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Judgements of grammaticality in aphasia: The special case of Chinese

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Abstract

Theories of agrammatism have been challenged by the discovery that agrammatic patients can make above-chance judgements of grammaticality. Chinese poses an interesting test of this phenomenon, because its grammar is so austere, with few obligatory features. An on-line grammaticality judgement task was conducted with normal and aphasic speakers of Chinese, using the small set of constructions that do permit judgements of grammaticality in this language. Broca's and Wernicke's aphasics showed similar patterns, with above-chance discrimination between grammatical and ungrammatical forms, suggesting once again that Broca's aphasics are not unique in the degree of sparing or impairment that they show in receptive grammar. However, even for young normals, false-negative rates were high. We conclude that there is some sensitivity to grammatical well-formedness in Chinese aphasics, but the effect is fragile for aphasics and probabilistic for normals, reflecting the peculiar status of grammaticality in this language.

Judgements of grammatical well-formedness have played an important role in theoretical linguistics since the 1950s, serving as the primary tool for the formulation and testing of competing syntactic theories (Levelt 1972, 1974, 1977, Newmeyer 1980). More recently, grammaticality judgments (also called 'error detection' or 'violation detection') have also contributed to our understanding of brain organization for language, serving to clarify the nature of the grammatical impairments observed in aphasic patients. The purpose of the present study is to add to the growing literature on grammaticality judgements in aphasia from the special perspective of Chinese, a language that raises interesting questions about the very concept of 'grammaticality'.

In the period between 1976 and 1985, numerous studies appeared suggesting that Broca's aphasics suffer from a centralized grammatical deficit that affects all aspects of language processing, receptive and expressive (e.g. Caramazza and Zurif 1976, Heilman

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and Scholes 1976, von Stockert and Bader 1976, Zurif and Caramazza 1976, Bradley et al. 1980). The claims that emerged from studies of agrammatic aphasia are illustrated by the following quote from Zurif and Caramazza (1976: 270, italics ours):

> The particular effects of anterior brain damage are not limited to speech; nor are these effects due to an economy of effort. Rather, at no level does the agrammatic patient appear fully capable of processing the small words of language, especially those words that function as syntactic markers for implicit grammatical structure.

This was a reasonable and influential hypothesis, but it was soon challenged by studies in several languages showing that agrammatic Broca's aphasics perform at above-chance levels in grammaticality judgement tasks (Linebarger et al. 1983, Wulfeck 1988, Shankweiler et al. 1989, Wulfeck and Bates 1991, Wulfeck et al. 1991). This discovery poses a serious problem for any theory that ascribes deficits in comprehension and/or production of grammar to the loss of a localized grammatical processor, i.e. the doctrine of central agrammatism (for reviews, see Bates and Wulfeck 1989, Bates et al. 1991). Some investigators continue to propose modified versions of the central agrammatism hypothesis, based on a more restricted set of structures and/or processes (Caplan 1987, Garrett 1992, Grodzinsky 1990, 1993, in press, Hickock et al. 1993, Mauner et al. 1993). However, the demonstration of grammaticality judgements in agrammatic aphasia has persuaded many investigators that grammatical knowledge is preserved in these patients, leading them to abandon central agrammatism in favour of a theory in which grammatical symptoms are produced indirectly, via damage to lexical, phonological and/or extra-linguistic mechanisms that interact with the grammar (Friederici 1985, Bates 1991, Prather et al. 1991, Hagoort 1993, Ostrin and Tyler 1993, Haarmann and Kolk 1994, Jarema and Friederici 1994, Milberg et al. 1995, Plaut 1995, Blumstein 1997, Dick et al. 1998). This shift in perspective is illustrated by the following quote from Zurif et al. (1993: 462):

> The brain region implicated in Broca's aphasia is not the locus of syntactic representations per se. Rather, we suggest that this region provides processing resources that sustain one or more of the fixed operating characteristics of the lexical processing system—characteristics that are, in turn, necessary for building syntactic representations in real time.

In the experiment described here, we will provide a further test of the hypothesis that aphasic patients retain detailed knowledge of their native grammar, even though they can no longer access that knowledge as efficiently as normal controls. We will focus on both fluent and non-fluent aphasic patients who are native speakers of a variant of Mandarin Chinese spoken in Taiwan, in an 'on-line' violation detection task similar to the ones that have been used with patients in other language groups (e.g. Shankweiler et al. 1989, Wulfeck et al. 1991, Devescovi et al. 1997). The term 'on-line' is used here to refer to any task that provides information about the time course of language processing. Although it could be argued that an on-line violation detection task has a much coarser temporal grain than other on-line language-processing tasks (e.g. cross-modal naming or other word-by-word tracking tasks), participants in our study (as in other on-line studies of grammaticality judgement) were free to make their judgement as soon as they had detected an error, before the sentence was complete (for a detailed discussion, see Blackwell and Bates 1995).

As we will explain in more detail later, the Chinese language offers a particularly interesting perspective on this issue, because it has properties that challenge the notion of grammaticality as it has been applied in studies of Indo-European languages. We will show that grammaticality judgement is a fragile and probabilistic phenomenon in

Chinese, even for college students. And yet, even under these conditions, fluent and non-fluent aphasic patients retain above-chance sensitivity to grammatical well-formedness in their language. Before we describe the experiment and our results for aphasic patients and controls, a brief review of Chinese grammar is in order, to illustrate exactly why the problem of grammaticality judgement is so interesting in this language.

Grammar and grammaticality in Chinese

The Chinese language has what may be the most austere grammar in the world, with a number of features that make it extremely difficult to create a sentence that is unambiguously ungrammatical. The relevant features include the following (all examples here and all stimuli in the experiment itself are in Mandarin Chinese).

Minimal morphology

Chinese has no conjugation paradigms (i.e. no inflections for tense, aspect, person or number on verbs) and no declension paradigms (i.e. no inflections for gender or number on nouns and/or their modifiers). Instead, grammatical relations are conveyed in Chinese through a combination of word order regularities (see later), free-standing grammatical function words, and a small set of particles (e.g. aspect markers). The latter can be viewed as bound morphemes (based on standard tests for interposition), but they are fixed in form and meaning and do not undergo the kind of variation that characterizes inflectional paradigms in other languages.

The class of grammatical function words or particles in Chinese includes the object marker ba (把), the passive marker bei (被), a small set of aspect markers to indicate completion or duration/iteration of the events encoded by the verb—including le (了), zai (在) and zhe (著)—a limited set of prepositions and quantifiers, together with a relatively large set of noun classifiers. The classifier set is particularly interesting because it occupies a middle ground between grammar and semantics. Nouns are assigned to classifiers based on features related to some abstract semantic dimensions, especially (though not exclusively) features related to physical shape. However, these semantic relations can vary from highly concrete and transparent to highly abstract and occasionally quite opaque.

Most of these function words or particles are monosyllables, and are near-homophones of semantically related content words (differing from their homophones primarily by degree of cliticization, i.e. low phonetic stress, or by shifts in the shape of the vowel). For example, notions of time and duration are indicated with syllables that have a transparent temporal meaning, e.g. 'chi-wan' (吃完), equivalent to saying something like 'Eat – finish' in English to indicate an activity that is already past. Noun-related notions like number are also indicated with a single particle 'men' (們), as in 'haizi-men' (孩子們), equivalent to something like 'child – many' to indicate the plural concept 'children'. Although these function words and particles are common in everyday discourse, they are optional in many contexts (see later), and as a result, they tend to be less frequent than their counterparts in Indo-European languages.

Minimal syntax

The canonical or pragmatically neutral word order in Chinese is Subject-Verb-Object (SVO), similar to many Indo-European languages. However, Chinese permits several pragmatically conditioned word order variations that would be illegal in English, including Subject-Object-Verb (SOV), Object-Subject-Verb (OSV) and Verb-Object-Subject (VOS) (Lu 1980, Li and Thompson 1981, Huang 1984, Li et al. 1993). For example:

SOV Wo yao chi le 我藥吃了 (I-medicine-eat-aspect marker)
OSV Yao wo chi le 藥我吃了 (medicine-I-eat-aspect marker)
VOS Chi le yao wo 吃了藥我 (eat-aspect marker-medicine-I)

Complicating matters further, Chinese also permits omission of both the subject and the object in free-standing declarative sentences. As a result, a fragment in the order VN (e.g. 'kan mama' or '看媽媽') could be interpreted either as Verb-Subject or VS (in which the mother is invited to see) or as Verb-Object or VO (in which the mother is being seen). Similarly, a fragment in the order NV (e.g. 'mama kan' or '媽媽看') could be interpreted either as Subject-Verb or SV (in which the mother sees) or as Object-Verb or OV (in which the mother is seen). In everyday language use, the choice between canonical and non-canonical interpretations rests on a complex interplay of lexical, semantic, pragmatic and/or prosodic factors. Taken out of context, many different orders are possible, and even though some combinations may be judged as 'odd' when Chinese listeners are asked to judge their well-formedness (Liu et al. 1992a,b), almost any combination can be interpreted reliably by native speakers (Li 1996, 1998).

Interacting constraints on morphosyntax

Although the order of basic sentence constituents is relatively flexible in Chinese, there are constraints on the placement of optional function words within a sentence frame. For example, the aspect marker zai occurs obligatorily in preverbal position (zaiV), while the aspect marker zhe is placed obligatorily in post-verbal position (V-zhe). Similarly, noun classifiers are obligatory whenever a noun is preceded and modified by a quantifier or a determiner. When this occurs, the classifier is placed obligatorily after the determiner and before the noun, as in 'si ding maozi' (四頂帽子, 'four [classifier] hat') or 'liang ben cidian' (兩本辭典, 'Two [classifier] dictionary').

There are also constraints on the positions of ba and bei within a sentence, and additional constraints on the sentence orders in which these particles usually occur. For example, the object marker ba occurs most often in SOV sentences, in the order N ba NV, while the passive marker bei occurs most often in OSV sentences, in the order N bei NV. Although these are the canonical orders for ba and bei, they are not absolute, because the frequent omission of both subjects and objects in Chinese permits a range of topicalised and/or afterthought structures that are marginally acceptable and/or interpretable to native speakers (Liu et al. 1992a,b, Li 1996). Furthermore, many native speakers accept the bare order NNV as an acceptable sentence, without object or passive markers, even though this is the structure in which the two markers are supposed to occur. When this occurs, both OSV and SOV interpretations are possible (Liu et al. 1992a,b, Li 1996).

