Time reference in agrammatic aphasia: A cross-linguistic study

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Abstract

It has been shown across several languages that verb inflection is difficult for agrammatic aphasic speakers. In particular, Tense inflection is vulnerable. Several theoretical accounts for this have been posed, for example, a pure syntactic one suggesting that the Tense node is unavailable due to its position in the syntactic tree (Friedmann & Grodzinsky, 1997); one suggesting that the interpretable features of the Tense node are underspecified (Burchert, Swoboda-Moll, & De Bleser, 2005; Wenzlaff & Clahsen, 2004, 2005); and a morphosemantic one, arguing that the diacritic Tense features are affected in agrammatism (Faroqi–Shah & Dickey, 2009; Lee, Milman, & Thompson, 2008). However recent findings (Bastiaanse, 2008) and a reanalysis of some oral production studies (e.g. Lee et al., 2008; Nanousi, Masterson, Druks, & Atkinson, 2006) suggest that both Tense and Aspect are impaired and, most importantly, reference to the past is selectively impaired, both through simple verb forms (such as simple past in English) and through periphrastic verb forms (such as the present perfect, 'has V-ed', in English). It will be argued that reference to the past is discourse linked and reference to the present and future is not (Zagona, 2003, in press). In-line with Avrutin's (2000) theory that suggests discourse linking is impaired in Broca's aphasia, the PAst DIscourse LInking Hypothesis (PADILIH) has been formulated. Three predictions were tested: (1) patients with agrammatic aphasia are selectively impaired in use of grammatical morphology associated with reference to the past, whereas, inflected forms which refer to the present and future are relatively spared; (2) this impairment is language-independent; and (3) this impairment will occur in both production and comprehension.

Agrammatic Chinese, English and Turkish speakers were tested with the Test for Assessing Reference of Time (TART; Bastiaanse, Jonkers, & Thompson, unpublished). Results showed that both the English and Turkish agrammatic speakers performed as hypothesized, showing a selective deficit for production of inflected forms referring to the past, despite the typological difference between the languages. The Chinese agrammatic speakers were poor in reference to the past as well, but reference to the present and future also was severely impaired. For comprehension, the results were strikingly similar for the three languages: reference to the past

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was impaired for all. These results confirmed our hypothesis that reference to the past is discourse linked and, therefore, grammatical morphology used for reference to the past is impaired in agrammatic aphasia, whether this is done through Tense and/or Aspect markers.

Keywords

1. Introduction

Agrammatic speech is characterized by omissions and substitutions of grammatical morphemes. Goodglass and Hunt (1958) showed that the vulnerability of a grammatical morpheme is dependent upon its function. In English, the –s of plural nouns (book<u>s</u>) is less prone to errors than the genitive –s (John'<u>s</u> book), which is better preserved than the Agreement –s (John read<u>s</u> the book). More recently, it has been demonstrated for a number of languages that Tense inflection is more impaired than Agreement and Mood inflection (Dutch: Kok, Kolk, & Haverkort, 2006; German: Burchert, Swoboda & De Bleser, 2005; Clahsen & Ali, 2009; Wenzlaff & Clahsen, 2004, 2005; Hebrew: Friedmann & Grodzinsky, 1997; Ibero-Spanish: Gavarró & Martínez-Ferreiro, 2007; but see Dutch: Bastiaanse, 2008; English: Lee et al., 2008).

Bastiaanse (2008) also reported a deficit with Tense in Dutch agrammatic speakers, but the problems of these patients were not restricted to Tensed verb forms, nor were present and past Tense equally impaired. She therefore argued that it is not Tense that is impaired in agrammatic aphasia, but time reference through verb forms in general; in particular, reference to the past is impaired. This was confirmed by a study on Turkish agrammatic speakers, who were more impaired in verb forms referring to the past than to the future (Yarbay Duman & Bastiaanse, 2009). This raises several questions, for example, whether time reference through grammatical morphology is also impaired in languages that do not use verb inflection but aspectual adverbs, like Chinese. Also, in order to fully understand the time reference problem in agrammatic aphasia, both production and comprehension should be studied in typological different languages. This is what we intend with the current study.

In the next section, time reference by grammatical morphology will be discussed. We will first clarify the terminology. This will be followed by a description of the time reference systems of the languages involved in the present study: Chinese, English and Turkish. Next, the results of the most relevant studies to agrammatic production and processing of time reference by grammatical morphology will be discussed in relation to the test designs that have been used. Then, a theory that can describe the reported results will be presented and the hypotheses will be formulated.

