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Asyntactic thematic role assignment by Mandarin aphasics: A test of the Trace-Deletion Hypothesis and the Double Dependency Hypothesis

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Abstract

This study examines the comprehension patterns of various sentence types by Mandarin-speaking aphasic patients and evaluates the validity of the predictions from the Trace-Deletion Hypothesis (TDH) and the Double Dependency Hypothesis (DDH). Like English, the canonical word order in Mandarin is SVO, but the two languages differ in that the head noun precedes the relative clause in English, but it follows the relative clause in Chinese. According to the Default Principle as stated in the TDH, the word order discrepancy will make subject relative clauses more difficult to comprehend for Mandarin agrammatics than object relative clauses, but the DDH predicts that agrammatic patients from the two languages have the same pattern of selective deficits. The results of this study support the prediction of the TDH.

Keywords: Aphasia; Agrammatism; Comprehension; Mandarin Chinese; Trace-Deletion Hypothesis; Double Dependency Hypothesis

1. Introduction

This study aims to examine Mandarin Chinese-speaking aphasic patients' comprehension on various types of sentences in order to investigate the validity of the predictions from two linguistically based hypotheses—the Trace-Deletion Hypothesis (TDH) and the Double Dependency Hypothesis (DDH). In neurolinguistic literature, the term "agrammatism" was initially used to refer to a selective disorder of speech production (i.e. sparse verbal output, disfluency, and omission of functional morphemes) but intact comprehension resulting from focal brain damage. Since Caramazza and Zurif's (1976) seminal work, this traditional view has been challenged, and more and more cross-linguistic studies have revealed that the comprehension of these patients may also be impaired, especially when the crucial cues to interpret the sentences are syntactic (e.g. for English, Heilman & Scholes, 1976; Schwartz, Saffran, & Marin, 1980, among many others; for German and Italian, Bates, Friederici, & Wulfeck, 1987; for Japanese, Hagiwara, 1993; Hagiwara & Caplan, 1990; for Mandarin Chinese, Su & Law, 1993; for Serbo-Croation, Lukatela, Shankweiler, & Crain, 1995; for Spanish, Beretta et al., 2001; Miera & Cuetos, 1998; for Cantonese, Law & Leung, 1998, 2000; for Hebrew, Friedmann, 2000; for Korean, Beretta et al., 2001; O'Grady & Lee, 2001, 2005). In the past three decades, various approaches have been proposed to account for agrammatic comprehension difficulties, including the phonological/morphological component deficit approach (e.g. Kean, 1977; Bradley, Garrett, & Zurif, 1980) and the complete loss of syntactic competence approach (e.g. Caramazza & Zurif, 1976; Caplan & Futter, 1986). However, these two approaches run into difficulties in the face of evidence that (1) comprehension deficits and telegraphic production may not necessarily co-occur (e.g. Miceli, Mazzucchi, Menn, &

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Goodglass, 1983), (2) these patients are aware of the meaning and the presence/absence of many functional morphemes in well-formedness judgment tasks (e.g. Linebarger, Schwartz, & Saffran, 1983; Lukatela, Crain, & Shankweiler, 1988), and (3) they show a word position effect like normal adults do in an on-line processing task (Shankweiler, Crain, Gorrell, & Tuller, 1989). In the current study, we will focus our discussion on accounts that posit partial loss of certain aspects of syntactic processing as the locus of agrammatic comprehension difficulties. This was the position first taken by Grodzinsky (1986, 1990, 1995).

Based on the syntactic theory (i.e. Government and Binding theory) of Chomsky (1981), Grodzinsky (1986, 1990) proposed the Trace-Deletion Hypothesis to account for agrammatic patients' chance-level performance in comprehending sentences with non-canonical Theme–Agent order as in (1), in contrast to their (near) normal performance on sentences with canonical Agent–Theme order as in (2).

(1) a. Passive: *The cat* was chased [*t*] by the dog.
b. Object-extracted relative: *The cat* that the dog chased [*t*] was small.
c. Object cleft: It was *the cat* that the dog chased [*t*].

(2) a. Active: The dog chased the cat.
b. Subject-extracted relative: *The dog* that [*t*] chased the cat was big.
c. Subject cleft: It was *the dog* that [*t*] chased the cat.

According to the TDH, syntactic representations in agrammatism are intact except in the following two respects (Grodzinsky, 1990, p. 97).

(3) The S-structure representation underlying agrammatic comprehension lacks traces. In interpretation, a Default Principle is invoked that is defined as follows: If a lexical NP has no theta-role (that is, it is in a non-thematic position), assign it the theta-role that is canonically associated with the position it occupies, unless this assignment is blocked. In this case assign it a role from the next lower level in the Thematic Hierarchy.

Based on the TDH, none of the moved elements (i.e. *the cat* in (1a–c) and *the dog* in (2b and c)) in passives, relative clauses, and cleft sentences in (1) and (2) can receive thematic roles because there are no traces to transmit the roles to the NPs. Since these moved NPs are in a position that precedes another NP in the clause, they are assigned the agent role based on the Default Principle. The assignment results in conflicting representations for the sentences in (1) as the other NP receives the agent role via either the preposition *by* or the verb. The chance-level performance is the consequence of guessing between the two NPs, both of which now bear the agent role. For the sentences in (2), the assignment of the Default Principle causes no problems because the non-moved NPs receive the theme role through the verb, and hence the representation matches the correct interpretation of the sentences.

Although agrammatic aphasic patients have been shown to demonstrate selective comprehension deficits on some constructions but not others, several studies also exhibit that they nevertheless can accurately judge the grammaticality of the constructions they fail to comprehend (Linebarger, 1989, 1990; Linebarger et al., 1983; Lukatela et al., 1988; Schwartz, Linebarger, Saffran, & Pate, 1987; Shankweiler et al., 1989). Take the active and passive sentences in (4) as examples. Linebarger (1989) found that agrammatic patients were able to discriminate the grammatical sentences from the ill-formed ones (4a and c) with a passive participle followed by a direct object.

(4) a. *John was finally kissed Louise.
b. The boy was followed by the girl.
c. *The boy was followed the girl.
d. The boy was following the girl.
e. John has finally kissed Louise.

In addition, agrammatics also preserved the ability to correctly judge constructions involving Wh-movement (as in (5)) and empty elements (as in (6)), which demonstrated that chain formation was intact in agrammatics.

(5) Wh-moved subcategorization (83.1% correct)
a. *The principal frowned the boy.
b. *Who did the principal frown?
c. Why did the principal frown?

(6) Empty elements (83.7% correct)
a. Frank thought he was going to get the job.
b. *Frank thought __ was going to get the job.
c. That's who Frank thought __ was going to get the job.
d. *Who __ thought __ was going to get the job?

However, there still exist some conditions which elicited relatively higher error rates[1] from patients' grammaticality judgments, such as the agreement between the subjects or the auxiliary verbs of a tag question and its host sentence, as shown in (7).

(7) a. *The little boy fell down, didn't it?
b. *John is very tall, doesn't he?

Other judgment tasks which caused difficulty for agrammatic patients also involve some kinds of agreement as well, e.g. Wh-head agreement (as in (8)), head–head agreement (i.e. misselection of auxiliaries as in (7b) and (9)), violations of gender or number in pronouns and reflexives (as in (10)).

[1] The agrammatic patients tended to over-accept the ill-formed sentences in these conditions.

(8) Wh-head agreement
a. *The pencil who he brought was nice.
b. The pencil which he brought was nice.

(9) Head–head agreement
*George was angry and so did Tom.

(10) a. *The famous man itself attended the ceremony.
b. *I helped themselves to the birthday cake.

Based on these findings, Linebarger and her colleagues argue that the sensitivity to grammatical deformations is strong evidence for agrammatic patients' preserved ability to recover syntactic structure, and that their difficulties on some conditions of comprehension and grammaticality judgment all involve noncategorial feature clashes between anaphorically linked elements. They suggest that although the agrammatics may correctly parse an input sentence (including intact chain formation between NPs and their traces as evidenced in well-formedness judgments), they are not able to make the mapping from grammatical functions to thematic roles. Further elaborating Linebarger and her colleagues' Mapping Hypothesis, Mauner, Fromkin, and Cornell (1993) proposed the Double Dependency Hypothesis (DDH) to account for agrammatic patients' problems with assigning thematic roles and judging agreement violations.

In order to account for the comprehension difficulties agrammatic patients display on thematic role assignment, the DDH posits a selective deficit as stated in the following (Mauner et al., 1993, p. 349).

(11) The Double Dependency Hypothesis
(i) The deficit underlying asyntactic comprehension affects the processing of syntactic referential dependencies, and
(ii) When there is only one such dependency the resulting syntactic representation, although abnormal, is not ambiguous, but when there are two such dependencies the resulting representation is semantically ambiguous.

According to this hypothesis, asyntactic comprehension with spared grammaticality judgment arises when subjects do not have, or cannot make use of, the Coindexation Condition.

(12) Coindexation Condition
If α is R-dependent on β, then they must bear the same R-index.

Assuming the VP-Internal Subject Hypothesis, the structures of the passive and the object-extracted relative clause are as depicted in (13a) and (14a), respectively.

(13) a. [The boy] was chase + en *t* by [the girl].
b. ⟨[the boy]$_i$, t_i⟩, ⟨[the girl]$_j$, -en$_j$⟩
c. ⟨[the boy]$_i$, t_j⟩, ⟨[the girl]$_j$, -en$_i$⟩

(14) a. [The boy] [Op that [the girl] is *t1* chasing *t2*] is tall.[2]
b. ⟨Op$_i$, *t2*$_i$⟩, ⟨[the girl]$_j$, *t1*$_j$⟩
c. ⟨Op$_i$, *t2*$_j$⟩, ⟨[the girl]$_j$, *t1*$_i$⟩

In each of the structures there are two thematic R-dependencies—in the passive, ⟨[*the boy*], *t*⟩ and ⟨[*the girl*], *-en*⟩, and in the object-extracted relative clause, ⟨*Op*, *t2*⟩ and ⟨[*the girl*], *t1*⟩. For the passive, suppose the R-expression *the boy* is marked with R-index *i*, and *the girl* with R-index *j*. There will be two possible assignments of indices to the dependent elements as shown in (13b and c). The Coindexation Condition will rule out (13c) for normal subjects, but since the agrammatic patients cannot make use of this condition, both assignments will be permitted. Object-extracted relative clauses are treated similarly, i.e. without the Coindexation Condition, indices can be arbitrarily assigned to the theta-positions occupied by the two traces as shown in (14b and c).

Unlike passives and object-extracted relative clauses, the direct objects in active declaratives and subject-extracted relative clauses do not move, and hence are assigned theta-roles directly, unaffected by the loss of the Coindexation Condition. The examples in (15a) and (16a) represent the structures for an active and a subject-extracted relative clause respectively under the VP-Internal Subject Hypothesis.