Although ba and bei are semantically and syntactically associated with the object role, they are far less productive than the familiar accusative markers used by many Indo-European languages. In addition to the probabilistic interactions with word order that we have just described, both markers are conditioned by extra-grammatical factors that cut across levels of analysis (and constrain the set of stimuli that we can use in the present experiment).

The object marker ba is derived from the verb ba (meaning 'take hold of' or 'grasp' in ancient Chinese). Although its original verbal meaning has virtually disappeared in modern Chinese, its trace can still be seen in that ba normally requires an object that is highly affected by the activity denoted by the verb (i.e. causative and resultative verbs). For this reason, traditional grammars have termed the ba construction 'the disposal construction' (Wang 1957). Additional constraints on the use of ba include the requirement that the object must be definite (although there are no articles in Chinese to indicate this fact), and the verb phrase in the ba construction must be structurally complex (i.e. single monosyllabic verbs cannot occur alone with ba—Ding 1961, Li 1990).

An equally complex story holds for the passive marker bei (meaning 'to cover, to wear' in ancient Chinese). This marker originated historically in association with adverse consequences, indicating that something unfortunate or undesired has happened (cf. Li and Thompson 1981). This association has weakened considerably in modern Chinese, with bei gradually extended to a broader range of contexts (Wang 1957, Chao 1968), but the correlation is still evident to many native speakers.

In the construction of materials for the present study, we have ensured that all of these extra-grammatical constraints are followed, to maximize the ecological validity of the items.

Creating grammatical violations in Chinese

Due to the interacting effects of optional function words, variable word order and omission of constituents, it is extraordinarily difficult to create unambiguous grammatical violations in Chinese. Almost any fragment, in any order, can be grammatical when taken out of context. In fact, the Chinese language does not have a term corresponding to the English word 'ungrammatical'. In studies of grammaticality judgements in Chinese (including the present study), we have used the following two expressions for 'grammatical',

(1) 'he yufa' (合語法)
suit language law
(2) 'tungshun' (通順)
smooth

and the corresponding two terms for 'ungrammatical',

(1) 'bu he yufa' (不合語法)
not suit language law
(2) 'bu tungshun' (不通順)
not smooth

The first term 'he yufa' (合語法) is the one that is usually used to translate the word 'grammar' in linguistic texts. The second term 'tungshun' (通順) can be variously translated as 'smooth', 'fluent', 'common', 'popular', 'well constructed' or 'containing no fallacy'. Although these instructions do elicit above-chance agreement among Chinese listeners on many sentence types (see later), participants sometimes ask us to explain what we mean, and they sometimes misunderstand our intent, speculating aloud about the social acceptability or semantic well-formedness of particular sentence stimuli. This contrasts markedly with our experience in studies of grammaticality judgements by aphasic speakers of English or Italian. In those languages, the notion of 'grammatical error' is easily grasped even by elderly patients and age-matched controls with a grade school education. In fact, grammaticality per se is not taught in traditional Chinese schools, in contrast with Western elementary schools in which papers are returned to pupils with grammatical errors marked in red. Finally, the ambiguous status of grammaticality is exacerbated by extensive dialectical and diachronic variation in all the dimensions of Chinese grammar that we have just described.

Under these circumstances, one might ask whether there is any point in conducting a study of grammaticality judgements in Chinese aphasics. There are four reasons why we believe that the enterprise has merit:

(1) If it can be shown that Chinese patients retain at least some sensitivity to structural well-formedness, despite the fragile nature of grammaticality judgements even in normal controls, then we would have particularly clear evidence for the claim that agrammatic aphasics retain knowledge of their native grammar (Bates and Wulfeck 1989, Bates et al. 1991, Devescovi et al. 1997).
(2) Because Chinese patients were not trained to make grammaticality judgements in school, above-chance performance in this group would increase our confidence that the judgement results reflect processes that are used in everyday life (as opposed to strategic, metalinguistic skills that bear no relation to real-time language processing—cf. Zurif and Grodzinsky 1983).
(3) If the results obtained with aphasic patients resemble the probabilistic judgements observed in healthy young controls, then we may draw useful inferences about the probabilistic nature of grammaticality judgement as a psychological process, and about the neural representations that support it (Levelt 1972, 1974, 1977, Blackwell et al. 1996).
(4) Finally, studies of grammaticality judgement in other languages have shown that some error types (i.e. morphological substitution) are harder for patients to detect than others (i.e. movement errors). This finding for receptive language processing bears an interesting resemblance to the error profiles that are typically reported for aphasic speech: Errors of grammatical substitution and/or omission are common in the speech of both fluent and non-fluent aphasics, but errors involving movement or misplacement are very rare (Bates et al. 1986, Bates et al. 1988, Menn and Obler 1990, Goodglass 1993). This parallel between receptive and expressive symptoms has been cited as evidence for the role of error monitoring in speech production: Those errors that are easiest to detect are weeded out during the speech-planning process, in normal speaking (Levelt et al. 1999) and in the speech of aphasic patients (Wulfeck et al. 1991, Blackwell and Bates 1995). Within the severe limits posed by the Chinese language, we will investigate whether sensitivity to movement errors is better preserved than sensitivity to other error types in this language as well.

Method

Participants

Participants in this study include 11 patients from the National Veteran's Administration Hospital in Taipei, and 37 students from two Taiwan universities (including 18 students who participated in a pretest, and 19 who participated in the final version of the study).[1] College students were volunteers, or they responded to ads and were paid for their participation.

All aphasic patients were at least six months post onset, and were classified by a Chinese standardization of the Boston Diagnostic Aphasia Examination (Li et al. 1994, based on Goodglass and Kaplan 1983). Six were classified as non-fluent Broca's aphasics, and five were classified as fluent Wernicke's aphasics. Demographic and neurological information about each patient is presented in table 1. As table 1 indicates, the patients vary markedly in age and etiology. Most patients had experienced cerebrovascular accidents to one side of the brain, but we also included three patients with head trauma (including one with some evidence of bilateral involvement), and one with post-viral leukoencephalopathy. Because all patients met our diagnostic criteria on standardized behavioural testing, we included them in the experiment. Inspection of data for individual patients revealed no obvious differences in performance on the grammaticality judgement task as a function of age or etiology.

Materials

The 122 grammatical and ungrammatical stimuli used in the main study are listed (with English translations) in Appendix 1. Because of the heterogeneous nature of grammatical structures and their associated violations in Chinese, we did not attempt an orthogonal design comparing error types over structures (in contrast, for example, with the orthogonal type by structure designs used by Wulfeck et al. 1991 and Devescovi et al. 1997). Instead, the stimuli were divided into three subsets, which were analysed separately: (1) the object-marking set (ba and bei), (2) the classifier set, and (3) the aspect set (zai and zhe). For each subtype within each set, we began with a list of grammatically correct sentences and then randomly assigned the target sentences to the experimental conditions that were possible for that subtype (correct, substitution, movement, etc.). Hence there are no confounds between sentence content and grammaticality conditions within any category.

The object/passive marker set contained a total of 60 sentences in the order NNV (Noun-Noun-Verb), 30 for the object marker ba and 30 for the passive marker bei. All of these sentences were semantically irreversible, to clarify which noun was supposed to take the agent role and which noun should be assigned the patient role. Semantic constraints were necessary because the contexts for ba and bei assume an SOV and an OSV order, respectively. Semantic plausibility was equivalent across conditions (OSV, SOV, grammatical and ungrammatical). In addition, all of the ba and bei sentences contained an aspect marker or other adverbial, guaranteeing a complex verb phrase (one of several constraints on use of object markers). Sentences were also constructed to ensure a good fit to the prototypic semantic conditions for use of these two markers, including a 'disposative' reading for sentences that ought to take the marker ba and an 'adverse consequences' meaning for sentences that ought to take the marker bei.

[1] It is customary to compare results for aphasic patients with age- and education-matched controls, in order to determine whether the pattern of deficits observed in these patients are due at least in part to these demographic factors. In the present study, we decided that a college-age control group would be more important for our purposes, due to the nature of our hypotheses: that aphasic patients would retain sensitivity to grammatically in patterns that are qualitatively (though not quantitatively) similar to the patterns observed under optional circumstances in healthy Chinese-speaking controls. Hence the college controls demonstrate optimal performance (which is still well below 100% in this language), a standard against which we can compare performance by both fluent and non-fluent aphasics.

Table 1. Patient information

Subject	Test age	Onset age	Sex	Handedness	Education	Classification	Neurological information	Lesion site
YC001	49	47	M	R	12	Wernicke	CVA	Left
WY301	16	15	F	R	9	Wernicke	Head injury	Left F-T-P
LS401	41	39	F	R	14	Wernicke	CVA	Left MCA territory (Frontoparietal area)
KH402	64	62	M	R	5	Wernicke	CVA	Left MCA/Left lentiform nucleus
CK409	76	75	M	R	9	Wernicke	CVA	Left posterior temporoparietal
CC002 (participated in zhe/zai section	37	26	M	R	16	Broca	Head injury	Left FTP hematoma
LJ102	40	39	M	R	12	Broca	Postviral leuko-encephalopathy	
LD202	34	31	M	R	12	Broca	Head injury	Bilateral subdural effusion of the frontal region
KL302 (participated in zhe/zai and aspect sections only)	67	66	M	R	12	Broca	CVA	Left MCA anterior territory
TC404	62	61	M	R	12	Broca	CVA	Left MCA branch
SE405	63	60	M	R	0	Broca	CVA	Left

For the ba set, 15 were correct sentences in the form 'S ba O V.' An example of a grammatical ba sentence would be:

Xiaogou ba tuoxie yao-lan 小狗 把 拖鞋 咬爛	Puppy ba slipper bite-decay

The 15 ungrammatical ba sentences contained three different kinds of violations, five for each type, as follows:

substitution (wrong marker for sentence type)	S	*bei	O	V
movement 1 (marker in preverbal position)	S	O	*ba	V
movement 2 (marker in post-verbal position)	S	O	V	*ba

For the bei set, 15 were correct sentences in the form 'O bei S V' (the expected context for passive markers). An example of a grammatically correct sentence would be:

Mianbao bei chushi kao-jiao 麵包 被 廚師 烤焦	Bread bei cook burnt-scorched

The 15 ungrammatical bei sentences also contained three different kinds of violations, five for each type, as follows:

substitution (wrong marker for sentence type)	O	ba*	S	V
movement 1 (marker in preverbal position)	O	S	bei*	V
movement 2 (marker in post-verbal position)	O	S	V	bei*

In the pretest phase, we also tried to determine whether it was possible to construct omission violations for the ba and bei markers, i.e. whether native speakers would accept or reject bare SOV and OSV sentence orders with no object or passive marker (cf. Liu et al. 1992a). Sentences of each type were included in the pretest but were excluded in the final version of the experiment, to simplify the task for aphasic patients.