1.1. Time reference through grammatical morphology

Reference to a certain time frame can be accomplished in several ways. One can use a lexical adverb or a prepositional phrase, like *yesterday, previously,* or *in the past* to refer to the past, *now* or *at this moment* for reference to the present and *in a minute* or *next year* to

refer to the future. However, in English we can also refer to the past through verb morphology. For expressing that the process of writing happened before the here and now, several verb forms can be used: *wrote, has written, has been writing, had been writing, was writing*. The form *wrote* is the 'simple past', the other forms are so-called 'periphrastic forms'. There are also several ways to refer to an event in the here and now in English: *writes, is writing, can write*. 'Writes' is called the 'simple present'; the other forms are, again, periphrastic forms. English does not have a 'simple future'; reference to the future can only be done through periphrastic verb forms: *will write, shall write, is going to write*. Notice that reference to the past, present and future is fundamentally different from past, present and future 'Tense'. Tense is a feature of the *finite* verb, the verb form that shows Agreement with the subject and can be used in past and present. In Table 1 some examples are given, showing that present finite verbs (Tensed verbs) may be used to refer to past, present or future.

This table shows that there is no one-to-one relation between Tense and time reference in English. In other languages, such as Greek and Turkish, the relation between Tense and reference to time is clearer. What these two languages have in common is that simple rather than periphrastic verb forms are used to refer to the future (see Table 2 for an example from Turkish).

In these languages, time reference is not only achieved by Tense: there is a complex interplay between Tense and Aspect, where Aspect denotes whether the action has been finished or is still going on. Perfect Aspects denote that the event started in the past and has been completed, whereas imperfect Aspect[1] indicates that the action is still going on. Greek, for example, has past, present and future Tense and perfect, imperfect and perfective Aspect. Both Tense and Aspect are marked on the finite verb. This interplay can also be seen in English: in 'he <u>has</u> been reading', the finite verb ('has') is in present Tense, the whole verb construction is in perfect Aspect and in combination with the participle 'been' and the present participle 'reading' the whole verb complex ('has been reading') refers to an event in the past. In languages with only or predominantly simple verb forms, this is expressed in one single word (okuyordu = 'has been reading' in Turkish).

Other languages do not express time reference through verb morphology. In Chinese, one of the languages examined in the current study, imperfective and perfective aspectual adverbs express time reference to the present and past, whereas uninflected modal auxiliaries are used to indicate the future. There are two imperfective aspectual adverbs in Chinese: the dynamic imperfective Aspect *zai*, and static imperfective Aspect marker *zhe*. These two Aspect markers are used to refer to the present. There are two perfective Aspect markers that subtly differ in meaning. Though both are used to refer to the past, *le* is simply perfective[2] and *guo* is experiential perfective. Futurity is expressed through modal auxiliaries, *yao* and *hui*. The two differ slightly in meaning. *Hui* is used to denote an objective futurity or

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[1]For English, the term 'progressive' is more usual than 'imperfect' to denote the durativity of an event. For most other languages (including, for example, Dutch, German, all Slavic languages and Turkish), the division is perfect–imperfect is more common. [2]When *le* comes at the end of the sentence, it becomes different from the postverbal *le*. The sentence final *le* scopes the entire sentence and shows the feature of perfect. The role of sentence final *le* is debated, but not relevant for the present study.

possibility whereas *yao* is used to denote a subjective futurity or possibility. In Table 3 some examples are given.

In sum, different languages have different ways to express time reference through Tense and Aspect. Some languages, like English, Dutch and Spanish, have a combination of simple verbs and periphrastic forms; other languages, such as Russian, Greek and Turkish have only or predominantly simple verb forms; and still other languages, such as Chinese, Indonesian and Thai, use free grammatical morphemes.

The present study compares production and comprehension of time reference through verb inflection and aspectual adverbs in English, Turkish and Chinese agrammatic speakers.