(15) a. [The boy] is *t* chasing [the girl].
b. ⟨[the boy]$_i$, t_i⟩, ⟨[the girl]$_j$⟩
c. ⟨[the boy]$_i$, t_j⟩, ⟨[the girl]$_j$⟩

(16) a. [The boy] [Op that *t1* is *t2* chasing [the girl]] is tall.
b. ⟨Op$_i$, *t2*$_i$⟩, ⟨[the girl]$_j$⟩
c. ⟨Op$_i$, *t2*$_j$⟩, ⟨[the girl]$_j$⟩

Both the active and the subject-extracted relative clause include a single thematic R-dependency—the chain ⟨[the boy], *t*⟩ in the active, and ⟨*Op*, *t1*, *t2*⟩ in the subject-extracted relative clause. Suppose the R-index of *the boy* is *i* and that of *the girl* is *j*. Under a coindexation deficit, the traces are not necessarily coindexed with *the boy* in the active or the Wh-operator *Op* in the subject-extracted relative clause. For the active, the indexing in (15b) is correct, whereas the indexing in (15c) results in both theta-roles being associated with *the girl*, while *the boy* has no role at all. Since no interpretation can be assigned to the orphaned NP *the boy* in (15c), the correct indexing in (15b) is assured by the requirement that syntactic clauses be interpretable even in the agrammatic's syntax. As with active declaratives, although the indexing in (16c) for subject-extracted

[2] '*Op*' represents a null Wh-operator that takes the place of the overt relative pronoun.

relative clauses is allowed by the agrammatic's grammar, it leads to a deviant interpretation and thus is rejected.

In addition to the accounts provided by the TDH and the DDH to explain agrammatic patients' selective comprehension deficits among the sentence types, a further prediction made by the TDH is that agrammatic aphasics should be able to perform well on comprehension of the matrix clauses for the relative construction in (1b) and (2b), repeated below as (17a and b), respectively.

(17) a. The cat$_i$ [that the dog chased t_i] was small.
b. The dog$_i$ [that t_i chased the cat] was big.

That is to say, although agrammatic aphasics may have difficulty interpreting who is chasing whom in an object-extracted relative clause such as (17a), they should have above-chance performance on comprehension of a subject-extracted relative clause as in (17b) and the matrix clauses of both (17a and b). However, the results in Caramazza and Zurif (1976) showed that Broca's and Conduction aphasics performed poorly in a sentence–picture matching task when presented with semantically reversible and improbable center-embedded (i.e. object-extracted) relative sentences paired with a syntactic distractor that reversed the thematic roles of the sentence and the adjective assignment. In addition, Sherman and Schweickert (1989) used active, passive, and center-embedded object relative sentences to pair with either a thematic role reversal distractor, a predicate-adjective relation reversal distractor that changed the adjective assignment, or a thematic role plus predicate–adjective relation reversal distractor. The results provided further evidence that agrammatic aphasics were as poor at determining adjective assignment (54.2% correct) as they were at determining thematic roles (41.7% correct) for center-embedded relative sentences, but they correctly interpreted most active and passive sentences. Based on these findings, Hickok (1992) proposed a Revised Trace-Deletion Hypothesis (RTDH), which, retaining the defining feature of the TDH (i.e. traces are deleted at the level of S-structure),[3] assumes that grammatical subjects receive theta-roles via a trace according to the VP-Internal Subject Hypothesis[4] (Koopman & Sportiche, 1991). The RTDH predicts that comprehension is above chance in cases where there is only one NP in the sentence that is available for interpretation as a given unsatisfied theta-role (e.g. active, subject cleft, and subject-extracted relative as in (18)). For the three types of sentences in (18), the theme role is grammatically specified by the direct object, but the agent role is unsatisfied as the trace is not present to transmit the role to the subject NP.

(18) a. The dog [$_{VP}$ * chased the cat].[5]
chase (* (cat))
b. It was the dog that [$_{VP}$ * chased the cat].
chase (* (cat))
c. The dog [that [$_{VP}$ * chased the cat]] is big.
chase (* (cat))

When there is more than one NP that is available for interpretation as a given unspecified role, comprehension will be poor, e.g. passive, object cleft, and object-extracted relative as in (19).

(19) a. The cat was chased * by the dog.
chase (Ø (*))[6]
b. It was the cat [that the dog [$_{VP}$ * chased *]]
chase (* (*))
c. The cat [that the dog [$_{VP}$ * chased *]] is small.
chase (* (*))

A crucial difference between the TDH and the RTDH resides in the prediction of the comprehension performance on predicate adjective sentences as in (20).[7]

(20) a. The dog [that [$_{VP}$ * chased the cat]] [$_{VP}$ * is big].
is big (*)
b. The cat [that the dog [$_{VP}$ * chased *]] [$_{VP}$ * is small].
is small (*)

[3] As pointed out in Footnote 12 of Hickok, Zurif, and Canseco-Gonzalez (1993), the RTDH (and TDH) is intended as a descriptive account of the data and not a theory of the actual deficit of the aphasic patients, and the term "trace deletion" is used as a convenient way of saying that antecedent-trace relations are not being established.

[4] The VP-Internal Subject Hypothesis states that grammatical subjects are originally generated inside the verb phrase (VP) and then raised to their surface position inside the inflection phrase (IP), leaving a trace in the position of extraction.

[5] The asterisk denotes a deleted trace. In addition to the syntactic representation, Hickok uses a thematic assignment representation (TAR) with the form "*verb* (x (y))", where x denotes the theta-role assigned to the subject, and y the theta-role assigned to the direct object.

[6] Following Grimshaw (1990), Hickok assumes that the external argument of the passive form of a verb is suppressed, as represented by the symbol Ø. Besides, it is also assumed that the by-phrases are not theta-marked and do not satisfy argument structure positions, and hence there are two NPs available for interpretation as a given unspecified theta-role for a passive sentence. However, it is noted that a fair amount of variation in performance on passives might be expected due to the availability of the by-phrase as a potential heuristic cue for interpretation (see Footnote 15 in Hickok et al., 1993).

[7] According to the RTDH, the adjectives of the matrix clauses in (20) do not receive a theta-role in the predicate-adjective constructions and hence are treated as part of the verb (Footnote 13 in Hickok et al., 1993).

In the agrammatic representation shown in (20), the matrix predicate has one unsatisfied role but there are two NPs in the sentence that are available for interpretation. Since there is more than one possible NP to fill in the unsatisfied role, the RTDH predicts poor comprehension performance on these sentences. Using a sentence–picture matching task and a truth-value judgment task, Hickok et al. (1993) provides evidence to support the RTDH from a case study of an agrammatic aphasic who displayed poor performance on the passive, the object cleft and the predicate adjective of subject relative constructions but nearly perfect performance on the subject cleft sentences.

To recapitulate, the afore-mentioned hypotheses (i.e. the TDH, the RTDH, and the DDH) all correctly predict that in English, agrammatic aphasics would display above-chance performance on active, subject-extracted relative clauses, and subject cleft sentences, but chance-level performance on passive, object-extracted relative clauses, and object cleft sentences. In addition, the RTDH also predicts that the matrix clauses of the relative construction will cause difficulties for these patients. The TDH differs from the DDH in that it postulates trace-deletion in the agrammatic syntactic representation, and it does not adopt the assumption of the VP-Internal Subject Hypothesis, and hence at most one trace is involved in those structures which result in comprehension problems. In the next section, we illustrate the similarities and differences with respect to the predictions of the hypotheses for the comprehension patterns of Mandarin-speaking aphasic patients.

2. Predictions of the hypotheses on mandarin agrammatism

The goal of this study is to test the two linguistically based hypotheses (i.e. the TDH and the DDH) on the comprehension of Mandarin Chinese-speaking aphasic patients. Like English, the canonical word order in Mandarin is SVO, but the two languages differ in that the head noun precedes the relative clause in English, but it follows the relative clause in Chinese. Since Mandarin is a language without rich inflectional morphology or case marking, the similarity and difference on word order between English and Mandarin provide a good contrast to evaluate the validity of the two hypotheses in two respects. The first issue we would like to examine is whether the comprehension deficits of Mandarin-speaking aphasics can better be accounted for by postulating one trace (as the TDH) or two thematic R-dependencies (as the DDH) in the representations, and whether patients assign thematic roles based on the Default Principle as stated in the TDH. Secondly, we are concerned with whether Mandarin-speaking aphasics will also show poor comprehension performance on the matrix predicate-adjective relation of relative constructions as predicted by the RTDH.

The test consists of seven types of sentences, as shown in (21) and (22).[8] It includes four types with canonical Agent–Theme order such as Active, BA object preposing construction, Object Relative, and Object Pseudo-Cleft,[9] and three types with non-canonical Theme–Agent order such as Passive, Subject Relative, and Subject Pseudo-Cleft. According to the TDH, the four sentence types with canonical Agent–Theme order should elicit above-chance performance, because after movement, the thematic roles assigned based on the Default Principle conforms to the correct representation (as in (21)). On the contrary, the three types with non-canonical Theme–Agent order should have chance-level performance, as the assignment of the Default Principle conflicts with the correct representations of these sentences (as in (22)).[10]

[8] Like previous studies (e.g. Caramazza & Zurif, 1976; Grodzinsky, 1989; Hickok et al., 1993; Sherman & Schweickert, 1989, among many others), we used action verbs in relative clauses and other types of sentences but predicate adjectives in the matrix clauses of the relative construction in order to keep the structures comparable to other studies, and to avoid the presupposition that the event encoded in a relative clause happens before the event depicted in the matrix clause, which may make the processing more complicated in a sentence–picture matching task.

[9] To our knowledge, only cleft sentences, but not pseudo-cleft sentences, have been used in testing agrammatic comprehension in English. We do not include cleft sentences because, as the example in (i) shows, a subject cleft sentence is identical to an active sentence with a copula *shi* 'to be' in the front, and the corresponding object cleft sentence in (ii) is not an acceptable form in Mandarin.

(i) shi da gou zhui xiao mao
be big dog chase small cat
"It was the big dog that chased the small cat."

(ii) ??shi xiao mao da gou zhui
be small cat big dog chase
"It was the small cat that the big dog chased."

Since pseudo-cleft sentences in English also extract either the subject or the object NP of a verb to the end of the sentence as in (21d) and (22c), the order of the two NPs is the same as in Mandarin. Therefore, even within English, pseudo-cleft sentences can be a good test for the predictions of the two hypotheses in comparison with the relative and cleft sentences; that is, the TDH will predict Object Pseudo-Cleft to elicit above-chance performance and Subject Pseudo-Cleft chance-level performance, whereas the DDH will predict the reverse.