The classifier set contained a total of 30 items, 15 grammatical and 15 ungrammatical. Two different sentence types were used, providing the obligatory determiner/quantifier context for noun classifiers: 'PRONOUN VERB QUANTIFIER [classifier] NOUN', as in:

Ta chang yi [shou] quzi 他 唱 一 首 曲子	He sings one [classifier] song

and 'PREPOSITION NOUN EXIST QUANTIFIER [classifier] NOUN', as in:

Jiaoshi li you yi [wei] laoshi 教室 裡 有 一 位 老師	Classroom-in exist one [classifier] teacher

Ungrammatical versions were divided into three subtypes (with five items in each), as follows:

substitution (wrong classifier for target noun)	QUANTIFIER [classifier*] NOUN
movement (classifier in post-nominal position)	QUANTIFIER NOUN [classifier]*
omission (classifier omitted in obligatory slot)	QUANTIFIER [0]* NOUN

Finally, there were 32 aspect items, 16 for the marker zai and 16 for the marker zhe, 8 correct and 8 incorrect for each type. The sentence frames for the aspect marker zhe (which can be roughly translated as the '-ing' suffix in a progressive form of the English verb) were all locative constructions (Chen 1978). (The reason for this is that, in ancient Chinese, the marker zhe appeared in post-verbal position within a preposition phrase that marked the goals of the action associated with a monosyllabic verb; it has since been reanalysed as a suffix in post-verbal position, but the locative reading of the goal-oriented verb is preserved.) Two kinds of locative contexts were used: a PREPOSITION NOUN VERB NOUN frame or a NOUN VERB NOUN frame with a locative meaning. For correct zhe sentences, the aspect marker was always located in post-verbal position, as in the following examples:

Tou shang dai-zhe caomao 頭 上 戴 著 草帽	Head-on wear-zhe hat
Yanjing han-zhe leishui 眼睛 含 著 淚水	Eyes hold-zhe tears

Two kinds of errors were possible for 8 grammatically incorrect zhe items (4 per type), e.g.

substitution (zai in the zhe position)	Sea-in drift-zai* log
movement (zhe in sentence-final position)	Sky-in float white-clouds-zhe*

For the zai constructions (which can also be roughly translated as the '-ing' suffix in a progressive English verb, but in preverbal position), the grammatical and ungrammatical items were all semantically irreversible sentences with two nouns and a transitive verb. In the 8 grammatically correct versions, zai appeared in the obligatory preverbal position, as in:

Puren zai ca zhuozi 僕人 在 擦 桌子	Servant zai wipe table

Two kinds of errors were possible for 8 grammatically incorrect zai items (4 per type), e.g.

substitution (zhe in the zai position)	Pony zhe* pull cart
movement (zai in sentence-final position)	Child play ball-zai*

In the pretest phase, we also tried out a set of 24 items, 12 grammatical and 12 ungrammatical, involving the aspect marker le (which can be approximately translated as the participial ending '-en' on some English verbs). These items were also excluded from the final version of the experiment used with aphasic patients.

In addition to these experimental items, we constructed a set of 12 practice sentences, four illustrating each of the structural categories that would be heard later (see Appendix 1). None of the practice items was used in the main experiment.

Apparatus and procedure

Materials were audio-recorded by a female native speaker of Mandarin Chinese (the variant spoken in Taiwan), and digitized using the Macintosh SoundEdit programme. The digitized auditory sentence stimuli were administered using a Macintosh microcomputer workstation, using the PsyScope experimental design and control shell developed by Cohen et al. (1993). Each sentence stimulus was preceded by an attention signal (a brief tone); 300 ms after the offset of the attention signal, the stimulus itself began, with reaction times yoked to the beginning of the sentence. Responses could occur anywhere from the beginning of the sentence to the end of a response window that continued for 3000 ms after the offset of the sentence. A fixed 1500-ms intertrial interval was set between the close of the response window and the beginning of the attention signal for the next trial. The experimental items were administered in a fixed random order. Responses were recorded by presenting one or two buttons on the CMU button box, an input/output buffer for the Macintosh that uses an independent time crystal with millisecond accuracy for manual or vocal response.

Participants were tested individually in a quiet room, with stimuli presented over two speakers on either side of the button box. They were instructed (for all aspects of the experiment, including baseline, practice and experimental items) that they had a limited amount of time to respond, and although they were not told exactly how long the reaction time window would be open, the timing parameters in the practice session matched the timing parameters in the main experiment, so that subjects had an opportunity to familiarize themselves with the timing requirements. At the beginning of the experiment they were given a series of baseline items to familiarize them with the button box. In the baseline series, the participants were told to listen for the words 'Zhengque' (正確) ('good' or 'correct') and 'Cuowo' (錯誤) ('bad' or 'mistake') presented over the speakers, and to press the button corresponding to each word. The red button (on the left side of the box) was assigned for good sentences and the yellow button (on the right side of the box) for bad sentences. (The colour red was chosen for correct sentences because it symbolizes joy or celebration in Chinese culture.) Participants were asked to use the index finger on their dominant hand to push both buttons.[2] No feedback was given to indicate correct or incorrect performance in the baseline task.

The practice items for each violation type were presented before the relevant section of the experiment (e.g. ba/bei practice items before the ba/bei block, aspect practice items before the aspect block, classifier practice items before the classifier block). With the practice sentences, participants were instructed to select the good or bad button to indicate whether the sentence was grammatical or not. No feedback was given to indicate whether the participants had responded correctly.

In the pretest experiment with college students only (see later), we compared two different kinds of grammaticality instructions to determine whether they would elicit differential performance on these stimuli. Seven subjects were told that some of the sentences would be 'tungshun' (通順, 'smooth', corresponding to the 'good' button) and some would be 'bu tungshun' (不通順, 'not smooth', corresponding to the 'bad' button); another 11 subjects were told that some of the sentences would 'he yufa' (合語法, 'suit language law', corresponding to the 'good' button) while others would be 'bu he yufa' (不合語法, 'not suit language law', corresponding to the 'bad' button). Statistical analyses indicated that results for the two different terms for grammaticality did not differ. Hence, in the main experiment, all aphasic subjects and college students only received the 'smooth/not smooth' instructions.

After the practice session, the experiment began. Pauses were provided between blocks, and the experimenter controlled advancement between items to ensure that subjects were able to respond. If the subject expressed fatigue, the session was interrupted and rescheduled. On a given trial, if the subject failed to respond within 3000 ms from the end of the sentence, that trial was registered as a 'non-response'.

[2] Note that some studies have shown a small reaction time advantage for the right-side button in right-hand subjects. If such a bias is operating in the present study, it would speed reaction times for correct detection of grammatical violations, compared with correct acceptance of grammatically well-formed sentences (Bates et al. 1996). As we shall see, our results for 'good' vs. 'bad' judgements yield results in the opposite direction.

Scoring, data preparation and analysis

In many of the published studies of grammaticality judgement in aphasia, grammatical and ungrammatical scores were converted into A′ scores, a non-parametric variant of the d′ signal detection statistic, used to control for response bias. However, in view of the rather low sensitivity to grammaticality evidenced even by healthy young controls in Chinese, we decided that it would be useful to keep the scores for grammatical and ungrammatical items separate, comparing them directly as levels of a single grammaticality factor, in order to determine whether Chinese listeners are able to discriminate at all between grammatical and ungrammatical variants on any given structure. Using 'percent correct' as a factor, random performance would mean that the participants in a given group were unable to discriminate between grammatical and ungrammatical variants. Suppose, however, that participants display a strong response bias, most likely (based on the judgement literature) in the direction of a preference for the 'good' button (accepting sentences that we had determined to be ungrammatical). In this case, one might expect 100% correct performance on 'good' items but 0% correct performance on 'bad' items. To control for this possibility, we conducted our analyses in two ways: (a) using 'percent correct' as the dependent variable, for grammatical vs. ungrammatical items, and (b) using 'percent choice of the "good" button' as the dependent variable, also for both grammatical and ungrammatical items.

For the reaction time analyses, all failures to respond and all incorrect responses were removed from the analyses, with RTs based on the remaining items. RTs were measured from the beginning of the sentence (for a detailed discussion of timing parameters in on-line studies of grammaticality judgement, see Blackwell and Bates 1995).

As noted earlier, two sets of items in the pretest (simple AVA and AAV sentences without ba or bei, aspect items with the marker le) were excluded from the main experiment, to simplify the procedure for aphasic patients. The main experiment included the remaining 122 items (60 for ba/bei, 30 for classifiers, 32 for aspect).

Results and discussion

Because of their heterogeneous nature, the three classes of error types (object/passive markers, classifiers, aspect markers) were treated as separate sub-experiments. Results for each section will be reported separately (both accuracy and RT, for college students and controls). Because of inhomogeneity of variance and differences in sample size, the aphasics and college students will not be compared directly in statistical analyses. Instead, we will use the data for college students to establish the pattern of 'optimal' performance in Chinese for these error types, and then report separate analyses for aphasic patients (with Broca's and Wernicke's aphasics treated as separate groups, and separate levels of the group factor).

Object/Passive markers (ba/bei)

College students: For the accuracy data, we began with two simple within-subject multivariate analyses of variance on the ba and bei items (collapsed over substitution and movement subtypes): one comparing grammatical vs. ungrammatical sentences on total percent correct, and another comparing grammatical vs. ungrammatical sentences on 'percent choosing the "good" button'. As noted earlier, these two separate analyses permit us to determine whether there is any sensitivity to grammatical violations in this group, assuming no response bias (raw percent correct) or assuming a bias to accept sentences as grammatical (percent choice of 'good'). The first analysis on raw percent correct just missed significance, $F(1, 18) = 3.23$, $p < .09$, reflecting 93.3% correct on 'good' items (s.e. = 2%) and 87.7% correct on 'bad' items (s.e. = 4.6%). Although the difference was not significant, this result demonstrates a bias towards incorrect acceptances of 'bad' sentences in normal young Chinese listeners, and the standard errors also indicate considerably greater variance on the ungrammatical items. However, the second analysis with percent choice of 'good' as the dependent variable was highly significant, $F(1, 18) = 173.78$, $p < .0001$, indicating that Chinese subjects are quite sensitive to the difference between our designated 'grammatical' and 'ungrammatical' items. Grammatical items were correctly accepted as grammatical 93.3% of the time (as noted earlier) but violations were incorrectly accepted as grammatical only 11.8% of the time, with substantial variation (s.e. = 4.5%).