1.2. Time reference in agrammatic aphasia

Tense, Aspect and time reference in agrammatic aphasia have recently been studied for a number of languages. Friedmann and Grodzinsky (1997) noted the difference in production of Agreement and Tense morphology in a Hebrew agrammatic speaker. This patient had fewer problems with Agreement features than with Tense features. Following Pollock (1989), they assumed that Tense and Agreement features are hosted by different nodes on the syntactic tree and that the Tense node is above the Agreement node. Based on this result, they formulated the Tree Pruning Hypothesis: in agrammatic production, the syntactic tree is pruned at the Tense node and, therefore, agrammatic speakers have problems producing Tense inflections. The Agreement node is intact, as demonstrated by intact realization of Agreement inflection in agrammatic production.

However, the Tree Pruning Hypothesis is no longer tenable for a number of reasons. For example, operations below the Tense and Agreement nodes in the syntactic tree are impaired in some languages (Bastiaanse, Koekkoek & Van Zonneveld, 2003) and Aspect, which is below Tense in the Greek syntactic tree, is seriously impaired (Nanousi, Masterson, Druks, & Atkinson 2006; Stavrakaki & Kouvava, 2003).

Several alternative accounts of the poor performance with respect to Tense have been formulated, because the Tense problems in agrammatic aphasia are obvious. These theories do not focus on the position of Tense morphology in relation to Agreement morphology in the syntactic tree, but relate the difficulties of agrammatic speakers to the fact that Tense morphology does not express an intrasentential relationship like Agreement, but rather a relationship between the time of speaking and the time of the event. Therefore, the explanation is not sought at a pure syntactic level, but at the interface between semantics and morphology. Wenzlaff and Clahsen (2004, 2005), formulated the Tense Underspecification Hypothesis, and argued that the interpretable features of Tense (+Past and –Past) are underspecified. Faroqi–Shah and Thompson (2007) and Faroqi–Shah and Dickey (2009) presented data showing that encoding and retrieval of diacritics of the Tense morpheme are impaired, thus suggesting that the deficit is morphosemantic in nature. All these theories are based on studies that addressed Tense (versus agreement and/or mood). However, if we take 'time reference', including both Tense and Aspect into account and focus on studies that used oral production, an interesting pattern emerges.

Simonsen and Lind (2002) and Stavrakaki and Kouvava (2003) analyzed spontaneous speech for verb inflection in Norwegian and Greek, respectively, and found that Tense/ Aspect production was impaired. The Norwegian patient did not produce any verb form referring to the past (Simonsen & Lind, 2002). The two Greek patients had severe problems with past Tense and perfective Aspect, both used to refer to an event in the past (Stavrakaki & Kouvava, 2003).

Nanousi et al. (2006) for Greek; Bastiaanse (2008) for Dutch; and Lee et al. (2008) for English used tests eliciting spoken verbs by sentence completion. Nanousi et al. (2006) analyzed the production of verbs inflected for Tense and Aspect. Their data showed that agrammatic speakers have problems with perfect and perfective Aspect. In Greek, perfect and perfective Aspect are used for reference to the past. They denote completion of an event. Bastiaanse (2008) showed that Dutch agrammatic speakers have problems producing verbs (simple past and past participles) that refer to the past. Lee et al. (2008) used an English version of the test used by Bastiaanse (2008). A reanalysis of the data from their second experiment shows a similar pattern as was found in Dutch: the simple past (V+ ed; 35.7% correct) is more difficult than the simple present (V+ s; 67.5%), and the present perfect (has V+ ed; 36.5%) that refers to the past is more difficult than the present progressive (is V+ ing; 85%) that refers to the present. In sum, Tense and Aspect problems have been reported for a number of languages; additionally, the studies of Bastiaanse (2008) and Lee et al. (2008) show that verb inflection problems are not restricted to finite verbs but that periphrastic forms are affected as well. These data suggest a specific problem with reference to the past (see Table 4). All verb forms in the rightmost column of Table 4 refer to the past, whereas the forms in the penultimate column refer to the present. Hence, verb forms referring to the past, both by past Tense verbs and by simple and periphrastic forms of perfect(ive) Aspect, are more vulnerable than verb forms referring to the present.

1.3. Time reference and discourse linking

In theoretical linguistics, a distinction has been made between binding relations and discourse linkedness. Binding relations are established within a sentence, such as the relation between the subject and the finite verb, as in he$_{3rd,sg}$ walks$_{3rd,sg}$, or between a reflexive and its antecedent, as in 'the boy$_i$ is washing himself$_i$'. In the latter sentence, the index i indicates that 'the boy' and 'himself' are 'bound', that is, they refer to the same person. In a sentence such as 'the boy$_i$ is washing him$_j$' this is not the case. 'Him' refers to someone other than 'the boy' and a relation should be established between 'him' and a person who is not mentioned in this sentence. In other words, 'him' is not locally bound. In order to interpret this pronoun, an extrasentential link should be made. This is called 'discourse linking'.