[10] Like English, the moved NP in the subject position of a passive sentence is assigned the Agent role according to the Default Principle, which conflicts with the Agent role of the NP in the by-phrase. As for Subject Relative and Subject Pseudo-Cleft sentences, since the moved NP appears in a position following another NP in the clause, i.e. the second NP position, it is assigned a Theme role based on the Default Principle as that is the thematic role canonically associated with the position it occupies. Therefore, unlike English object-extracted relative clauses, in which two NPs bear the Agent role, in Mandarin Subject Relative and Subject Pseudo-Cleft sentences, two NPs receive the Theme role, and hence chance performance is predicted. As pointed out in Footnote 2 of Hickok et al. (1993), given that one theta-role is assigned normally, the aphasic patients should be able to infer that the remaining role goes with the other NP. However, the results from previous and the current study show that patients with comprehension deficits are unable to do this.

(21) a. Active (A)

Agent			*Theme*		Normal assignment
[da	gou]	zhui	[xiao	mao]	
big	dog	chase	small	cat	
Agent			*Theme*		Default Principle

"The big dog chased the small cat."

b. BA Object Preposing Construction (B)

Agent			*Theme*				Normal assignment
[da	mao]	ba	[xiao	gou_i]	zhuipao	t_i	
big	cat	BA	small	dog	chase-away		
Agent			*Theme*				Default Principle

"The big cat chased away the small dog."

c. Object Relative (OR)

Agent				*Theme*				Normal assignment
[gou	zhui	t_i]	de	[mao_i]	hen	da		
dog	chase		COMP	cat	very	big		
Agent				*Theme*				Default Principle

"The cat that the dog chased was very big."

d. Object Pseudo-Cleft (OPC)

Agent							*Theme*	Normal assignment
[xiao	mao	zhui	t_i]	de	shi	[da	gou_i]	
small	cat	chase		DE	BE	big	dog	
Agent							*Theme*	Default Principle

"What the small cat chased was the big dog."

(22) a. Passive (P)

Theme			*Agent*				Normal assignment
[xiao	gou_i]	bei	[da	mao]	zhui	t_i	
small	dog	by	big	cat	chase		
Agent			*Agent*				Default Principle

"The small dog was chased by the big cat."

b. Subject Relative (SR)

	Theme		*Agent*				Normal assignment
[t_i	zhui	gou]	de	[mao_i]	hen	xiao	
	chase	dog	COMP	cat	very	small	
	Theme		*Theme*				Default Principle

"The cat that chased the dog was very small."

c. Subject Pseudo-Cleft (SPC)

	Theme					*Agent*		Normal assignment
[t_i	zhui	da	mao]	de	shi	[xiao	gou_i]	
	chase	big	cat	DE	BE	small	dog	
	Theme					*Theme*		Default Principle

"What chased the big cat was the small dog."

For relative construction, since the head noun precedes the relative clause in English but follows the clause in Mandarin, the crucial difference between the predictions of the TDH on English and Mandarin is that subject-extracted relatives will be predicted to cause no difficulty for English-speaking agrammatics but to elicit chance-level performance for Mandarin-speaking patients as in (22b). For BEI passive construction, (22a) illustrates the conflicting representations under the assumption that Mandarin passives are derived in a similar way to English (i.e. the Movement approach, e.g. Li, 1990). However, if we consider Chinese passives as biclausal sentences in which *bei* is analyzed as a verb taking an embedded clause as its

Table 1
Predictions of the TDH on the seven types of sentences in Mandarin

Sentence types	Prediction	Sentence types	Prediction
Active	Above-chance	BA Construction	Above-chance
Passive		Subject Relative	Chance
Movement approach	Chance	Object Relative	Above-chance
Non-Movement approach		Subject Pseudo-Cleft	Chance
Subject in Spec of IP	Above-chance	Object Pseudo-Cleft	Above-chance
VP-Internal subject	Chance		

complement and the Theme NP does not move from the post-verb position[11] (as shown in (23), i.e. the Non-Movement approach, e.g. Huang, 1999; Tang, 2001; Ting, 1998; among others), there can be two possible predictions. The first possibility assumes that subject is directly generated as [Spec, IP] in Mandarin Chinese, as proposed in Aoun and Li (1989), and hence the TDH will predict above-chance performance since no trace is present in the syntactic representation. The second possibility assumes that the VP-Internal Subject Hypothesis also applies in Mandarin (e.g. Huang, 1993), and the Default Principle will assign the Agent role to the matrix subject NP, which conflicts with the correct representation, and hence chance-level performance will be predicted.

(23) The Non-Movement Approach of Chinese Passive Construction

a. [$_{IP}$ Theme-NP [$_{VP}$ *bei* [$_{IP}$ Op [$_{IP}$ Agent-NP V t_{Op}]]]]

b. [$_{IP}$ Zhangsan$_i$ [$_{VP}$ *bei* [$_{IP}$ Op$_i$ [$_{IP}$ laoshi ma-le t_{Opi}]]]]
Zhangsan BEI teacher scold-ASP
"Zhangsan was scolded by the teacher."

c. [$_{IP}$ Zhangsan$_i$ [$_{VP}$ *bei* [$_{IP}$ Op$_i$ [$_{IP}$ laoshi ma-le ta$_i$ yidun]]]]
Zhangsan BEI teacher scold-ASP he once
"Zhangsan was scolded once by the teacher."

Table 1 summarizes the predictions of the TDH on the seven types of sentences in Mandarin.

For the DDH, since it relies on whether the sentences involve one or two moved NPs to account for the selective comprehension deficits, it has basically the same predictions on the pattern of performance for English and Mandarin. For sentences in which the object NP is displaced, given that the subject moves from [Spec, VP], comprehension will break down, for there are two possibilities to relate the two NPs to the two thematic roles. That is to say, assuming that Mandarin passives are derived in a similar way to English (i.e. the Movement approach, e.g. Li, 1990) and that the VP-Internal Subject Hypothesis also applies in Mandarin (e.g. Huang, 1993), the DDH will predict that like English, Mandarin agrammatics will find Passive, Object Relative, and Object Pseudo-Cleft hard to comprehend, whereas Active, Subject Relative, and Subject Pseudo-Cleft will be easier. However, if the VP-Internal Subject Hypothesis is not assumed, i.e. if the subject is directly generated in [Spec, IP] (e.g. Aoun & Li, 1989), the two types of relative and pseudo-cleft sentences will be predicted to elicit above-chance performance in Mandarin, as only one thematic R-dependency is present in the representation. For Passive, if the Non-Movement approach is taken, and the VP-Internal Subject Hypothesis is assumed, comprehension may break down, for there are two antecedent-trace relations—one for the matrix subject NP and the other for the embedded subject NP. However, if the subject is directly generated in [Spec, IP], the DDH will predict above-chance performance. As for BA construction, if *ba* is analyzed as a verb and the Theme NP base-generated in the post-*ba* position (i.e. the Non-Movement approach, e.g. Bender, 2000), the DDH predicts that above-chance performance will be elicited, since at most one NP (i.e. the Agent subject) is moved when the VP-Internal Subject Hypothesis is assumed, as shown in (24). On the other hand, if the Theme NP is analyzed as moving from the post-verb to the post-*ba* position (i.e. the Movement approach, e.g. Zou, 1993), the prediction will be chance-level performance if the VP-Internal Subject Hypothesis is assumed, but above-chance performance if the subject is considered to be directly generated in [Spec, IP], as illustrated in (25).

[11] Note that the Theme NP is considered as not moved from the post-verb position only for long passives, i.e. with the Agent NP following *bei*. According to this analysis, the Theme NP in the embedded clause is a null operator undergoing A′-movement and will be bound by the matrix subject NP. For short passives, i.e. without the Agent NP, they are argued to involve A-movement of PRO.

(24) The Non-Movement Approach of BA Construction

[IP ta [VP ba [NP pingzi] [VP zhuangman-le shui]]]
he BA bottle fill-ASP water
"He filled the bottle with water."

(25) The Movement Approach of BA Construction

[IP ta [BAP ba pingzi$_i$ [VP zhuangman-le t_i]]]
he BA bottle fill-ASP
"He filled the bottle."

The detailed predictions of the DDH on the performance of Mandarin-speaking agrammatic patients with respect to the seven types of sentences are summarized in Table 2.

In addition to the above predictions on the comprehension of various sentence types, we will also test the prediction of the RTDH, i.e. whether Mandarin-speaking aphasics will show poor comprehension performance on the matrix predicate–adjective relation in relative constructions if the VP-Internal Subject Hypothesis is assumed.

3. Methods

3.1. Materials

Seven types of sentences were employed for this study, as illustrated in (21) and (22). Each type of sentences was composed of the same set of 10 action verbs, 12 animate nouns, nine inanimate nouns, and six pairs of adjectives.[12] In addition, each type of sentence construction consisted of three semantic conditions—reversible (in which both argument nouns were animate, as shown in (21) and (22)), plausible (in which the agent was animate and the theme inanimate, as in (26a)), and implausible (in which the agent was inanimate but the theme animate, as in (26b)). The semantic conditions were manipulated to examine the possibilities that Broca's aphasics rely on semantic constraints instead of syntactic information for sentence comprehension (as found in Caramazza & Zurif, 1976), or that these patients fail to assign thematic roles and adjectives only in complex structures (e.g. center-embedded relative sentences, as found in Sherman & Schweickert, 1989). Ten trial sentences were constructed for each condition, hence generating 30 trials for each of the seven types of sentences.

(26) a. Plausible

xiao gou zhui da qiu
small dog chase big ball
"The small dog chased the big ball."

b. Implausible

xiao qiu zhui da gou
small ball chase big dog
"The small ball chased the big dog."

Appendix A lists all the 30 active sentences and the other six types of sentences were derived from these active sentences by applying the relevant transformations.

Two versions of the comprehension test were developed based on the same set of sentences, and the only difference between the two versions was in the number of pictures accompanying the target sentence.[13] Version One consisted of 210 trial sentences (10 trials × 3 conditions × 7 sentence types), and the picture that depicted the meaning of the target sentence was presented with three distractor pictures—a lexical reversal distractor that changed the adjective assignment, a thematic role reversal distractor, and a lexical plus thematic role reversal distractor. In Version Two, each target sentence appeared twice, once with a thematic

[12] The ten action verbs were *la* 'to pull', *da* 'to beat', *zhui* 'to chase', *tui* 'to push', *bao* 'to hold in the arms', *tuo* 'to drag', *bei* 'to carry on the back', *yao* 'to bite', *pai* 'to pat', *tian* 'to lick'. The six pairs of adjectives included *hei*/*bai* 'black/white', *pang*/*shou* 'fat/thin', *da*/*xiao* 'big/small', *nianqing*/*lao* 'young/old', *fang*/*yuan* 'square/round', *gao*/*ai* 'tall/short'. The nine inanimate nouns were *chezi* 'car', *shadai* 'sandbag', *qiu* 'ball', *yizi* 'chair', *shu* 'book', *pixiang* 'suitcase', *beibao* 'backpack', *xie* 'shoe', *zhuozi* 'table'. The twelve animate nouns included *nanhai* 'boy', *nuhai* 'girl', *nanren* 'man', *nuren* 'woman', *gou* 'dog', *mao* 'cat', *yisheng* 'doctor', *bingren* 'patient', *xiaotou* 'thief', *jingcha* 'policeman', *shizi* 'lion', *xiong* 'bear'.