A third analysis was conducted on reaction times for grammatical vs. ungrammatical ba/bei items, yielding a significant difference, $F(1, 18) = 5.58$, $p < .03$, with slower RTs on ungrammatical items (mean = 2233 ms, s.e. = 131 ms) and faster RTs on grammaticals (mean = 2206 ms, s.e. = 85 ms).

At the next level, analyses were conducted focusing only on the three error types (substitution, preverbal movement, post-verbal movement) collapsed across ba/bei items. A simple one-way analysis of variance on percent correct (i.e. correct rejections) yielded a significant main effect, $F(2, 17) = 4.52$, $p < .03$, reflecting higher accuracy on the two types of movement errors (91.6% on both types, s.e. = 4.3% and 3.7% respectively) and lower accuracy and greater variance on the substitution errors (80.0%, s.e. = 6.7%). This result is in the direction that we would expect from prior studies of both normals and aphasics in English and Italian (Wulfeck et al. 1991, Blackwell and Bates 1995). The analysis of variance over reaction times also reached significance $F(2, 17) = 13.15$, $p < .0004$, reflecting slower RTs on the substitution items (mean = 2479 ms, s.e. = 136 ms) and faster RTs on the two movement types (2201 ms with s.e. = 143 ms, and 2034 ms with s.e. = 132 ms, respectively).

Aphasic patients: Two of the six Broca's patients were unable to complete the ba/bei section of the experiment (see table 1). Hence analyses in this section are based on data for four Broca's aphasics and five Wernicke's. A 2 (Broca. vs. Wernicke) × 2 (grammatical vs. ungrammatical) multivariate analysis of variance was conducted twice, over percent correct judgements and over percent choice of the 'good' button for ba/bei items. In the analysis over percent correct, the effect of grammaticality missed significance $F(1, 7) = 4.35$, $p < 0.08$), although the average for grammatical items (79.2%) was numerically higher than the average for ungrammatical items (44.5%). There was no main effect of group ($F < 1.0$) and no group by grammaticality interaction $F(1, 7) = 1.94$, n.s.

The near-random performance observed for ungrammatical items could be taken to indicate a complete absence of sensitivity to grammaticality for this aspect of Chinese grammar, reflecting only a strong bias to accept sentences that we had construed as violations. This possibility was addressed in the second analysis comparing percent choice of the 'good' button, which revealed a significant main effect of grammaticality on this dependent variable, $F(1, 7) = 14.09$, $p < .007$). As a group, aphasics averaged 79.2% correct acceptances on grammatical items, corresponding to 90.8% for Broca's (s.e. = 4.9%) and 70.0% for Wernicke's (s.e. = 12%). However, the aphasics averaged only 42.9% incorrect acceptances on ungrammatical items, corresponding to 52.5% for

Broca's (s.e. = 15%) and 35.3% for Wernicke's (s.e. = 11.4%). We may conclude, at minimum, that Chinese aphasics are troubled by the ba/bei violations and hence less willing to accept them as correct. However, this analysis failed to yield a significant effect of group ($F < 1.0$), and the interaction was also non-significant, $F(1, 7) = 2.02$, n.s., indicating that fluent and non-fluent aphasics show comparable profiles of sparing and impairment on these items.

Overall, reaction times for aphasic patients averaged 2816 ms, reflecting an average of 2749 ms for Broca's (s.e. = 388 ms) and 2870 ms for Wernicke's (s.e. = 296 ms). These patient RTs are approximately 350 ms longer than the overall mean of 2462 ms observed with college students. However, keeping in mind that these response times are measured from the beginning of the sentence, we may conclude that these patients are making their responses 'on-line', in response to the time pressures imposed by the task, even though they are (not surprisingly) much less efficient than young college controls. Reaction times on the ba/bei items were also in the same direction reported for college controls, with numerically slower RTs for ungrammatical items (mean = 2880 ms, with incorrect acceptances and failures to respond excluded from the analysis), approximately 100 ms slower than RTs on grammatical items (mean = 2783 ms). However, the analysis of variance over reaction times failed to yield any significant effects (i.e. no effect of item type or aphasia group, and no interaction), due at least in part to substantial individual variability and small sample size.

At the next level, we conducted a 2 (Broca vs. Wernicke) × 3 (substitution vs. the two movement types) analysis of variance on percent correct rejections of the ungrammatical ba/bei items. The effect of item type just missed significance $F(2, 6) = 4.06$, $p < .08$, reflecting numerically lower performance on the substitution errors (mean = 32.2% correct) compared with the two movement types (means = 50% and 43.4%, respectively). Although this effect is in the predicted direction (with worse performance on substitution errors—Wulfeck et al. 1991, Devescovi et al. 1997), the standard errors were very large (from 7.4% to 20.6%), indicating high variability for these aphasic patients. The main effect of group was not significant, nor was the group by grammaticality interaction ($F < 1.0$ in both cases).

We also attempted to conduct a parallel 2 × 3 analysis of variance on the RT data for aphasic patients on the ba/bei violation types. However, because RT analyses are conducted only on correct trials, the poor performance by aphasic patients meant that too many data were removed to permit a stable and meaningful analysis. In fact, with errors removed, only one of the four Broca's aphasics had enough data points across cells to enter into the analysis.

We may conclude that aphasic patients do retain some sensitivity to the contrast between grammatical and ungrammatical object- and passive-marking items, in the direction observed for young Chinese normals (with a strong bias towards incorrect acceptance of ba/bei violations, especially those that involve a substitution error). However, their capacity to choose between grammatical and ungrammatical items is fragile and highly variable.

Noun classifiers

College students: A simple one-way analysis comparing percent correct for grammatical vs. ungrammatical noun classifier items yielded a significant main effect of grammaticality, $F(1, 18) = 20.29$, $p < .0003$, with substantially higher accuracy for grammaticals (mean = 92.6%, s.e. = 2.6%) than ungrammaticals (mean = 74.0%, s.e. = 5.1%). The second one-way analysis treating percent choice of 'good' as the dependent variable also reached significance, $F(1, 18) = 94.44$, $p < .0001$, demonstrating clear differentiation between correct sentences and violations even though these normal subjects did have a strong tendency to accept classifier violations as correct (mean = 25.3%, s.e. = 5.1%).

The analysis of variance over the reaction time data (with incorrect responses and failures to respond removed from the analysis) also yielded a significant effect of grammaticality, $F(1, 28) = 9.69$, $p < .006$, reflecting slower RTs on the classifier violations (mean = 2548 ms, s.e. = 110 ms) compared with the correct classifier items (mean = 2376 ms, s.e. = 99 ms). Hence, even when they do correctly reject a classifier violation, young Chinese listeners take approximately 172 milliseconds longer to make up their minds than they do to accept correct classifier items. This is, if anything, in the opposite direction from what we would expect if we remember that a grammatical sentence is not really grammatical until it is over, whereas a sentence with an error could (at least in principle) be rejected before the end of the sentence (Blackwell et al. 1996). Hence the RT results are further testimony to the fragile and probabilistic nature of these grammatical judgements in the Chinese language.

The next set of analyses focused only on violations, comparing the three classifier violation types (substitution, movement, omission). No significant effects of violation type were detected in the accuracy analysis for normal controls, $F(2, 17) = 1.03$, n.s., although accuracy on the classifier omissions was numerically smaller (mean = 66.3%) than the other two violation types (movement = 77.9%, substitution = 77.9%). The RT analysis also failed to reveal a significant effect of violation type, $F(2, 15) = 1.80$, n.s. We note in this regard that data for two college subjects were lost in the RT analysis over violation types, because these subjects made so many errors (failures to respond or incorrect acceptances of classifier errors) that there were not sufficient data to support an RT analysis after errors were removed. It should be clear from these analyses that classifier errors are particularly difficult for Chinese listeners to detect, including young college students.

Aphasic patients: One Broca's aphasic was unable to complete the classifier section of the grammaticality judgement task (see table 1), so analyses in this section are restricted to five Broca's and five Wernicke's aphasics. A 2 (Broca vs. Wernicke) × 2 (grammatical vs. ungrammatical) multivariate analysis of variance over total percent correct yielded a significant main effect of grammaticality, $F(1, 8) = 7.80$, $p < .03$, reflecting substantially more correct acceptances (mean = 77.4%. s.e. = 20.5%) than correct rejections (mean = 44%, s.e. = 29%). There was no significant main effect of group ($F < 1.0$) and no group by grammaticality interaction ($F < 1.0$). Again, the near-random performance on ungrammatical classifier items might be taken to reflect loss of sensitivity to these contrasts. However, the analysis of variance on percent choice of 'good' also yielded a significant main effect of grammaticality, $F(1, 8) = 9.02$, $p < .02$, which means that patients were indeed sensitive to the difference between correct classifier items (correctly accepted 77.4% of the time) and classifier violations (incorrectly accepted only 46% of the time). In this analysis, as in the analyses for ba/bei items, there was no main effect of group and no group by grammaticality interaction ($F < 1.0$ in both cases).

Collapsing over patients and levels of grammaticality, the mean reaction time for the aphasic patients on classifier items was 2921 ms (s.e. = 167 ms). This is somewhat slower than the average RTs observed for patients on ba/bei items (mean = 2816 ms), and approximately 460 ms slower than the average for college students on classifiers (mean = 2462 ms). Hence, even though they are able to come up with a response 'on-line', this task is very difficult for Chinese aphasics. The analysis of variance comparing reaction times on grammatical vs. ungrammatical items yielded no effect of grammaticality ($F < 1.0$), although patients were numerically slower on ungrammaticals (mean = 2960 ms) than grammaticals (mean = 2882 ms). There was also no main effect of group ($F < 1.0$) and no group by grammaticality interaction in the RT analysis, $F(1, 8) = 1.36$, n.s.