Discourse-linking also plays a role in other constructions, for example, when interpreting *which*-questions. 'Which' in a sentence such as 'which boy is the girl pushing?' presupposes that there is a group of boys and one of them is being pushed by the girl. Therefore, interpretation of 'which' also requires discourse linking. In *who*-questions ('who is the girl pushing?') such a presupposition is not needed and therefore, *who*-questions are not discourse linked.

This distinction between bound and discourse-linked reference has been demonstrated to be relevant in language processing. Shapiro (2000) used a cross-modal lexical priming task and showed that gap filling was slower in *which*-questions (such as 'which boy$_i$ is the girl chasing i') than in *who*-questions ('who$_i$ is the girl chasing i'). It has been shown that (discourse linked) pronouns are harder to understand for Broca's patients than (bound) reflexives (Grodzinsky, Wexler, Chien, Marakovizt & Solomon, 1993) and pronouns are also harder to produce (Drijbooms & Bastiaanse, 2011 for French-Dutch bilingual agrammatic speakers; Sanchez, Martínez Ferreiro, & Bastiaanse, in press for Spanish agrammatic speakers).[3] Similarly, sentences with discourse-linked wh-words (*which*-questions) are more difficult to comprehend than sentences with locally bound wh-words (*who*-questions; Hickok & Avrutin, 1995). Avrutin (2006) proposed a model that assumes interaction between two levels of linguistic processing. There is a narrow syntactic processing (more or less synonymous with establishing sentence internal relationships, such as Agreement) and linguistic context (comparable to discourse linking). He argues that individuals with agrammatic aphasia do not have sufficient processing resources for simultaneous processing at these two levels. This results in competition between narrow syntax and discourse linking. Usually narrow syntax wins, because this is least costly. Avrutin (2000, 2006) also argues that Tense, in general, is discourse linked and will therefore be difficult for agrammatic speakers.

However, Avrutin's idea on Tense being discourse linked may be too broad. Zagona (2003), for example, suggested that reference to the present should be considered as a kind of 'binding relation': there is simultaneity between the evaluation time ('speech time') and the 'event time' (Zagona, 2003). When referring to the past, speech time and event time do not coincide. In that case, a relation should be established between speech time and an earlier event and this relation, according to Zagona (2003), is discourse linked. Reference to the future usually is seen as a subclass of present Tense (Zagona, in press) and therefore not discourse linked. However, reference to a certain time point (or 'event time') cannot be made, as there is no event yet. Therefore, reference to the future is not bound within the sentence (Zagona, p.c.). Discourse linking is, thus, required for past Tense, but not for Tense in general, as Avrutin (2000, 2006) suggested. We also think that both Avrutin's (2000, 2006) and Zagona's (2003) ideas are too narrow, because not only reference to the past through Tense is discourse linked, but through periphrastic verb forms ('has walked') as well. We would like to rephrase Avrutin's and Zagona's ideas: reference to the past through verb inflection requires discourse linking. Therefore, verb forms referring to the past are more complex than those referring to the present or future. This is reflected in longer RTs in non-brain-damaged individuals (Faroqi–Shah & Dickey, 2009; Jonkers, Koopmans, Menninga & Zoodsma, 2007) and in more problems producing verb forms referring to the past in agrammatic aphasic individuals (Bastiaanse, 2008; Faroqi–Shah & Dickey, 2009; Faroqi–Shah & Thompson, 2007; Lee et al., 2008; Yarbay Duman & Bastiaanse, 2009). We call this theory that predicts that agrammatic speakers suffer from selective problems with reference to the past through grammatical morphology because this requires discourse linking the PAst DIscourse LInking Hypothesis (PADILIH).

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[3]But see Choy and Thompson (2010) who found no difference between reflexives and pronouns in agrammatism.

1.4. The current study

On the basis of the cross-linguistic data presented above, one may conclude that agrammatic speakers have problems referring to a past time frame with verb morphology, irrespective of the language and irrespective of whether reference to the past is expressed by a finite verb or by a periphrastic verb form. This raises several questions.

