and non-base case are difficult to produce and the Broca patients have a tendency to produce sentences in base order and base case (Yarbay Duman et al., 2007; see Chapter 2, 2008; see Chapter 3). Apart from that, Yarbay Duman et al. (2008; see Chapter 3) shows that object relative clauses are more problematic for some patients than subject relative clauses: the order is derived and case is non-basic in object relatives. This is compatible with a processing disorder: when sentence structures deviate from normal, processing demands are higher and, therefore, these sentences are harder to produce and comprehend than base sentences. The present study shows that the derivational variables add up: if both word order and case are non-base, sentences are more difficult than when only word order is derived. This means that the poor performance in derived sentences cannot be explained by guessing behaviour in patients, although the scores do end up around 50% correct. Interestingly, some recent findings from eye-tracking studies (Dickey et al., 2007) also show that ‘guessing’ is not what Broca patients do when they match a picture with a spoken sentence.

The eye-tracking study of Dickey et al. (2007) suggests that Broca patients assign the wrong thematic role during processing. The patients fixated on a picture that matches the moved element at the position of the verb: they looked at the moved-element picture for the correct trials in the same way as the control participants did. The patients looked first at the moved-element picture and then at a competitor following the verb, but only in the incorrect trials. Besides, their fixations were as fast as the control participants’ fixations during sentences with movement. Accordingly, a representation account (Grodzinsky, 1995), which predicts that the patients use qualitatively different strategies – such as having two agents because of a default guessing strategy – than non-brain-damaged individuals do, cannot account for these findings. Apparently, the patients assign the wrong roles during processing.
In sum, when syntactic information (here, word order) and morphological information (here, case) have to be integrated, the performance of Broca patients decreases in comprehension and production.