At the next level, we conducted a separate 2 (Broca vs. Wernicke) × 3 (omission, substitution, movement) analysis of variance comparing performance by aphasic patients on the three classifier violation types. The effect of violation type just missed significance, $F(2, 7) = 4.01$, $p < .07$, reflecting higher accuracy on movement errors (mean = 62%) and lower accuracy on errors of classifier omission (mean = 34%) and substitution (mean = 36%). These results are in the direction that we would predict based on findings for aphasic patients in other languages, although the difference is clearly not robust. Not surprisingly, in view of the high variability and small sample size, the main effect of group and the group by grammaticality interaction both failed to reach significance ($F < 1.0$ in both cases).

Finally, we attempted a parallel analysis of variance on the reaction times for the three types of classifier errors. Once again, so many data were lost when incorrect responses were removed that only two Broca's and four Wernicke's had sufficient data to merit further analysis—too few to justify a statistical comparison. We note, however, that mean RTs for these remaining patients were numerically greater for classifier substitution errors (mean = 3212 ms for Broca's, 3791 ms for Wernicke's) compared with errors of omission (3017 ms for Broca's, 2927 ms for Wernicke's) or movement (2877 ms for Broca's, 2852 ms for Wernicke's). Again, this is in the direction that we would predict based on results for aphasic patients in other languages (Wulfeck et al. 1991, Devescovi et al. 1997).

Aspect markers

College students: The simple one-way analysis of variance over accuracy scores on aspect items yielded a significant main effect, $F(1, 18) = 13.41$, $p < .002$, reflecting greater accuracy on grammatical items (95.7%, s.e. = 1.9%) than ungrammaticals (84.2%, s.e. = 4.1%). When the analysis was repeated using percent choice of the 'good' button as the dependent variable, a large and significant effect of grammaticality was obtained, $F(1, 18) = 240.82$, $p < .0001$, which indicates that Chinese college students are indeed sensitive to these aspect violations, incorrectly accepting them only 14.5% of the time (s.e. = 3.7%).

An analysis of variance on the reaction time scores (with failures to respond and incorrect acceptances removed) also yielded a reliable effect of grammaticality, $F(1, 18) = 5.58$, $p < .03$. College students took substantially more time to correctly reject an ungrammatical sentence (mean = 2129, s.e. = 103 ms) than to correctly accept a grammatical sentence (mean = 1970 ms, s.e. = 60 ms). This is true even though, in principle, a violation could be rejected before the end of the sentence whereas a sentence can only be judged as grammatical when it is complete.

At the next level, the two violation types that were possible for aspect items (movement vs. substitution) were analysed for both accuracy and reaction times. The analysis of accuracy failed to reach significance, $F(1, 18) = 2.59$, $p < 0.13$, although accuracy was numerically higher for movement errors (88.8%) than substitution errors

(79.6%). The analysis over reaction times just missed significance, $F(1, 18) = 4.07$, $p < .06$, reflecting numerically slower RTs on substitution items (mean = 2251 ms) compared with movement violations (mean = 2036 ms). These results are in the direction that we would predict based on studies of grammaticality judgements in other languages (e.g. Blackwell and Bates 1995), but the data for normal Chinese listeners are so variable that this difference is difficult to detect.

Aphasic patients: All six Broca's aphasics and all five Wernicke's aphasics were able to complete the aspect section of the grammaticality judgement task. Accuracy scores for the aspect items were subjected to a 2 (Broca vs. Wernicke) × 2 (grammatical vs. ungrammatical) multivariate analysis of variance, which yielded a significant main effect of grammaticality, $F(1, 9) = 22.20$, $p < .002$. However, the main effect of group and the group by grammaticality interaction were both non-significant ($F < 1.0$). Once again, the accuracy scores suggested relatively high correct acceptance (mean = 84.7%, s.e. = 5.6%), but near-random performance on the ungrammatical items (mean = 40.9%, s.e. = 11%). A second analysis of variance using percent choice of 'good' as the dependent variable indicated that the patients were indeed sensitive to the difference between the correct and incorrect item types, $F(1, 9) = 19.17$, $p < .002$, with levels of correct acceptance of grammaticals (84.7%) exceeding incorrect acceptance of ungrammaticals (mean = 46.1%, s.e. = 23%). Once again, the main effect of group and the group by grammaticality interaction did not even approach significance ($F < 1.0$).

Analysis of the reaction times for aspect items failed to reveal a main effect of grammaticality for aphasic patients, $F(1, 9) = 2.19$, $p < .18$, nor did the main effect of group or the group by grammaticality interaction reach significance ($F < 1.0$ in both cases). Once again, the results were numerically similar to results for college students, with slower responses for ungrammatical items (mean = 2831 ms) and faster responses on grammatical items (mean = 2662 ms). However, there was far too much individual variability in these data to permit detection of an RT effect with a small sample size, within or across groups.

At the next level, we conducted a 2 (Broca vs. Wernicke) × 2 (movement vs. substitution) multivariate analysis of accuracy on the aspect violations only. The accuracy analysis yielded no significant effect of item type, $F(1, 9) = 1.06$, n.s., although the scores were numerically similar to those of normal controls, with higher accuracy for movement errors (mean = 47.7%) than for substitution errors (mean = 34.1%). The effects involving group were not significant ($F < 1.0$ in both cases).

Finally, the same analysis over violation types was attempted for the RT data. When trials with failures to respond or incorrect acceptances were excluded, only three of the six Broca's and four of the five Wernicke's had enough data to support a statistical analysis. Acutely aware that such an analysis is on the margins of statistical acceptability, we decided to conduct the analysis but to interpret the results with maximal caution. The main effect of item type just missed significance, $F(1, 5) = 5.87$, $p < .06$, reflecting a trend towards faster RTs on the movement errors (mean = 2730 ms) compared with the substitution errors (mean = 3048 ms). This result is in the same direction observed in college students, but the effect is marginal in both cases. The main effect of group did not even approach significance ($F < 1.0$). However, we did obtain the only significant interaction involving group in the entire series of grammaticality judgement analyses, $F(1, 5) = 10.56$, $p < 0.03$. Examination of cell means revealed that the effect of violation type was large for Broca's aphasics (mean = 2555 ms and s.e. = 357 ms for movement errors; mean = 3365 ms and s.e. = 177 ms for substitution errors), and vanishingly small for Wernicke's aphasics (mean = 2861 ms and s.e. = 407 ms for movement errors; mean = 2810 ms and s.e. = 360 ms for substitution errors). One might infer that aspect substitution errors are especially difficult for these three non-fluent Broca's aphasics. However, in view of the very small sample size and high variability, and the absence of a group difference in any of the other analyses, we underscore the need to replicate these findings with further (and perhaps larger) samples of Chinese patients.

To facilitate comparison across data sets, results for college students and aphasic patients on the three sections of the study are summarized in figure 1, for mean percent choice of the 'good' button on grammatically correct vs. incorrect sentences.

Summary and conclusions

As we noted at the outset, the Chinese language is unusual in the austerity of its grammar: no inflectional paradigms, variable word order, extensive omission of sentence constituents (both subject and object), with free-standing function words and particles that are optional in all but a relatively small set of contexts. Indeed, this language does

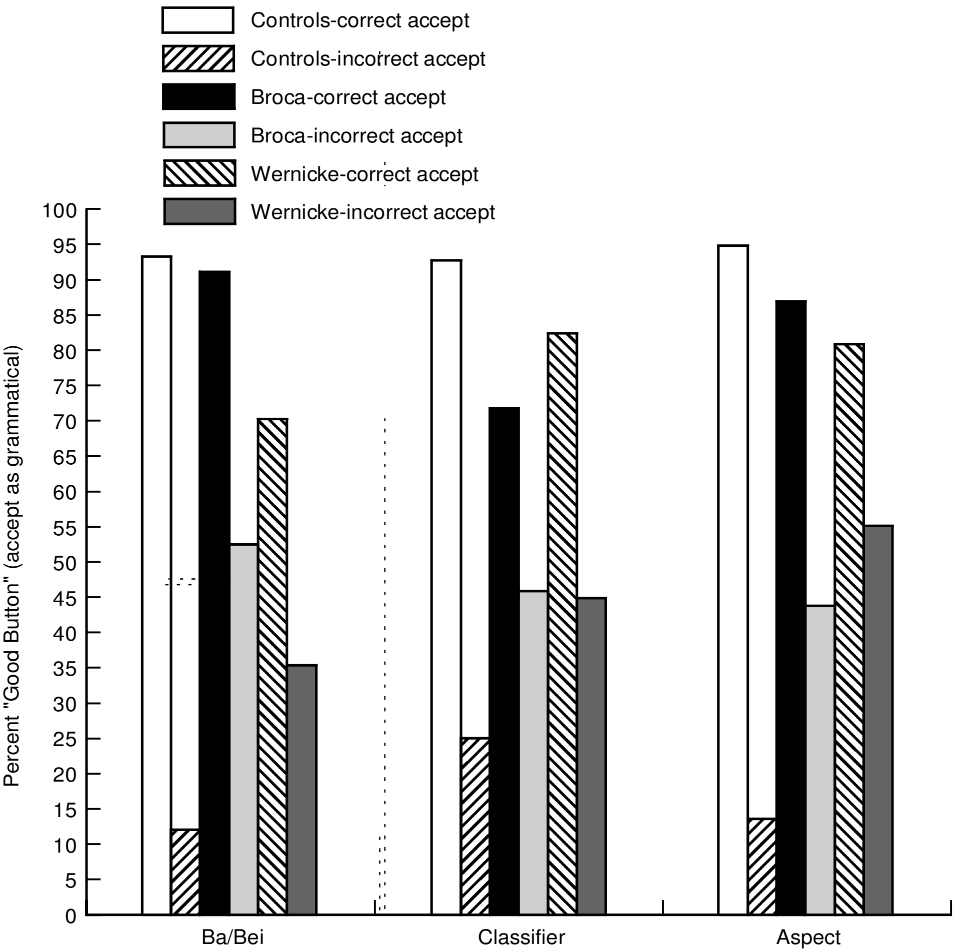

Figure 1. Percent correct vs. incorrect acceptance of items as 'good' in Chinese aphasics and controls.

not even have a widely accepted term for 'grammatical' or 'ungrammatical'. For all of these reasons, the study of grammaticality judgements in Chinese aphasic patients can offer new insights into complex issues of language localization and language impairments following unilateral brain injury.