[13] Version One was first developed under the assumption that if the agrammatic patient's deficit is solely syntactic, the lexical reversal distractor will not be their possible choice, and only the correct picture and the thematic role reversal distractor will be relevant. Besides, the lexical plus thematic role reversal distractor will sometimes be wrongly chosen only for relative construction. However, among the four Broca's aphasics tested using Version One, only one patient exhibited selective comprehension deficits, we hence conjectured that a four-choice picture task might be too difficult to process for some patients and thus developed Version Two. One anonymous reviewer suggested that generally at chance performance be found only in Version One but not in Version Two. We checked previous studies using a sentence–picture matching task, and found that Grodzinsky (1989), Beretta and Munn (1998) and Miera and Cuetos (1998) used a three-choice task, but Caramazza and Zurif (1976), Sherman and Schweickert (1989), Hickok et al. (1993), Lukatela et al. (1995), and Beretta et al. (2001) adopted a two-choice task. Regarding the criteria for chance level, we considered both 50% and 75% for Version One, as discussed in Section 4 on results. What is noteworthy is that LDC, who participated in both versions of tests, exhibited selective comprehension deficits on thematic role assignment but not on adjective assignment, regardless of the number of distractor pictures.

Table 2
Predictions of the DDH on the seven types of sentences in Mandarin

Sentence types	Prediction	Sentence types	Prediction
Active	Above-chance		
Passive		Subject–relative	
Movement approach	Chance	Subject in Spec of IP	Above-chance
Non-Movement approach		VP-Internal Subject	Above-chance
Subject in Spec of IP	Above-chance	Object Relative	
VP-Internal Subject	Chance	Subject in Spec of IP	Above-chance
BA Construction		VP-Internal Subject	Chance
Movement approach		Subject Pseudo-Cleft	
Subject in Spec of IP	Above-chance	Subject in Spec of IP	Above-chance
VP-Internal Subject	Chance	VP-Internal Subject	Above-chance
Non-Movement approach		Object Pseudo-Cleft	
Subject in Spec of IP	Above-chance	Subject in Spec of IP	Above-chance
VP-Internal Subject	Above-chance	VP-Internal Subject	Chance

role reversal distractor, and once with a lexical reversal distractor, thus generating 420 trial sentences. All the pictures were simple, black and white line drawings. Figs. 1 and 2 illustrate the pictures used for a sentence in reversible and plausible conditions, respectively. In both versions, the trial sentences were divided into 7 (for Version One)

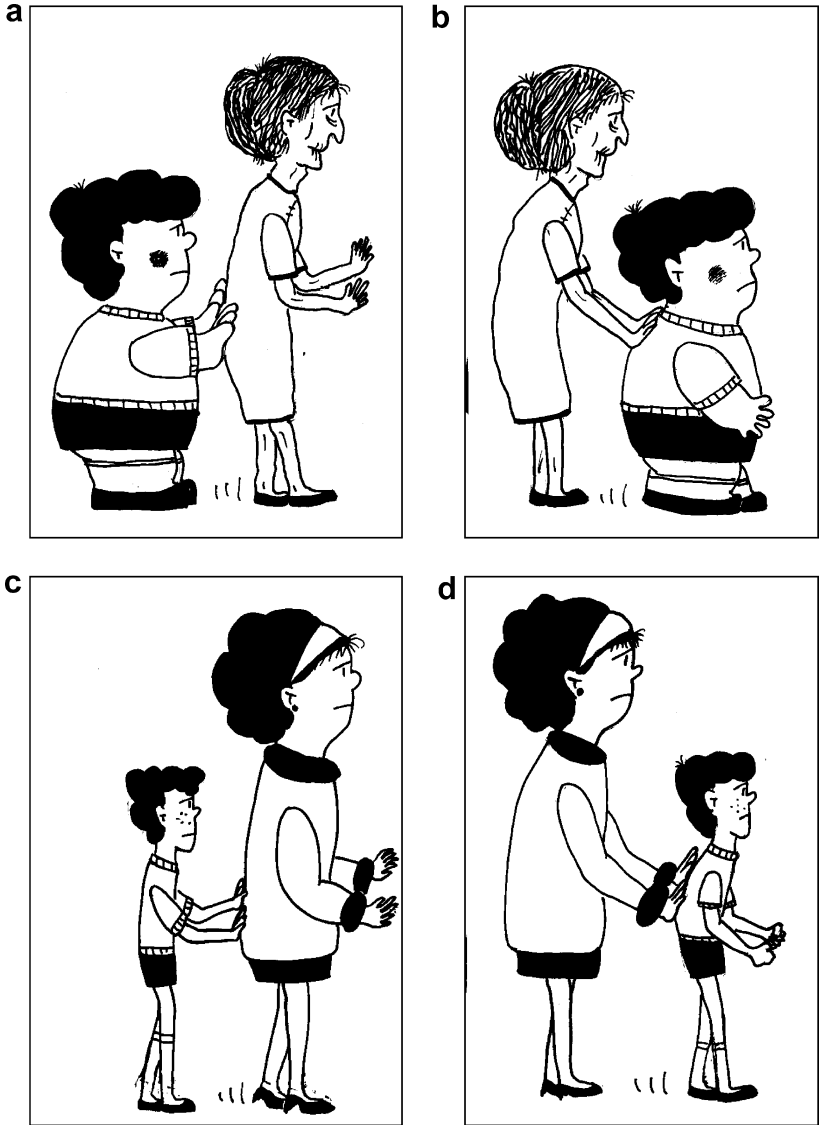

Fig. 1. Pictures used for *pang nanhai tui lao popo* "A fat boy is pushing an old lady." (a) Target picture. (b) Thematic role reversal distractor. (c) Lexical reversal distractor. (d) Lexical plus role reversal distractor.

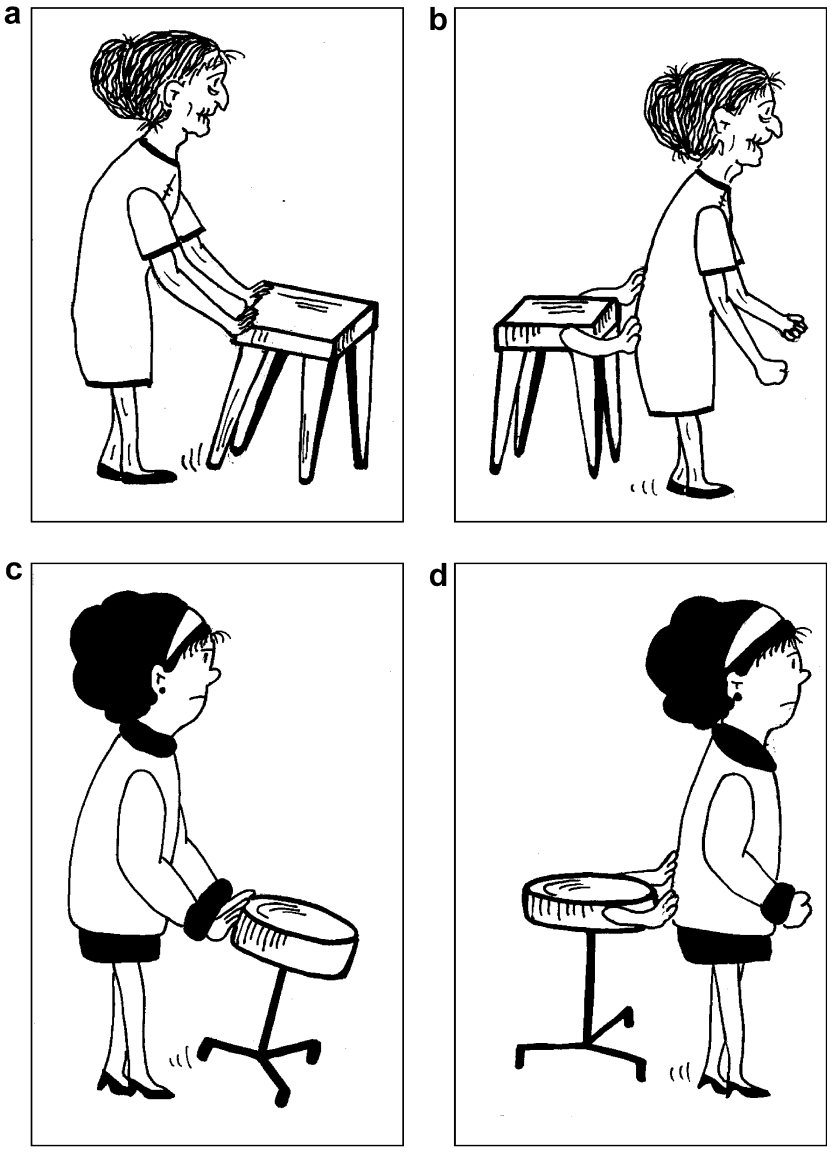

Fig. 2. Pictures used for *lao popo tui fang yizi* "An old lady is pushing a square stool." (a) Target. (b) Thematic role reversal distractor. (c) Lexical reversal distractor. (d) Lexical plus role reversal distractor.

or 14 (for Version Two) blocks, with reversibility conditions and sentence types counter-balanced in each block.

3.2. Procedure

A sentence–picture matching task was administered. At the beginning of the test, each subject was familiarized with the task with twelve practice trials, including one trial for active and passive sentences, and two trials for the other five types of sentences. Before each sentence was presented, the picture array was exposed. The subject was asked to listen to each sentence as many times as he/she needed and look carefully at all the pictures in the array, and then point to the picture that best depicted the meaning of the sentence. Feedback was given to the subject for the practice trials but not for the experimental trials. Subjects were tested individually in a quiet room in either one 1-h session or two half-hour sessions. All the responses of each subject were recorded on an answer sheet by the investigator.