The first is whether these problems with expressing reference to the past through morphology are restricted to verb inflection. This question is addressed in the present study by including data from Chinese, which uses aspectual adverbs rather than verb morphology. The PADILIH is language independent and, thus, predicts that Chinese agrammatic speakers will have problems with aspectual adverbs.

A second question is whether agrammatic production of reference to the future through verb morphology is spared. Only three studies assessed reference to the future in sentence completion. Nanousi et al. (2006) found no problems with future Tense (which, in Greek, is expressed on the finite verb). Yarbay Duman and Bastiaanse (2009) found that future Tense/ imperfect Aspect finite verbs were relatively spared compared to past Tense/perfect Aspect finite verbs in Turkish agrammatic speakers. Finally, Abuom, Obler and Bastiaanse (2011) described two multilingual agrammatic speakers in whom reference to the future was spared in both English and Swahili (a highly inflectional language that marks Tense/Aspect by an infix in a very complex finite verb form), whereas reference to the past was severely impaired in English, but intact in Swahili. Although the data on reference to the future in agrammatic aphasia are, as yet, quite sparse, it seems as though reference to the future is relatively spared compared to reference to the past, at least in production. Reference to the future is usually seen as a subclass of present Tense (Zagona, in press) and, therefore, not discourse linked. However, reference to a certain time point (or 'event time') cannot be made, as there is no event yet. Hence, reference to the future is not bound within the sentence either (Zagona, p.c.). The PADILIH predicts that reference to the future will be relatively spared, since it is not discourse linked.

The third question is whether there will be quantitative and qualitative differences between the languages due to their structural and morphological differences. As discussed above, Chinese, English and Turkish have very different ways to express time reference morphologically: Chinese only has free grammatical morphemes, Turkish only has verb inflections and English has a combination of free and bound grammatical morphemes. There are several theories that predict different patterns of performance in the three languages. According to Bates, Friederici, and Wulfeck (1987), problems with grammatical morphemes are motivated by so-called 'cue validity'. They argue that classes of grammatical morphemes that have many members are less prone to errors than classes that have only a few members. According to this theory, the very extensive Turkish verb inflection paradigm will be relatively spared and the few English verb inflections will be vulnerable. Menn and Obler (1990), on the basis of their large cross-linguistic data base, propose the opposite of Bates et al. (1987); that is, the larger the paradigm, the more prone to errors it is. Bastiaanse, Jonkers, Ruigendijk and Van Zonneveld (2003), however, argued that it is not the size of the paradigm, but rather the function that is provided by the inflection that is decisive for the error pattern. Since the present study tested the same function in the three languages

(Chinese, English and Turkish), Bastiaanse et al. (2003) predict no cross-linguistic differences. According to Grodzinsky (1990), agrammatic speakers will omit bound grammatical morphemes if the result is an existing word, but will substitute the morpheme when an omission results in a nonword. He thus predicts that English agrammatic speakers will omit the *–ed* of the past Tense verb, because the stem is an existing word. However, Turkish agrammatic speakers will substitute the past Tense ending, since omission will result in a nonword. This theory also predicts that unbound grammatical morphemes, such as aspectual adverbs in Chinese, will be omitted.

The fourth question is whether these selective problems of agrammatic patients are restricted to production. A number of grammaticality judgment studies have been conducted and, in general, individuals with Broca's aphasia perform poorly on these tasks (Wenzlaff & Clahsen, 2004, 2005 for German; Faroqi–Shah & Thompson, 2007; Faroqi–Shah & Dickey, 2009 for English). Auditory comprehension has been tested by Jonkers and Bruin (2009), who found that, in Dutch individuals with Broca's aphasia, comprehension of past Tense is more impaired than comprehension of present Tense. Since Avrutin's (2006) competition model is mainly based on comprehension data, we hypothesize that comprehension of reference to the past will be impaired.

To test these four hypotheses, we tested both oral production and comprehension of past, present and future time reference morphology in Chinese, English and Turkish agrammatic speakers and thus enables us to address the question of correspondence between oral production and auditory comprehension.

2. Methods

2.1. Participants

Eleven Chinese (Mandarin speakers from Taiwan), twelve English and eight Turkish agrammatic speakers participated in the study. All but one English-speaking patient had a left hemisphere lesion and they were all aphasic due to a single stroke (except for one Chinese-speaking and one English-speaking patient, who suffered brain damage due to traumatic brain injury; since their performances followed the pattern of the stroke patients, it was decided to include them). Mean age, time post-onset and gender are given in Table 5; the individual data are given in Appendix 1.