First, we have shown that Chinese aphasics do retain at least some sensitivity to structural well-formedness in their language, evident in the significant difference between correct acceptance of grammatical items and incorrect acceptance of ungrammatical items in all three structural categories (object/passive marking, noun classifiers, aspect marking). This adds to a growing body of evidence suggesting that some degree of grammatical knowledge is preserved in aphasia despite moderate to severe deficits in the processes by which that knowledge is accessed and used in real time, in both comprehension and production (Linebarger et al. 1983, Bates and Wulfeck 1989, Shankweiler et al. 1989, Bates et al. 1991, Wulfeck et al. 1991, Devescovi et al. 1997). Such results suggest, in turn, that grammatical knowledge may be broadly distributed in the brain, so that bases for some grammaticality judgements remain even when the neural substrates of fluent language use have been damaged or destroyed. This conclusion is compatible with demonstrations of grammaticality judgement in the right hemisphere of split-brain patients (Baynes and Gazzaniga 1988), and with visual hemifield studies showing that the right hemisphere is sensitive to grammatical violations (Liu et al. 1999).

In this regard, we note that there were no systematic differences between Broca's and Wernicke's aphasics in our study, a result consistent with reports for other languages and inconsistent with the claim that Broca's area plays a special role in the processing and/or representation of morphosyntax (Caplan 1987, Grodzinsky 1990, 1993, in press, Mauner et al. 1993). The only significant finding involving aphasia group was a small but reliable group by violation type interaction in the aspect-marking data, with Broca's aphasics showing a selective slowing in response to substitution errors that was missing in the Wernicke group. We underscore the need for caution in the interpretation of this small finding. With small sample sizes, large variance and multiple analyses, it is possible that this result could have been obtained entirely by chance. Even if we take the result at face value, its interpretation is debatable. Does the fact that Broca's aphasics take longer to resolve aspect substitutions mean that they are less sensitive to these items, or more sensitive? We are reminded of a finding by Huber, Friederici and colleagues (Huber et al. 1990, Wilbertz et al. 1991), who compared gaze duration on grammatical violations in German-speaking Broca's and Wernicke's aphasics using an eye-movement-monitoring paradigm. They report that Broca's aphasics look longer at grammatical violations and check back to points earlier in the sentence, as if they were struggling to resolve the error; by contrast, Wernicke's produce eye movements that are compatible with the conclusion that they did not notice the error at all. In this task (as in the present study), we might infer that grammatical sensitivity is greater in those patients who spend more time analysing a grammatical violation. For the most part, however, our results and others in the literature suggest that Broca's and Wernicke's aphasics are equally impaired (and equally spared) in their ability to detect grammatical errors.

Second, our results for Chinese help to clarify some issues that have been raised regarding the status of grammaticality judgments in normals and aphasics. In response to the landmark paper by Linebarger et al. (1983) demonstrating preservation of grammaticality judgements in agrammatic aphasics, Zurif and Grodzinsky (1983) suggested that such results may reflect 'off-line' metalinguistic strategies that are quite different from the automatic and modular grammatical processes that are used in everyday life. A partial response to this critique has already been offered in multiple studies showing that patients can also perform above chance in 'on-line' reaction time studies where they are forced to respond under time pressure (e.g. Shankweiler et al. 1989, Wulfeck and Bates 1991, Devescovi et al. 1997, and the present study). However, the possibility remains that the judgement task itself (on-line or off-line) elicits the kind of pedantic metalinguistic processes that are taught in Western elementary schools. Such strategies are not taught in traditional Chinese schools; indeed, the Chinese language does not even have a common term for 'ungrammatical'. Hence our findings for Chinese bolster the argument that grammaticality judgement is an ecologically valid technique, sensitive to grammatical processes that are used in real life (for a detailed discussion, see Blackwell et al. 1996).

Third, the parallels that we have uncovered here between Chinese aphasic patients and normal controls offer further insights into the nature of these processes. In Chinese, judgements of grammaticality are fragile and probabilistic, compared with the robust judgements obtained in other languages. In our previous studies of grammaticality judgements in English and Italian (e.g. Wulfeck et al., 1991, Blackwell and Bates, 1995, Devescovi et al., 1997), performance by normal controls was very close to ceiling. For example, Devescovi et al. report that college students average 97.34% correct acceptance of grammatical sentences and 97.22% correct rejections of ungrammatical items—far higher than the rates reported here for Chinese college students. Their elderly controls also showed such high sensitivity to grammaticality that it was impossible to conduct analyses of variance on the accuracy data. The contrast with our Chinese findings is striking: College students showed high correct acceptance rates for grammatical items (ranging from 92.6% to 95.7%) but they showed much lower hit rates on ungrammatical items, ranging from a high of 91.6% for movement violations on ba/bei items to a low of 66.3% correct for violations involving classifier omission. We must conclude that grammaticality judgement is a probabilistic phenomenon for naive listeners, a claim that has been made for English (Blackwell et al. 1996, see also Levelt 1974, Smyth 1986) but is incontrovertibly true for Chinese. Of course the apparently 'poor' performance by normal native speakers of Chinese on this task must be understood as an appropriate reaction by sophisticated listeners to the flexible and context-dependent nature of their language. Within this context, it is all the more remarkable that sensitivity to grammatical errors can be demonstrated in Chinese aphasics.

Fourth and finally, studies in other languages have shown that errors of substitution are harder to detect than errors involving movement, a finding that parallels the relative absence of movement errors in the expressive language of both normals and aphasics (see also Menn and Obler 1990). Our results for Chinese are consistent with this pattern, although the evidence on this point is relatively weak. Among Chinese normals, a selective disadvantage for substitution errors only reached significance in the ba/bei analyses (both accuracy and reaction time), although results were in the same direction for aspect and classifier items as well. Results were also in the predicted direction for Chinese aphasics, but failed to reach significance ($p < .10$ for classifier and ba/bei items). The weakness of this effect is perhaps not surprising in view of the fragile and probabilistic nature of grammaticality judgements even among Chinese normals, but it may also reflect the fact that so much omission and movement of elements is permitted in Chinese that even the most egregious errors can sound acceptable depending on how they are construed. We should point out, however, that all of the error types used in this experiment involved high-frequency constructions (e.g. high-frequency classifiers), and they were designed to be as strong and as evident to native speakers as possible within these constraints.

We conclude that Chinese aphasic patients do retain at least some sensitivity to grammatical well-formedness in an on-line judgement task. The next step will be to determine whether well-formedness constraints are also present in syntactic priming tasks in which no judgement of any kind is required (e.g. Bates, Devescovi et al. 1996, Bates, Pizzamiglio et al. 1996, Liu 1996, Federmeier and Bates 1997). Our ongoing studies of syntactic priming in Chinese normals indicate that reaction times for word recognition (measured in a cued-shadowing task) and word production (measured in a picture-naming task) are faster in a grammatical congruent context and slower in an ungrammatical context, relative to neutral control phrases like 'Now please say_____'. Studies are now underway to determine whether the same patterns of syntactic facilitation and inhibition are observed in Chinese aphasics.

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Appendix 1

1::MarkerBaCorrect1 The earthquake destroyed the highway.

Dizhen	ba	gonglu	zhenduan
earthquake	BA	highway	shake-break
地震	把	公路	震斷

2::MarkerBaCorrect2 The typhoon broke the big tree.

Taifeng	ba	dashu	chuiduan
typhoon	BA	big tree	blow-break
颱風	把	大樹	吹斷

3::MarkerBaCorrect3 The child drank the soda.

Xiaohai	ba	qishui	heguang
child	BA	soda	drink-up
小孩	把	汽水	喝光

4::MarkerBaCorrect4 The trash blocked the drainpipe.

Lese	ba	shuiguan	duzhu
trash	BA	water pipe	block-up
垃圾	把	水管	堵住

5::MarkerBaCorrect5 The oven baked the duck.

Kaoxiang	ba	yazi	kaoshou
oven	BA	duck	bake-ripen
烤箱	把	鴨子	烤熟

6::MarkerBaCorrect6 The wife cooked the dinner.

Taitai	ba	wancan	zhuhao
wife	BA	dinner	cook-well
太太	把	晚餐	煮好

7::MarkerBaCorrect7 The calf kicked the pail.

Xiaoniu	ba	shuitong	tidao
calf	BA	bucket	kick-fallen
小牛	把	水桶	踢倒

8::MarkerBaCorrect8 The errand man turned off the light.

Gongyou	ba	diandeng	guandiao
errand man	BA	light	turn-off
工友	把	電燈	關掉

9::MarkerBaCorrect9 The landlord moved the furniture.

Fangdong	ba	jiaju	banzou
landlord	BA	furniture	move-away
房東	把	傢俱	搬走

10::MarkerBaCorrect10 The younger brother broke the toy:

Didi	ba	wanju	nonghuai
younger brother	BA	toy	do-broken
弟弟	把	玩具	弄壞

11::MarkerBaCorrect11 The car hit the railing.

Chezi	ba	langan	zhuangwai
car	BA	railing	hit-aslant
車子	把	欄杆	撞歪

12::MarkerBaCorrect12	The train crushed the snail.			
	Huoche	ba	guaniu	yasi
	train	BA	snail	crush-die
	火車	把	蝸牛	壓死
13:MarkerBaCorrect13	The elephant stepped on the cake.			
	Daxiang	ba	dangao	caibian
	elephant	BA	cake	step-flat
	大象	把	蛋糕	踩扁
14::MarkerBaCorrect14	The elder sister finished the homework.			
	Jiejie	ba	gongke	zuohao
	elder sister	BA	homework	do-well
	姐姐	把	功課	做好
15::MarkerBaCorrect15	The mailman sent the letters.			
	Youchai	ba	xinjian	songzou
	mailman	BA	letters	send-away
	郵差	把	信件	送走
16:MarkerBaSubstitutio	Aunt threw away the leftover.			
	Ayi	*bei*	shengcai	diudiao
	aunt	*BEI*	leftover	throw-away
	阿姨	*被*	剩菜	丟掉
17:MarkerBaSubstitutio	The coat was splashed wet by rain.			
	Dayu	*bei*	waitao	linshi
	big rain	*BEI*	coat	drip-wet
	大雨	*被*	外套	淋濕
18::MarkerBaSubstitutio	The car was driven away by the driver.			
	Siji	*bei*	chezi	kaizou
	driver	*BEI*	car	drive-away
	司機	*被*	車子	開走
19::MarkerBaSubstitutio	The hair was disturbed by wind.			
	Dafeng	*bei*	toufa	chuiluan
	big wind	*BEI*	hair	blow-mess
	大風	*被*	頭髮	吹亂
20::MarkerBaSubstitutio	The vegetables were eaten by the worm.			
	Chungzi	*bei*	qingcai	chidiao
	worm	*BEI*	vegetables	eat-up
	蟲子	*被*	青菜	吃掉
21::MarkerBaMoveI1	The rope was cut up by the scissors.			
	Jiandao	shengzi	jianduan	*ba*
	scissors	rope	cut-up	*BA*
	剪刀	繩子	剪斷	*把*
22:MarkerBaMoveI2	The slippers were bitten through by the puppy.			
	Xiaogou	tuoxie	yaolan	*ba*
	puppy	slippers	bite-decay	*BA*
	小狗	拖鞋	咬爛	*把*