3.3. Subjects

Nine aphasic subjects participated in this study, including six non-fluent type aphasics (four males and two females) and three fluent Wernicke-type aphasics (all males). Four of the Broca-type aphasics (LDC, ZZH, LGC, and HYY) were tested using Version One, and the other five subjects were tested using Version Two except for LDC, who participated in the study with both versions of the test.[14] All were outpatients of the Speech Pathology Division of the Department of Physical Medicine and

[14] Since Version One was administered before Version Two was developed, the other three Broca-type aphasics were not available when Version Two was carried out except for LDC.

Rehabilitation at Taipei Veterans General Hospital in Taiwan. All subjects were right-handed native speakers of Mandarin Chinese, and had at least 6 years of education. The age range was 31–71 for the non-fluent type aphasics and 60–63 for the fluent Wernicke-type aphasics. The classification of patients was based on a Mandarin version of the Boston Diagnostic Aphasia Examination (BDAE, Goodglass & Kaplan, 1972), and all the patients were at least 3 months post-onset at the beginning of testing. Neurologically intact control subjects, matched for age and educational background, were also tested. Since the control subjects performed flawlessly on both Version One and Version Two, they will not be discussed further. Detailed information about each patient is given in Table 3.

4. Results

4.1. Version One

Four of the Broca-type aphasics were tested using Version One. Table 4 presents the percentage of errors by the four subjects on the seven types of sentences.

The four Broca's aphasics did not display a homogeneous pattern of responses to the seven types of sentences in Version One. LDC had more difficulties on Subject Relative and Subject Pseudo-Cleft. ZZH showed above-chance performance for all sentence types, whereas LGC and HYY evidenced problems for virtually all types of sentences. The effect of sentence type was examined in a one-way analysis of variance with number of errors in the three semantic conditions as the random variable for each subject. Only LDC showed a significant effect on this variable ($F(6,12) = 10.29$, $p = .0002$), and the error rates from the other three subjects did not differ significantly among the seven sentence types ($p > .05$).

Table 4
Percentage of errors on each sentence type by four Broca-type aphasics (Version One)

Subject	A	P	B	SR	OR	SPC	OPC
LDC	3	10	10	43[a]	10	57[a,b]	3
ZZH	17	23	13	30	27	30	20
LGC	47[a,b]	53[a,b]	43[a]	53[a,b]	43[a]	57[a,b]	47[a,b]
HYY	73[b]	70[b]	67[a,b]	67[a,b]	50[a,b]	57[a,b]	63[a,b]

[a] 50% as chance-level error rate ($N = 30$, $df = 1$). Since each sentence was paired with four pictures in Version One, we consider both 50% error rate (i.e. assuming the patients did not have problems with lexical adjective assignment) and 75% error rate (i.e. assuming all the four pictures were randomly selected by the patients) as chance-level.
[b] 75% as chance-level error rate ($N = 30$, $df = 3$).

For LDC, a post hoc Tukey test revealed that Subject Relative elicited significantly worse performance than either Active, Object Pseudo-Cleft ($q(7,12) = 4$, $p < .01$), or Passive, BA construction, Object Relative ($q(7,12) = 3.33$, $p < .05$), and that Subject Pseudo-Cleft elicited worse performance than either Active, Object Pseudo-Cleft ($q(7,12) = 5.34$, $p < .01$), or Passive, BA construction, Object Relative ($q(7,12) = 4.67$, $p < .01$), but the comparison between Subject Relative and Subject Pseudo-Cleft was not significant ($p > .05$).

Since only LDC demonstrated a selective pattern of comprehension, and his performance for active sentences was nearly perfect, we further examined the types of errors he committed, i.e. whether he tended to select a role reversal distractor, a lexical reversal distractor, or a lexical plus role reversal distractor. As shown in Table 5, 33 out of the 41 total errors made by LDC were thematic role reversal errors. This is particularly obvious for the two sentence types on which he had chance-level performance, i.e. Subject Relative and Subject Pseudo-Cleft, in which the errors were predominantly role reversal. This demonstrated that the comprehension difficulty he had mainly involved the

Table 3
Background Information on Aphasic Subjects

Subjects	BDAE classification	Sex	Age at the time of testing	Time post-onset	Education (years)	Etiology
LDC	Broca (apraxia)	M	31	1 yr 4 months 1 yr 6 months	12	Head injury (subdural effusion in L frontal region)
ZZH	Broca	M	71	8 months	6	CVA (L frontal)
LGC	Broca	F	55	7 months	6	CVA (L basal ganglia & corona radiation)
HYY	Broca (apraxia)	F	59	3 yr	6	L MCA (middle cerebral artery) territory infarction
CQM	Broca (anomia)[a]	M	40	14 yr 1 month	16	Head injury (L intra-cerebral hemorrhage)
LCS	Trans. Motor	M	31	1 yr 8 month	18	L intra-cerebral hemorrhage
XHY	Wernicke	M	60	3 month	12	Lacunar infarction (L corona radiation)
KHC	Wernicke	M	62	4 month	9	Lacunar infarction (L lentiform nucleus)
XCJ	Wernicke	M	63	8 month	14	Cerebral infarction (L temporal-parietal)

[a] As one of the anonymous reviewers pointed out, Broca's aphasia is generally associated with anomia. However, for CQM, his picture naming for the Mandarin version of BDAE scored lower than LDC (49% vs. 82% correct, respectively), but his phrase repetition (scored 6) and sentence reading (scored 9) were higher than LDC (scored 2 and 4, respectively). As for word discrimination, CQM scored 52, which was comparable to LDC (64), LCS (51), and LGC (51). In general, CQM's naming problem was more profound, but his speech production problem was relatively milder than other Broca's patients. Although Broca's aphasia may sometimes be associated with anomia, the two types of symptoms do not necessarily go hand in hand. For example, the anomic patients in Miera and Cuetos (1998) do not demonstrate the kind of comprehension difficulties found in their agrammatic patients.

Table 5
Number of errors for each distractor type by LDC

	Role reversal	Lexical reversal	Role and lexical reversal
Active	0	0	1
Passive	0	2	1
BA Construction	3	0	0
Subject-relative	10	2	1
Object-relative	2	0	1
Subject Pseudo-Cleft	17	0	0
Object Pseudo-Cleft	1	0	0

assignment of thematic roles rather than the predicate-adjective relation as predicted by the RTDH.

Table 6 presents the individual subjects' error rates on the three semantic conditions.

In general, reversible and non-reversible implausible sentences were more difficult than non-reversible plausible sentences. As for the comparison of reversible and non-reversible implausible sentences, LDC and ZZH showed more errors on the former, but LGC and HYY displayed more problems on the latter. To examine the differences among the three semantic conditions, the data were submitted to a one-way analysis of variance with number of errors in each sentence type as the random variable. No significant difference was found for LDC and HYY ($p > .05$), but a significant effect was obtained for ZZH ($F(2,12) = 12.83$, $p = .0003$) and LGC ($F(2,12) = 7.58$, $p = .004$). A post hoc Tukey test showed that for ZZH, plausible non-reversible sentences were significantly easier than reversible ($q(3,12) = 3.14$, $p < .01$) and implausible non-reversible sentences ($q(3,12) = 2$, $p < .05$), but the difference between reversible and implausible non-reversible sentences was not significant ($p > .05$). For LGC, only the difference between plausible and implausible non-reversible sentences reached significance ($q(3,12) = 3.14$, $p < .05$).

4.2. Version Two

Three of the non-fluent aphasics (two Broca-type and one transcortical motor) and three fluent Wernicke-type aphasics were tested using Version Two. Table 7 shows the percentage of errors made by each patient for the seven sentence types.

For the three non-fluent type aphasics, CQM demonstrated above-chance performance on all the sentence types, whereas LDC and LCS had more difficulties on Subject Relative and Subject Pseudo-Cleft than on the other five types of sentences.[15] As for the three Wernicke's aphasics, XHY and XCJ displayed chance-level performance on the two types of relative sentences (XCJ also had chance-level performance on Passive), but KHC showed chance-level performance on Active, Passive, and BA constructions. The results were submitted to a one-way analysis of variance to examine the effect of sentence type. A significant effect was found for the three non-fluent type aphasics, i.e. LDC ($F(6,12) = 15.085$, $p = .000022$), LCS ($F(6,12) = 7.94$, $p = .0007$), and CQM ($F(6, 12) = 4.16$, $p = .013$), but not for the three fluent type patients (i.e. XHY, XCJ, and KHC, $p > .05$). Post hoc Tukey analyses revealed that for LDC, Subject Relative elicited significantly worse performance than Active ($q(7,12) = 7.67$, $p < .01$), Passive ($q(7,12) = 4.67$, $p < .05$), BA construction ($q(7,12) = 7$, $p < .01$), Object Relative ($q(7,12) = 6.34$, $p < .01$), and Object Pseudo-Cleft ($q(7,12) = 6.67$, $p < .01$). LDC's Subject Pseudo-Cleft was also significantly worse than Active ($q(7,12) = 7.33$, $p < .01$), Passive ($q(7,12) = 4.33$, $p < .05$), BA construction ($q(7,12) = 6.66$, $p < .01$), Object Relative ($q(7,12) = 6$, $p < .01$), and Object Pseudo-Cleft ($q(7,12) = 6.33$, $p < .01$). For LCS, Subject Relative was significantly worse than Active, Object Pseudo-Cleft ($q(7,12) = 6.33$, $p < .01$), BA construction ($q(7, 12) = 5.33$, $p < .01$), and Object Relative ($q(7,12) = 5$, $p < .01$). His Subject Pseudo-Cleft also elicited significantly worse performance than Active and Object Pseudo-Cleft ($q(7,12) = 4.66$, $p < .05$). For CQM, none of the sentence types differed significantly from each other.

Table 7
Percentage of errors on each sentence type by each subject for Version Two

Subject	A	P	B	SR	OR	SPC	OPC
LDC	0	15	3	38[a]	7	37	5
LCS	3	18	8	35	10	27	3
CQM	3	12	5	12	15	15	5
XHY	27	37	35	42[a]	47[a]	22	33
XCJ	32	42[a]	35	38[a]	42[a]	35	32
KHC	40[a]	40[a]	40[a]	30	35	32	37

[a] 50% as chance-level performance ($N = 60$, $df = 1$).

The results in Table 7 include both trials with thematic role distractor and trials with lexical distractor. In order to investigate the predictions of the hypotheses in more detail, we list the number of errors for the two types of distractors in each sentence type in Table 8.

The three non-fluent patients (i.e. LDC, LCS, and CQM) exhibited a distinctive pattern from the three fluent patients regarding distractor types; that is, they hardly made any errors (at most 3) when the target picture was

Table 6
Percentage of errors on each semantic condition by four Broca-type aphasics (Version One)

Subject	Reversible	Plausible	Implausible
LDC	26	13	20
ZZH	37	6	26
LGC	50	33	64
HYY	63	57	71

[15] Although LDC and LCS made more errors on Subject Relative and Subject Pseudo-Cleft than on the other five types of sentences, only LDC's error rate on Subject Relative was in chance-level. The error rates of LDC's Subject Pseudo-Cleft and LCS's Subject Relative were slightly above chance.