23::MarkerBaMoveI3	The clerk was fired by the boss.			
	Laoban	zhiyuan	kaichu	*ba*
	boss	clerk	fire	*BA*
	老板	職員	開除	*把*
24::MarkerBaMoveI4	The tooth was extracted by the dentist.			
	Yayi	zhuya	badiao	*ba*
	dentist	decayed tooth	pull-away	*BA*
	牙醫	蛀牙	拔掉	*把*
25::MarkerBaMoveI5	The pillow was scratched by the kitten.			
	Xiaomao	zhentou	zhuapo	*ba*
	kitten	pillow	scratch-broken	*BA*
	小貓	枕頭	抓破	*把*
26::MarkerBaMoveII1	The jewelry was stolen by the burglar.			
	Xiaotou	zhubao	*ba*	touzou
	burglar	jewelry	*BA*	steal
	小偷	珠寶	*把*	偷走
27::MarkerBaMoveII2	The skin was tanned by the sun.			
	Taiyang	pifu	*ba*	shaihei
	sun	skin	*BA*	darken
	太陽	皮膚	*把*	曬黑
28::MarkerBaMoveII3	The cookies were eaten by the mouse.			
	Laoshu	binggan	*ba*	chiguang
	mouse	cookies	*BA*	eat-up
	老鼠	餅乾	*把*	吃光
29::MarkerBaMoveII4	The glass was broken by the boy.			
	Nanhai	boli	*ba*	dapo
	boy	glass	*BA*	hit-broken
	男孩	玻璃	*把*	打破
30::MarkerBaMoveII5	The roof was destroyed by the lightning.			
	Shandian	wuding	*ba*	dapo
	lightening	roof	*BA*	hit-broken
	閃電	屋頂	*把*	打壞
31::MarkerBeiCorrect1	The baby was frightened by the firecracker.			
	Yinger	bei	bianpao	xiaku
	baby	BEI	firecracker	frighten-cry
	嬰兒	被	鞭炮	嚇哭
32::MarkerBeiCorrect2	Grandpa was woken up by the bell.			
	Yeye	bei	lingsheng	chaoxing
	grandpa	BEI	bell	wake-up
	爺爺	被	鈴聲	吵醒
33:MarkerBeiCorrect3	The fence was knocked away by the piggy.			
	Liba	bei	xiaozhu	zhuangdao
	fence	BEI	piggy	knock-fallen
	籬笆	被	小豬	撞倒

34::MarkerBeiCorrect4	The balloon was pierced by the thumb tack.			
	Qiqiu	bei	tuding	cipo
	balloon	BEI	thumb tacks	thrust-broken
	汽球	被	圖釘	刺破
35::MarkerBeiCorrect5	The rabbit was killed by the gun.			
	Tuzi	bei	lieqiang	dasi
	rabbit	BEI	hunting gun	hit-dead
	兔子	被	獵鎗	打死
36::MarkerBeiCorrect6	The clothes were scratched by the branch.			
	Yifu	bei	shuzhi	huapo
	clothes	BEI	branch	scratch
	衣服	被	樹枝	劃破
37::MarkerBeiCorrect7	The city was ruined by the bomb.			
	Chengshi	bei	zhadan	zhahui
	city	BEI	bomb	explode-ruin
	城市	被	炸彈	炸毀
38:MarkerBeiCorrect8	The trousers were scratched by the nail.			
	Kuzi	bei	dingzi	goupo
	trousers	BEI	nail	hook-broken
	褲子	被	釘子	勾破
39::MarkerBeiCorrect9	The shoe was worn down by the husband.			
	Xiezi	bei	xiansheng	chuanpo
	Shoes	BEI	husband	wear-torn
	鞋子	被	先生	穿破
40::MarkerBeiCorrect10	The islet was submerged by the water.			
	Xiaodao	bei	haishui	yanmo
	islet	BEI	sea water	submerge
	小島	被	海水	淹沒
41::MarkerBeiCorrect11	The vase was dashed by the younger sister.			
	Huaping	bei	meimei	shuaipo
	vase	BEI	younger sister	throw-broken
	花瓶	被	妹妹	摔破
42::MarkerBeiCorrect12	The house was burned down by the fire.			
	Fangzi	bei	dahuo	shaodiao
	house	BEI	fire	burn-up
	房子	被	大火	燒掉
43::MarkerBeiCorrect13	The score sheets were gathered by the teacher.			
	Kaojuan	bei	laoshi	shouqu
	score sheet	BEI	teacher	collect-away
	考卷	被	老師	收去
44:MarkerBeiCorrect14	The building was torn apart by the workers.			
	Dalou	bei	gongren	chaidiao
	building	BEI	worker	take-apart
	大樓	被	工人	拆掉

45::MarkerBeiCorrect15 The milk was thrown away by the uncle.

Niunai	bei	shushu	daodiao
milk	BEI	uncle	fall-away
牛奶	被	叔叔	倒掉

46::MarkerBeiSubstition The egg was crushed by the rock.

Jidan	*ba*	shitou	yapo
egg	*BA*	rock	press-broken
雞蛋	*把*	石頭	壓破

47::MarkerBeiSubstition The river was polluted by the waste water.

Heliu	*ba*	feishui	wuran
river	*BA*	waste water	pollute
河流	*把*	廢水	污染

48::MarkerBeiSubstition The dish was broken by the maid.

Panzi	*ba*	yongren	dapo
dish	*BA*	maid	break
盤子	*把*	佣人	打破

49::MarkerBeiSubstition The finger was sandwiched in the iron door.

Shouzhi	*ba*	tiemen	jiadao
finger	*BA*	iron-door	sandwich
手指	*把*	鐵門	夾到

50::MarkerBeiSubstition The key was taken away by the friend.

Yaoshi	*ba*	pengyou	nazou
key	*BA*	friend	take-away
鑰匙	*把*	朋友	拿走

51::MarkerBeiMoveI1 The wall was stained by the child.

Qiangbi	xiaohai	*bei*	nongzang
wall	child	*BEI*	make-dirty
牆壁	小孩	*被*	弄髒

52::MarkerBeiMoveI2 The bridge was washed away by the flood.

Qiaodun	hongshui	*bei*	chongkua
bridge	flood	*BEI*	wash-destroyed
橋墩	洪水	*被*	沖垮

53::MarkerBeiMoveI3 The skirt was bought by the girl.

Qunzi	nyunhai	*bei*	maizou
skirt	girl	*BEI*	buy-away
裙子	女孩	*被*	買走

54::MarkerBeiMoveI4 The elder brother was made to repeat grade by the school.

Gege	xuexiao	*bei*	liuji
elder brother	school	*BEI*	repeat grade
哥哥	學校	*被*	留級

55::MarkerBeiMoveI5 The leaves were blown by the wind.

Yezi	kuangfeng	*bei*	chuiluo
leaves	wind	*BEI*	blow-fallen
葉子	狂風	*被*	吹落

56::MarkerBeiMoveII1	The chicken was captured by the eagle.					
	Xiaoji	laoying	zhuazou	*bei*		
	chicken	eagle	catch-away	*BEI*		
	小雞	老鷹	抓走	*被*		
57::MarkerBeiMoveII2	The banana was eaten by the monkey.					
	Xiangjiao	houzi	chidiao	*bei*		
	banana	monkey	eat-up	*BEI*		
	香蕉	猴子	吃掉	*被*		
58::MarkerBeiMoveII3	The door was pushed by the bear.					
	Damen	Gouxiong	tuikai	*bei*		
	door	bear	push-away	*BEI*		
	大門	狗熊	推開	*被*		
59::MarkerBeiMoveII4	The purse was stolen by the pickpocket.					
	Qianbao	pashou	pazou	*bei*		
	purse	pickpocket	pickaway	*BEI*		
	錢包	扒手	扒走	*被*		
60::MarkerBeMoveII5	The bread was scorched by the cook.					
	Mianbao	chushi	kaojiao	*bei*		
	bread	cook	bake-scorched	*BEI*		
	麵包	廚師	烤焦	*被*		
61::ClassifierCorrect1	He said a dirty word.					
	Ta	shuo	le	yi	ju	zanghua
	he	say	ASP	one	CL	dirty wood
	他	說	了	一	句	髒話
62::ClassifierCorrect2	He sang a song.					
	Ta	chang	le	yi	shou	quzi
	he	sing	ASP	one	CL	song
	他	唱	了	一	首	曲子
63::ClassifierCorrect3	He told a story.					
	Ta	shuo	le	yi	duan	gushi
	he	say	ASP	one	CL	story
	他	說	了	一	段	故事
64::ClassifierCorrect4	There is a steamship by the harbor.					
	Gangkou	bian	you	yi	sao	lunchuan
	harbor	side	exist	one	CL	steamship
	港口	邊	有	一	艘	輪船
65::ClassifierCorrect5	There is a Banyan tree in the yard.					
	Yuanzi	li	you	yi	ke	rongshu
	yard	in	exist	one	CL	Banyan tree
	院子	裡	有	一	棵	榕樹
66::ClassifierCorrect6	There is a house on the hill.					
	Shanpo	shang	you	yi	jian	fangzi
	hill	on	exist	one	CL	house
	山坡	上	有	一	間	房子

67::ClassifierCorrect7	There is a shirt in the case.					
	Xiangzi	li	you	yi	jian	chenshan
	case	in	exist	one	CL	shirt
	箱子	裡	有	一	件	襯衫
68::ClassifierCorrect8	There is an umbrella in the bag.					
	Daizi	li	you	yi	ba	yusan
	bag	in	exist	one	CL	umbrella
	袋子	裡	有	一	把	雨傘
69::ClassifierCorrect9	There is a bus by the bus stop.					
	Zhanpai	bian	you	yi	liang	gongche
	bus stop	side	exist	one	CL	bus
	站牌	邊	有	一	輛	公車
70::ClassifierCorrect10	There is a row of buildings by the road.					
	Malu	bian	you	yi	pai	loufang
	road	side	exist	one	CL	buildings
	馬路	邊	有	一	排	樓房
71::ClassifierCorrect11	There is a newspaper in the room.					
	Fangjian	li	you	yi	fen	baozhi
	room	in	exist	one	CL	newspaper
	房間	裡	有	一	份	報紙
72::ClassifierCorrect12	There is a tiger in the cage.					
	Longzi	li	you	yi	zhi	laohu
	cage	in	exist	one	CL	tiger
	籠子	裡	有	一	隻	老虎
73::ClassifierCorrect3	There is a lamp by the window.					
	Chuanghu	bain	you	yi	zhan	taideng
	window	side	exist	one	CL	lamp
	窗戶	邊	有	一	盞	檯燈
74::ClassifierCorrect4	There is a pair of socks in the basin.					
	Penzi	li	you	yi	shuang	wazi
	basin	in	exist	one	CL	socks
	盆子	裡	有	一	雙	襪子
75::ClassifierCorrect5	There is a pair of bowl and chopsticks on the plate.					
	Panzi	shang	you	yi	fu	wankuai
	plate	on	exist	one	CL	bowl-chopsticks
	盤子	上	有	一	副	碗筷
76::ClassifierSubstitution	He shot a movie.					
	Ta	pai	le	yi	*mian*	dianying
	he	shoot	ASP	one	*CL*	movie
	他	拍	了	一	面	電影
77::ClassifierSubstitution	There is a picture on the table.					
	Zhuozi	shang	you	yi	*jian*	tuhua
	table	on	exist	one	*CL*	picture
	桌子	上	有	一	*間*	圖畫

78::ClassifierSubstitution There is a castle by the river.

Xiaohe	bian	you	yi	*di*	chengbao
river	side	exist	one	*CL*	castle
小河	邊	有	一	*滴*	城堡

79::ClassifierSubstitution There is a leaf in the pond.

Chitang	li	you	yi	*bu*	yiezi
pond	in	exist	one	*CL*	leaf
池塘	裡	有	一	*部*	葉子

80::ClassifierSubstitution There is a hat in the closet.

Guizi	li	you	yi	*xiang*	maozi
closet	in	exist	one	*CL*	hat
櫃子	裡	有	一	*項*	帽子

81::ClassifierMove1 He made a phone call.

Ta	da	le	yi	dianhua	*tong*
he	dial	ASP	one	phone call	*CL*
他	打	了	一	電話	*通*

82::ClassifierMove2 There is a smoke above the roof.

Wuding	shang	you	yi	nongyan	*gu*
roof	above	exist	one	smoke	*CL*
屋頂	上	有	一	濃煙	*股*

83::ClassifierMove3 There is a restaurant by the market.

Shichang	bian	you	yi	canting	*jia*
market	side	exist	one	restaurant	*CL*
市場	邊	有	一	餐廳	*家*

84::ClassifierMove4 There is a dictionary in the satchel.

Shubao	li	you	yi	zidian	*ben*
satchel	in	exist	one	dictionary	*CL*
書包	裡	有	一	字典	*本*

85::ClassifierMove5 There is a wound on his forehead.

Etou	shang	you	yi	shangkou	*dao*
forehead	on	exist	one	wound	*CL*
額頭	上	有	一	傷口	*道*

86::ClassifierOmission1 He got a big illness.

Ta	sheng	le	yi	*0*	dabing
he	get	ASP	one	*0*	big illness
他	生	了	一	*0*	大病

87::ClassifierOmission2 There is a teacher in the classroom

Jiaoshili	li	you	yi	*0*	laoshi
classroom-in	in	exist	one	*0*	teacher
教室	裡	有	一	*0*	老師

88::ClassifierOmission3 There is a necklace in the drawer.

Chouti	li	you	yi	*0*	xianglian
drawer	in	exist	one	*0*	necklace
抽屜	裡	有	一	*0*	項鍊

89::ClassifierOmission4 There is a scarf on her neck.

Bozi	shang	you	yi	*0*	weijin
neck	on	exist	one	*0*	scarf
脖子	上	有	一	*0*	圍巾

90::ClassifierOmission5 There is a banana in the kitchen.

Chufang	li	you	yi	*0*	xiangjiao
kitchen	in	exist	one	*0*	banana
廚房	裡	有	一	*0*	香蕉

91::AspectZheCorrect1 Someone hanged the picture on the wall

Qiang	shang	gua	zhe	tuhua
wall	on	hang	ZHE	picture
牆	上	掛	著	圖畫

92::AspectZheCorrect2 Someone wore a smile in the mouth corner.

Zuijiao	gua	zhe	weixiao
mouth-corner	hang	ZHE	smile
嘴角	掛	著	微笑

93::AspectZheCorrect3 Someone held the puppy in the hand.

Shou	li	bao	zhe	xiaogou
hand	in	enfold	ZHE	puppy
手	裡	抱	著	小狗

94::AspectZheCorrect4 The log was drifting in the sea.

Hai	li	piao	zhe	mutou
sea	in	drift	ZHE	log
海	裡	漂	著	木頭

95::AspectZheCorrect5 The rocks piled on the ground.

Di	shang	dui	zhe	shitou
ground	on	pile	ZHE	rocks
地	上	堆	著	石頭

96::AspectZheCorrect6 The white clouds were drifting in the sky.

Kong	zhong	piao	zhe	baiyun
sky	in	drift	ZHE	white cloud
空	中	飄	著	白雲

97::AspectZheCorrect7 Someone smeared bread with butter.

Mianbao	tu	zhe	naiyou
bread	spead	ZHE	butter
麵包	塗	著	奶油

98::AspectZheCorrect8 Someone hid the secret in the heart.

Xinli	li	cang	zhe	mimi
heart	in	hid	ZHE	secret
心	裡	藏	著	祕密

99::AspectZheSubstitutio Someone wore the straw hat on the head.

Tou	shang	dai	*zai*	caomao
head	on	wear	*ZAI*	straw hat
頭	上	戴	*在*	草帽

100::AspectZheSubstituti Someone filled the gruel in the bowl.

Wan	li	cheng	*zai*	xifan
bowl	in	take	*ZAI*	gruel
碗	裡	盛	*在*	稀飯

101::AspectZheSubstituti Someone tied the bandage on the leg.

Datui	bang	*zai*	bengdai
leg	tie	*ZAI*	bandage
大腿	綁	*在*	繃帶

102::AspectZheSubstituti Someone carried the luggage on the shoulder.

Jian	shang	kang	*zai*	xingli
shoulder	on	carry	*ZAI*	luggage
肩	上	扛	*在*	行李

103::AspectZheMove1 Someone lifted the fruit in the hand.

Shou	shang	ti	shuiguo	*zhe*
hand	on	lift	fruit	*ZHE*
手	上	提	水果	*著*

104::AspectZheMove2 Someone held the tears in his eyes.

Yanjing	han	leishui	*zhe*
eyes	hold	tears	*ZHE*
眼睛	含	淚水	*著*

105::AspectZheMove3 Someone placed the photo on the desk.

Zhuo	shang	bai	zhaopian	*zhe*
desk	on	place	photo	*ZHE*
桌	上	擺	照片	*著*

106::AspectZheMove4 Someone embroidered the lace on the pillow.

Zhentou	xiu	huabian	*zhe*
pillow	embroider	lace	*ZHE*
枕頭	繡	花邊	*著*

107::AspectZaiCorrect1 The elder brother is whistling.

Gege	zai	chui	koushao
elder brother	ZAI	blow	whistle
哥哥	在	吹	口哨

108::AspectZaiCorrect2 The younger sister is watching TV.

Meimei	zai	kan	dianshi
younger sister	ZAI	watch	TV
妹妹	在	看	電視

109::AspectZaiCorrect3 The servant is wiping the table.

Yongren	zai	ca	zhuozi
servant	ZAI	wipe	table
佣人	在	擦	桌子

110::AspectZaiCorrect4 The pony is pulling the cart.

Xiaoma	zai	la	chezi
pony	ZAI	pull	cart
小馬	在	拉	車子

111::AspectZaiCorrect5	The boy is playing basketball.			
	Nanhai	zai	da	lanqiu
	boy	ZAI	play	basketball
	男孩	在	打	籃球
112::AspectZaiCorrect6	The girl is picking the wide flowers.			
	Nyuhai	zai	cai	yehua
	girl	ZAI	pick	wide flower
	女孩	在	採	野花
113::AspectZaiCorrect7	The child is playing the ball.			
	Xiaohai	zai	wan	piqiu
	child	ZAI	play	ball
	小孩	在	玩	皮球
114::AspectZaiCorrect8	Mom is answering the phone.			
	Mama	zai	jie	dianhua
	mom	ZAI	answer	phone
	媽媽	在	接	電話
115::AspectZaiSubstituti	Dad is hitting the cockroach.			
	Baba	*zhe*	da	zhanglang
	dad	*ZHE*	hit	cockroach
	爸爸	*著*	打	蟑螂
116::AspectZaiSubstituti	The host is slicing the fruit.			
	Zhuren	*zhe*	qie	shuiguo
	host	*ZHE*	slice	fruit
	主人	*著*	切	水果
117::AspectZaiSubstituti	Grandpa is clipping his fingernails.			
	Yeye	*zhe*	jian	zhijia
	grandpa	*ZHE*	clip	fingernails
	爺爺	*著*	剪	指甲
118::AspectZaiSubstituti	The tiger is chasing the zebra.			
	Laohu	*zhe*	zhui	banma
	tiger	*ZHE*	chase	zebra
	老虎	*著*	追	斑馬
119::AspectZaiMove1	The piggy is eating the feeds.			
	Xiaozhu	chi	siliao	*zai*
	piggy	eat	feeds	*ZAI*
	小豬	吃	飼料	*在*
120::AspectZaiMove2	The younger brother is taking a nap.			
	Didi	shui	wujiao	*zai*
	younger brother	sleep	afternoon nap	*ZAI*
	弟弟	睡	午覺	*在*
121::AspectZaiMove3	The baby is learning to walk.			
	Wawa	xue	zoulu	*zai*
	baby	learn	walking	*ZAI*
	娃娃	學	走路	*在*
122::AspectZaiMove4	The elder sister is playing the piano.			
	Jiejie	tan	gangqin	*zai*
	elder sister	play	piano	*ZAI*
	姐姐	彈	鋼琴	*在*