Table 8
Number of errors for Thematic Role Distractor vs. Lexical Distractor on each sentence type by each subject for Version Two[c]

Subject	A	P	B	SR	OR	SPC	OPC
LDC	0/0	6/3	2/0	23[b]/0	3/1	21[b]/1	3/0
LCS	1/1	11[a]/0	5/0	20[a]/1	5/1	16[a]/0	2/0
CQM	1/1	5/2	2/1	7/0	7/2	9/0	2/1
XHY	7/9	13[a]/9	9/12[a]	16[a]/9	17[a]/11[a]	8/5	10[a]/10[a]
XCJ	12[a]/7	16[a]/9	12[a]/9	17[a]/6	16[a]/9	15[a]/6	10[a]/9
KHC	15[a]/9	17[a]/7	14[a]/10[a]	12[a]/6	10[a]/11[a]	13[a]/6	17[a]/5

[a] 50% as chance level performance.
[b] Below chance performance ($N = 30$, $df = 1$).
[c] The number in front of the slash is the errors from thematic role trials, and that after the slash from lexical trials.

Table 9
Percentage of errors on each semantic condition by each subject for Version Two[a]

Subject	Reversible	Plausible	Implausible
LDC	17	14	14
LCS	14	19	11
CQM	9	9	11
XHY	38	35	31
XCJ	36	36	37
KHC	39	25	44

[a] Here both sentences with thematic role distractor and lexical distractor were included for analysis. Sentences with thematic role distractor showed the same pattern; i.e. only KHC had a significant effect.

paired with a lexical distractor, whereas the fluent aphasics made at least five errors out of 30 trials with a lexical distractor across all the sentence types. This amounts to saying that the errors committed by the non-fluent aphasics were mainly thematic role assignment, whereas the errors made by the fluent aphasics could be either thematic role assignment or adjective assignment. Like the results of LDC in Version One, the prediction of the RTDH that agrammatics would also have difficulty on the predicate adjective assignment of the matrix clause in relative construction was not attested by our results from the non-fluent patients in Version Two, either.

Since the hypotheses we are concerned with (i.e. the TDH and the DDH) mainly consider thematic role assignment, we take the error rates of the seven sentence types with thematic role distractor for further analysis. For the three non-fluent aphasics, CQM demonstrated above chance performance for all the sentence types, LCS showed chance-level performance for Passive, Subject Relative, and Subject Pseudo-Cleft, and LDC had below chance performance on Subject Relative and Subject Pseudo-Cleft, but above chance performance for the other five types of sentences. For the three fluent aphasics, XCJ and KHC displayed chance-level performance on all the sentence types, and XHY had chance-level performance on Passive, Subject Relative, Object Relative, and Object Pseudo-Cleft. The results were submitted to a one-way analysis of variance to examine the effect of Sentence Type. A significant effect was found for the three non-fluent aphasics, i.e. LDC ($F(6,12) = 24.56$, $p = .000001$), LCS ($F(6,12) = 8.06$, $p = .00067$), and CQM ($F(6,12) = 4.47$, $p = .0099$), but not for the three fluent aphasics ($p > .05$). Post hoc Tukey analyses revealed that for LDC, Subject Relative elicited significantly more errors than Active ($q(7,12) = 7.67$, $p < .01$), Passive ($q(7,12) = 5.67$, $p < .01$), BA construction ($q(7,12) = 7$, $p < .01$), Object Relative and Object Pseudo-Cleft ($q(7,12) = 6.67$, $p < .01$). His Subject Pseudo-Cleft also had significantly more errors than Active ($q(7,12) = 7$, $p < .01$), Passive ($q(7, 12) = 5$, $p < .01$), BA construction ($q(7,12) = 6.33$, $p < .01$), Object Relative and Object Pseudo-Cleft ($q(7, 12) = 6$, $p < .01$). For LCS, Subject Relative had significantly more errors than Active ($q(7,12) = 6.34$, $p < .01$), BA construction and Object Relative ($q(7,12) = 5$, $p < .01$), and Object Pseudo-Cleft ($q(7,12) = 6$, $p < .01$). His Subject Pseudo-Cleft also had significantly more errors than Active ($q(7,12) = 5$, $p < .01$), and Object Pseudo-Cleft ($q(7,12) = 4.66$, $p < .01$). For CQM, Subject Pseudo-Cleft elicited significantly more errors than Active ($q(7,12) = 2.67$, $p < .05$), BA construction and Object Pseudo-Cleft ($q(7,12) = 2.33$, $p < .05$).

Table 9 presents the individual subjects' error rates on the three semantic conditions.

Although the four non-fluent aphasics in Version One all showed clearly lower error rates for plausible non-reversible condition, the pattern was not found for either the non-fluent or the fluent patients in Version Two except for KHC. The effect of Semantic Conditions was examined in a one-way analysis of variance, and a significant effect was obtained only for KHC ($F(2,12) = 7.92$, $p = .0034$). A post hoc Tukey test showed that KHC's implausible non-reversible condition elicited significantly more errors than plausible non-reversible condition ($q(3,12) = 3.86$, $p < .05$), but the comparison between reversible and plausible non-reversible conditions did not reach significance.

5. Discussion

The results from our Mandarin-speaking aphasics demonstrated a distinction in comprehension performance between clinical aphasic syndromes; that is, none of the fluent Wernicke's aphasics showed selective pattern of comprehension difficulty, but three out of the six non-fluent aphasics did. What the fluent Wernicke's aphasics in this study displayed was an across-the-board problem with all of the sentence types tested. This differs from Lukatela et al. (1995), who found that Serbo-Croatian-speaking Broca's and Wernicke's aphasics as well as normal subjects showed the same pattern of errors, and they differed from each other only on the quantity of errors made. One possibility for this cross-linguistic discrepancy is that Mandarin does not have rich case morphology to provide cues for thematic role assignment as Serbo-Croatian does, and hence has to rely more on word order for sentence interpretation. This conjecture is supported by Caramazza and

Zurif's (1976) study in English, another language without rich case morphology. The results reported in Caramazza and Zurif (1976) showed that, unlike their normal subjects and Broca's or Conduction aphasics, the English-speaking Wernicke's aphasics had chance-level performance even for active sentences and semantically-constrained center-embedded sentences. In contrast, although not all of the Broca's patients showed selective deficits as an effect of sentence complexity, a subgroup of these patients (i.e. LDC, LCS, and CQM) did evince difficulties on some types but not others. The finding that only a subgroup of agrammatic aphasics manifests selective comprehension deficits is in line with the studies by Berndt, Mitchum, and Haendiges (1996) for English, Burchert, De Bleser, and Sonntag (2003) for German, and Caramazza, Capasso, Capitani, and Miceli (2005) for Italian, among others.

With respect to the manipulation of semantic conditions, it is noteworthy that unlike Sherman and Schweickert (1989), who found both semantic and syntactic information contributed to sentence comprehension in the agrammatic patients they tested, the three non-fluent aphasics who showed sentence type effect in our study did not display any significant effect on semantic constraints. Table 10 presents the detailed results from these three patients (LDC, LCS, and CQM).

As can be seen in Table 10, although for Subject Pseudo-Cleft, LDC made slightly less errors in plausible non-reversible condition than the other two conditions in both Version One and Version Two, and for Passive, he made more errors in reversible condition than the other two conditions in Version Two, the tendency was not consistent as it did not carry over to relative construction. Besides, neither LCS nor CQM demonstrated any tincture of adopting semantically based heuristic procedures. However, among the six patients (three Broca's from Version One and three Wernicke's from Version Two) who showed across-the-board difficulties for all sentence types, three of them (two Broca's, i.e. ZZH and LGC, and one Wernicke's, i.e. KHC) exhibited significant effects on semantic conditions; i.e. plausible non-reversible sentences were easier than reversible and implausible non-reversible ones. This finding suggests that, at least for the aphasic patients in the current study, heuristic procedures are employed only when the syntactic processing breaks down, and the adoption of heuristics is not limited to agrammatic patients. Therefore, syntactic and semantic processing can indeed be dissociable as postulated in Caramazza and Zurif (1976).

Table 10
Number of errors in each condition/sentence type from LDC, LCS, and CQM

Subject	A	P	B	SR	OR	SPC	OPC
LDC (Version One)							
Reversible	1	2	1	5	2	7	0
Plausible	0	1	0	4	0	3	1
Implausible	0	0	2	4	1	7	0
LDC (Version Two)							
Reversible	0	6	0	8	1	9	0
Plausible	0	2	2	7	1	5	2
Implausible	0	1	0	8	2	8	1
LCS							
Reversible	1	2	2	6	3	6	0
Plausible	0	7	2	8	2	7	1
Implausible	1	2	1	7	1	3	1
CQM							
Reversible	2	1	1	2	4	2	1
Plausible	0	3	1	2	2	3	1
Implausible	0	3	1	3	3	4	1

One of our major research interests for the current study is in which of the linguistically based hypotheses (i.e. the TDH or the DDH) can better account for our Mandarin results. Recall the predictions from the two hypotheses as summarized in Tables 1 and 2. The crucial distinction between the TDH versus the DDH resides in the relative construction and the pseudo-cleft sentences. According to the TDH, whether the order of the NPs in a sentence conforms to the canonical Agent-Theme order of the language plays an important role in determining how agrammatic patients interpret the sentence, and hence it predicts that for Mandarin, subject relative and subject pseudo-cleft sentences will pose more difficulty than object relative or object pseudo-cleft sentences. On the other hand, the DDH relies on the number of chains in the sentence as an index of comprehension difficulty, and thus predict that Mandarin, like English, will find that object relative and object pseudo-cleft sentences elicit more errors than subject relative and subject pseudo-cleft constructions if the VP-Internal Subject Hypothesis is adopted. However, under the assumption that in Mandarin Chinese, subject is directly generated as [Spec, IP], the DDH will predict the two types of relative and pseudo-cleft sentences to elicit above-chance performance. Our results from LDC and LCS, who displayed chance or below chance performance on subject relative and subject pseudo-cleft sentences but near normal performance on object relative and object pseudo-cleft, show that the prediction of the TDH but not the DDH is supported. A similar pattern was also found from a Mandarin-speaking Broca's aphasic CZ as reported in Su and Law (1993), and three Cantonese-speaking aphasics—LCC (transcortical motor aphasia) and WCK (conduction aphasia) in Law and Leung (1998), and CKC (anomic aphasia) in Law and Leung (2000).[16] Among the cases reported in either Mandarin or Cantonese who exhibited selective comprehension impairment, none of them showed the pattern as predicted by the DDH, i.e. above chance performance on subject relative but chance or below chance performance on object relative sentences.

[16] The error rates on subject relative sentences by these patients were—CZ (42.5%, chance), LCC (35%, chance), CKC (35%, chance), and WCK (70%, below chance), and the error rates for object relative sentences were all above chance—CZ (17.5%), LCC (20%), CKC (0), and WCK (0). The results of WCK were from a visual modality task and those of the other three patients were from an auditory task.

With respect to the active, passive, and BA constructions, although LDC, LCS and CQM all made more errors on passive than on active or BA constructions, only LCS showed chance-level performance on passive when thematic role reversal distractors were considered (as in Table 8). Similar variation was also found in Cantonese. The Cantonese-speaking patients LCC, THM, and WCK in Law and Leung (1998) showed above chance performance on active sentences but chance-level performance on full passive sentences in both visual and auditory modality tasks, whereas WPC displayed above chance performance in a visual modality task, but chance-level performance in an auditory modality task on both active and passive sentences. Another two Cantonese-speaking patients CKC and LKH reported in Law and Leung (2000) showed above chance accuracy on active, the corresponding BA sentences, and passive sentences in visual comprehension, but in auditory comprehension CKC exhibited chance-level performance on full passive but above chance performance on the other two types of sentences, whereas LKH demonstrated chance-level performance on all the three sentence types. Since Mandarin- and Cantonese-speaking patients did not all demonstrate chance-level performance on passives, one may conjecture that this can be attributed to the equivocal status of Mandarin and Cantonese passives as being derived through movement or not. However, previous studies on English (Berndt et al., 1996) and Italian (Caramazza et al., 2005) also revealed extensive variability in agrammatic aphasic patients' comprehension of active and passive sentences. Both studies found three distinct patterns of performances: both active and passive comprehended better than chance; both sentence types comprehended no better than chance; active sentences comprehended better than chance, but passive sentences comprehended no better than chance. Since similar variability exists cross-linguistically, a better explanation should be that the by-phrase provides a potential heuristic cue for interpretation in the passive sentences (e.g. Footnote 15 in Hickok et al., 1993), but such a cue is not available for either relative construction or pseudo-cleft sentences. As for the pattern of results from the BA construction, it can be easily explained by the TDH, as the two NPs follow the canonical Agent–Theme order, regardless of whether the movement or non-movement analysis is adopted. To account for the overall above chance performance on the BA construction, the DDH will have to assume a non-movement analysis, or to stipulate that the subject is directly generated in [Spec, IP]. The latter possibility will then lead to the prediction that the relative and the pseudo-cleft sentences all elicit above-chance performance in Mandarin, which is not verified by our results.

In general, the patterns of selective comprehension deficits found from the non-fluent Mandarin-speaking agrammatic patients in the current study and the Cantonese-speaking patients in Law and Leung (1998, 2000) can better be accounted for by the TDH than by the DDH. The results may suggest that the VP-Internal Subject Hypothesis does not apply in Mandarin or in Cantonese, and the Default Principle is adopted to help determining the assignment of thematic roles by agrammatic patients. However, when we consider the Non-Movement approach of Chinese BEI passive construction, i.e. if *bei* is analyzed as a verb taking an embedded clause as its complement and the Theme NP does not move from the post-verb position, the prediction made by the TDH would be above-chance performance under the assumption that the subject is directly generated in [Spec, IP] (see Table 1). Neither the results from the Mandarin-speaking patients in the current study nor the patterns found in Cantonese as reported in Law and Leung (1998, 2000) substantiate this prediction. Therefore, the VP-Internal Subject Hypothesis may still apply in Mandarin as well as in Cantonese, and what is crucial about agrammatic thematic role assignment resides in the Default Principle. Moreover, the relative ease of the object-extracted relative and pseudo-cleft sentences versus the difficulty of the subject-extracted sentences for Mandarin- and Cantonese-speaking agrammatic patients also shed light on the important role played by the canonical Agent-Theme order in languages without rich inflectional or case morphology as Mandarin and Cantonese, regardless of the number of chains in the sentence. The findings from the current study suggest that when syntactic representation cannot be consistently utilized for interpretation, the cognitive mechanisms underlying agrammatic sentence processing employ the canonical Agent–Theme order as stated in the Default Principle for sentence comprehension. Accordingly, the Default Principle should be indispensable in accounting for agrammatic patients' selective comprehension deficits, especially when word order is the exclusive cue for interpretation.

Our second research issue concerns the prediction of the RTDH that agrammatic patients would also have difficulty on the predicate adjective assignment of the matrix clause in relative construction, it was not supported by the results from any of our non-fluent patients as shown in Tables 5 and 8, nor by the results from Cantonese in Law and Leung (1998, 2000). This finding suggests that since in English a relative clause intervenes between the subject NP and the matrix predicate, whereas in Mandarin the two are adjacent to each other (as shown in (27)), a "long-distance association" (Hickok et al., 1993, p. 387) between the subject NP of a matrix clause and its VP-internal trace is the source of comprehension difficulty found in English.

(27) a. Subject-Relative (SR)
zhui gou de mao hen xiao
chase dog COMP cat very small
"The cat that chased the dog was very small."

b. Object-Relative (OR)
gou zhui de mao hen da
dog chase COMP cat very big
"The cat that the dog chased was very big."

A final point worth mentioning is whether the selective comprehension deficits manifested in agrammatic patients reflect a deficiency in the linguistic structures as proposed in the hypotheses discussed here, or result from a general limitation in processing capacity (e.g. Crain, Ni, & Shankweiler, 2001; Haarmann & Kolk, 1991; Miyake, Carpenter, & Just, 1994, 1995). Although in the current study we do not have direct evidence to address this question, the findings from other relevant studies may shed some light on the issues. Regarding the relation between working memory limitation and sentence comprehension, Miera and Cuetos (1998) found that Spanish-speaking agrammatic patients displayed selective comprehension deficits but not anomic patients, but the two groups of patients both had a low memory span compared with normal subjects. In addition, the Hebrew-speaking agrammatic aphasics tested in Friedmann and Gvion (2003) failed in the comprehension of object relatives but not on subject relatives, but the conduction aphasics, although showing severe working memory limitation, did well on all types of relative clauses irrespective of the antecedent-gap distance. Since patients in the current study were not under any kind of time constraints when they were tested, it would be unlikely that the selective patterns found from the three patients resulted from limited processing capacity. As for whether agrammatic comprehension reflects any deficits in chain formation, Zurif, Swinney, Prather, Solomon, and Bushell (1993) report that Broca's aphasics in their study did not show the normal priming for the head noun phrase of the relative clause at the corresponding position in the relative clause where a trace is linked to the head noun via a chain, whereas Wernicke's aphasics showed the normal processing reflection of chain formation. Another piece of evidence comes from a recent study by Friedmann, Novogrodsky, and Gvion (2005), in which they explored the nature of deficits in Hebrew-speaking agrammatic patients and children with syntactic SLI who had difficulties understanding object relative clauses. The subjects were asked to read aloud and paraphrase noun–verb homographs incorporated in object relative clauses as shown in the following example.

(28) *ha-baxur*$_1$ she-ha-yeled ahav t_1 GZR itonim yeshanim

the-guy$_1$ that-the-boy liked t_1 cut/carrot newspapers old

"The guy that the boy liked cut old newspapers."

The results showed that the majority (87%) of errors made by agrammatic patients were to read the homograph which should be a verb as a noun after the trace in relative clauses, but children with SLI read the homographs after the trace correctly, although both groups failed to interpret the object relative sentences.

To sum up, the data obtained in this study from Mandarin-speaking aphasics allow us to conclude that syntactic and semantic processing can indeed be dissociable. In addition, despite some problems regarding the Default Principle as discussed in Mauner (1995) and Beretta and Munn (1998), among others, our results from Mandarin as well as previous studies in Cantonese by Law and Leung (1998, 2000) all showed the principle as stated in the TDH can better account for the selective comprehension deficits than the DDH for these two languages. Like English, the canonical word order in Mandarin is SVO, but the two languages differ in that the head noun precedes the relative clause in English, but it follows the relative clause in Chinese. Although both hypotheses can explain the patterns found in English, our results provide clear evidence for the important role the canonical Agent–Theme order plays in agrammatic comprehension. In order to have a better understanding about the nature of deficits in agrammatic comprehension, more cross-linguistic studies on languages with word order properties similar to Mandarin and Cantonese (e.g. the relative construction in Japanese or Korean) are certainly needed to provide more empirical evidence to test the validity of the predictions from these linguistically based hypotheses and to examine the interaction of the canonical Agent–Theme order and morphological cues on aphasic sentence processing.

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Appendix A. Trials for active sentences

I. Reversible condition

1. nianqing nyuren la shou nanhai
   young woman pull skinny boy
   "The young woman pulled the skinny boy."
2. shou nyuhai da pang nanren
   skinny girl hit fat man
   "The skinny girl hit the fat man."

3. da gou zhui xiao mao
   big dog chase small cat
   "The big dog chased the small cat."
4. lao popo tui pang nanhai
   old lady push fat boy
   "The old lady pushed the fat boy."
5. pang nanhai bao lao popo
   fat boy hold old lady
   "The fat boy held the old lady."
6. shou yisheng tuo pang bingren
   skinny doctor drag fat patient
   "The skinny doctor dragged the fat patient."
7. pang nanren bei shou nyuhai
   fat man carry skinny girl
   "The fat man carried the skinny girl."
8. xiao mao yao da gou
   small cat bite big dog
   "The small cat bit the big dog."
9. ai xiaotou pai gao jingcha
   short thief pat tall policeman
   "The short thief patted the tall policeman."
10. xiao shizi tian da xiong
    small lion lick big bear
    "The small lion licked the big bear."

II. Plausible condition

1. pang nanhai la bai chezi
   fat boy pull white car
   "The fat boy pulled the white car."
2. pang nanren da hei shadai
   fat man hit black sandbag
   "The fat man hit the black sandbag."
3. xiao gou zhui da qiu
   small dog chase big ball
   "The small dog chased the big ball."
4. lao popo tui fang yizi
   old lady push square chair
   "The old lady pushed the square chair."
5. nianqing nyuren bao da shu
   young woman hold big book
   "The young woman held the big book."
6. shou yisheng tuo xiao pixiang
   skinny doctor drag small suitcase
   "The skinny doctor dragged the small suitcase."
7. pang nanren bei xiao beibao
   fat man carry small backpack
   "The fat man carried the small backpack."
8. da mao yao hei xie
   big cat bite black shoe
   "The big cat bit the black shoe."
9. shou nanhai pai bai zhuozi
   skinny boy pat white table
   "The skinny boy patted the white table."
10. da shizi tian xiao qiu
    big lion lick small ball
    "The big lion licked the small ball."

III. Implausible condition

1. hei chezi la shou nanhai
   black car pull skinny boy
   "The black car pulled the skinny boy."
2. bai shadai da shou nanren
   white sandbag hit skinny man
   "The white sandbag hit the skinny man."
3. xiao qiu zhui da gou
   small ball chase big dog
   "The small ball chased the big dog."
4. yuan yizi tui nianqing nyuren
   round chair push young woman
   "The round chair pushed the young woman."
5. xiao shu bao lao popo
   small book hold old lady
   "The small book held the old lady."
6. da pixiang tuo pang yisheng
   big suitcase drag fat doctor
   "The big suitcase dragged the fat doctor."
7. da beibao bei shou nanren
   big backpack carry skinny man
   "The big backpack carried the skinny man."
8. bai xie yao xiao mao
   white shoe bite small cat
   "The white shoe bit the small cat."
9. hei zhuozi pai pang nanhai
   black table pat fat boy
   "The black table patted the fat boy."
10. xiao qiu tian da shizi
    small ball lick big lion
    "The small ball licked the big lion."

References

Aoun, J., & Li, Y.-H. A. (1989). Scope and constituency. *Linguistic Inquiry, 20*, 141–172.

Bates, E., Friederici, A., & Wulfeck, B. (1987). Comprehension in aphasia: a cross-linguistic study. *Brain and Language, 32*, 19–67.

Bender, E. (2000). The syntax of Mandarin BA: reconsidering the verbal analysis. *Journal of East Asian Linguistics, 9*, 105–145.

Beretta, A., & Munn, A. (1998). Double-agents and trace-deletion in agrammatism. *Brain and Language, 65*, 404–421.

Beretta, A., Schmitt, C., Halliwell, J., Munn, A., Cuetos, F., & Kim, S. (2001). The effects of scrambling on Spanish and Korean agrammatic interpretation: why linear models fail and structural models survive. *Brain and Language, 79*, 407–425.

Berndt, R. S., Mitchum, C. C., & Haendiges, A. N. (1996). Comprehension of reversible sentences in "agrammatism": a meta-analysis. *Cognition, 58*, 289–308.

Bradley, D. C., Garrett, M. E., & Zurif, E. B. (1980). Syntactic deficits in Broca's aphasia. In D. Caplan (Ed.), *Biological studies of mental processes*. Cambridge, MA: MIT Press.

Burchert, F., De Bleser, R., & Sonntag, K. (2003). Does morphology make the difference? Agrammatic sentence comprehension in German. *Brain and Language, 87*, 323–342.

Caplan, D., & Futter, C. (1986). Assignment of thematic roles by an agrammatic aphasic patient. *Brain and Language, 27*, 111–134.

Caramazza, A., & Zurif, E. B. (1976). Dissociation of algorithmic and heuristic processes in language comprehension: evidence from aphasia. *Brain and Language, 3*, 572–582.

Caramazza, A., Capasso, R., Capitani, E., & Miceli, G. (2005). Patterns of comprehension performance in agrammatic Broca's aphasia: a test of the Trace Deletion Hypothesis. *Brain and Language, 94*, 43–53.

Chomsky, N. (1981). *Lectures on Government and Binding*. Dordrecht: Foris.

Crain, S., Ni, W., & Shankweiler, D. (2001). Grammatism. *Brain and Language, 77*, 294–304.

Friedmann, N. (2000). Agrammatic comprehension of OVS and OSV structures in Hebrew. *Behavioral and Brain Sciences, 23*, 33–34.

Friedmann, N., & Gvion, A. (2003). Sentence comprehension and working memory limitation in aphasia: a dissociation between semantic-syntactic and phonological reactivation. *Brain and Language, 86*, 23–39.

Friedmann, N., Novogrodsky, R., & Gvion, A. (2005). Syntactic movement in agrammatism and S-SLI: two different impairments. Talk given in Generative Approaches to Language Acquisition (GALA), September 8–10, Siena, Italy.

Goodglass, H., & Kaplan, E. (1972). *The assessment of aphasia and related disorders*. Philadelphia, PA: Lea & Febiger.

Grimshaw, J. (1990). *Argument structure*. Cambridge, MA: MIT Press.

Grodzinsky, Y. (1986). Language deficits and the theory of syntax. *Brain and Language, 27*, 135–159.

Grodzinsky, Y. (1989). Agrammatic comprehension of relative clauses. *Brain and Language, 37*, 480–499.

Grodzinsky, Y. (1990). *Theoretical perspectives on language deficits*. Cambridge, MA: MIT Press.

Grodzinsky, Y. (1995). A restrictive theory of trace deletion in agrammatism. *Brain and Language, 50*, 27–51.

Hagiwara, H. (1993). The breakdown of Japanese passives and theta-role assignment principle by Broca's aphasics. *Brain and Language, 45*, 318–339.

Hagiwara, H., & Caplan, D. (1990). Syntactic comprehension in Japanese aphasics: effects of category and thematic role order. *Brain and Language, 38*, 159–170.

Haarmann, H. J., & Kolk, H. H. J. (1991). A computer model of the temporal course of agrammatic sentence understanding: the effects of variation in severity and sentence complexity. *Cognitive Science, 15*, 49–87.

Heilman, K. M., & Scholes, R. J. (1976). The nature of comprehension errors in Broca's, Conduction, and Wernicke's aphasias. *Cortex, 12*, 258–265.

Hickok, G. (1992). Agrammatic comprehension and the trace-deletion hypothesis. Occasional Paper No. 45, MIT Center for Cognitive Science. MIT, Cambridge, MA.

Hickok, G., Zurif, E., & Canseco-Gonzalez, E. (1993). Structural description of agrammatic comprehension. *Brain and Language, 45*, 371–395.

Huang, C.-T. J. (1993). Reconstruction and the structure of VP: some theoretical consequences. *Linguistic Inquiry, 24*, 103–138.

Huang, C.-T. J. (1999). Chinese passives in comparative perspective. *Tsing Hua Journal of Chinese Studies, 29*, 423–509.

Kean, M. L. (1977). The linguistic interpretation of aphasic syndromes: agrammatism in Broca's aphasia, an example. *Cognition, 5*, 9–46.

Koopman, H., & Sportiche, D. (1991). The position of subjects. *Lingua, 85*, 211–258.

Law, S.-P., & Leung, M.-T. (1998). Sentence comprehension in Cantonese Chinese aphasic patients. *Aphasiology, 12*, 49–63.

Law, S.-P., & Leung, M.-T. (2000). Sentence processing deficits in two Cantonese aphasic patients. *Brain and Language, 72*, 310–342.

Li, Y.-H. A. (1990). *Order and constituency in Mandarin Chinese*. Dordrecht: Kluwer Academic.

Linebarger, M. C. (1989). Neuropsychological evidence for linguistic modularity. In G. N. Carlson & M. K. Tanenhaus (Eds.), *Linguistic structure in language processing* (pp. 197–238). Dordrecht: Kluwer.

Linebarger, M. C. (1990). Neuropsychology of sentence parsing. In A. Caramazza (Ed.), *Cognitive neuropsychology and neurolinguistics* (pp. 55–122). Hillsdale, NJ: Erlbaum.

Linebarger, M. C., Schwartz, M. F., & Saffran, E. M. (1983). Sensitivity to grammatical structure in so-called agrammatic aphasics. *Cognition, 13*, 361–392.

Lukatela, K., Crain, S., & Shankweiler, D. (1988). Sensitivity to inflectional morphology in agrammatism: investigation of a highly inflected language. *Brain and Language, 33*, 1–15.

Lukatela, K., Shankweiler, D., & Crain, S. (1995). Syntactic processing in agrammatic aphasia by speakers of a Slavic language. *Brain and Language, 49*, 50–76.

Mauner, G. (1995). Examining the empirical and linguistic bases of current theories of agrammatism. *Brain and Language, 50*, 339–368.

Mauner, G., Fromkin, V. A., & Cornell, T. L. (1993). Comprehension and acceptability judgments in agrammatism: disruptions in the syntax of referential dependency. *Brain and Language, 45*, 340–370.

Miceli, G., Mazzucchi, A., Menn, L., & Goodglass, H. (1983). Contrasting cases of Italian agrammatic aphasia without comprehension disorder. *Brain and Language, 19*, 65–97.

Miera, G., & Cuetos, F. (1998). Understanding disorders in agrammatic patients: capacity or structural deficits? *Brain and Language, 64*, 328–338.

Miyake, A., Carpenter, P. A., & Just, M. A. (1994). A capacity approach to syntactic comprehension disorders: making normal adults perform like aphasic patients. *Cognitive Neuropsychology, 11*, 671–717.

Miyake, A., Carpenter, P. A., & Just, M. A. (1995). Reduced resources and specific impairments in normal and aphasic sentence comprehension. *Cognitive Neuropsychology, 12*, 651–679.

O'Grady, W., & Lee, M. (2001). The isomorphic mapping hypothesis: evidence from Korean. *Brain and Cognition, 46*, 226–230.

O'Grady, W., & Lee, M. (2005). A mapping theory of agrammatic comprehension deficits. *Brain and Language, 92*, 91–100.

Schwartz, M. F., Linebarger, M. C., Saffran, E. M., & Pate, D. S. (1987). Syntactic transparency and sentence interpretation in aphasia. *Language and Cognitive Processes, 2*, 85–113.

Schwartz, M. F., Saffran, E. M., & Marin, O. S. M. (1980). The word order problem in agrammatism: I.Comprehension. *Brain and Language, 10*, 249–262.

Shankweiler, D., Crain, S., Gorrell, P., & Tuller, B. (1989). Reception of language in Broca's aphasia. *Language and Cognitive Processes, 4*, 1–33.

Sherman, J. C., & Schweickert, J. (1989). Syntactic and semantic contributions to sentence comprehension in agrammatism. *Brain and Language, 37*, 419–439.

Su, Y.-C., & Law, S.P. (1993) A study of syntactic comprehension of a Chinese agrammatic patient. Paper presented at the International Conference on Chinese Linguistics 2, Paris.

Tang, S.-W. (2001). A complementation approach to Chinese passives and its consequences. *Linguistics, 39*, 257–295.

Ting, J. (1998). Deriving the bei-construction in Mandarin Chinese. *Journal of East Asian Linguistics, 4*, 319–354.

Zou, K. (1993). The syntax of the Chinese BA construction. *Linguistics, 31*, 715–736.

Zurif, E., Swinney, D., Prather, P., Solomon, J., & Bushell, C. (1993). An on-line analysis of syntactic processing in Broca's and Wernicke's aphasia. *Brain and Language, 45*, 448–464.