The patients were all classified as having Broca's aphasia with the Concise Chinese Aphasia Test (CCAT; Zhong, Li, & Zhang &, 2003) for Chinese, the Western Aphasia Battery (Kertesz, 1982) for English, and the Gülhane Aphasia Test (Tanrıda, 1993) for Turkish. To ensure the aphasia type, a narrative sample was elicited (a standardized interview and description of the Flood Rescue picture, following the procedures of Olness, 2006). Only data from individuals who were classified as Broca's patients and produced clearly agrammatic speech were included in the study, as judged by both the speech therapist and the experimenter: their speech rate was severely reduced and they spoke in short, grammatically simple utterances.

For each language, age- and education-matched non-brain-damaged monolingual speakers (11 for Chinese, 12 for English, 7 for Turkish) were used as control groups. These were individuals with normal or corrected to normal vision and hearing who had no history of neurological illness, drugs or alcohol abuse.

2.2. Materials

The *Test for Assessing Reference of Time* (TART: Bastiaanse, Jonkers, & Thompson, 2008) was used. This test was developed for a cross-linguistic project to examine production and comprehension of grammatical morphology associated with time reference. It can be used in virtually every language (right now data from more than 15 languages are being collected).

2.2.1. TART-production—For the production test, 11 pairs of transitive action verbs were selected. The verbs in each pair can select a common object, for example, *to iron/to fold a shirt; to peel/to eat an apple*. A complete list of the verbs is given in Appendix 2. Colored photographs were developed to depict the actions, three for each verb, one showing the action being finished, one showing it going on and one with the action about to start. These pictures were used to elicit verb forms and aspectual adverbs that refer to the past, present and future, respectively.

In order to elicit verb forms and aspectual adverbs that refer to past, present and future, we chose a sentence production priming paradigm. For each language the most frequent forms used to refer to the past, present, and future were compared to a neutral form in the current analysis. To elicit production of a target form, two pictures were presented side-by-side, showing two actions in a particular time frame with the same object, with the infinitive form printed above the pictures (see Fig. 1 for an example from the English version).

2.2.1.1. The English TART-production: For English the following forms were elicited: simple past (+ed; e.g., *painted*), present progressive (+ing), future (will + infinitive), and the neutral form (the infinitive, through the frame 'wants to' + infinitive). The participant was shown the two pictures and, using the left picture, primed to produce the verb (complex) plus the direct object using the right picture. In order to provide an obligatory context for the past, present and future readings of the sentence, temporal adverbs were used for both the prime and target: 'previously' for reference to the past, 'now' for reference to the present and 'soon' for reference to the future. An example for eliciting the simple past is:

> Examiner: *Here are two pictures. They show the actions 'peel' and 'eat'. For this one* (examiner points to the left photo), *I could say, "Previously the man peeled an apple"; for this picture* (examiner points to the target photo on the right) *you could say, "Previously the man ......"*

> Participant: "*.... ate[4] an apple*"

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[4]No allowance was made for regular and irregular past Tense or participles because the TART was developed to be used with many languages and verbs that are irregular in one language may be regular in another. In the English version, 7 out of 20 verbs were irregular. Performance across the English agrammatic participants was comparable between regular (52% correct) and irregular (50% correct) past tense verbs. Turkish only has regular past Tense and participles.

2.2.1.2. The Chinese TART-production: In the Chinese version, sentences with *le* were used to refer to the past. *Le* is used postverbally. In this position, it expresses perfective Aspect. It was elicited by the lexical adverb *gancai:* 'just'. For reference to the present, (preverbal) *zai* was used. This is the progressive marker, which gives the sentence a reading equivalent to the English present progressive. For elicitation the lexical adverb *xianzai:* 'now' was added. (Preverbal) *yao* was used for reference to the future. This is an imperfective form and similar to 'will' in English. It was elicited by *dengyixia:* 'later'. For the neutral reading, a sentence verb without aspectual adverb was elicited by the lexical adverb *jingchang*: 'often'. For example[5]:

Examiner:	zhenusheng xianzai *zai* zhe yifu zhenusheng xianzai
	woman now ASP fold sweater woman now
	'Now the woman is folding the sweater. Now the woman .....'
Participant:	[*zai* tan yifu]
	[ASP iron sweater]
	'is ironing the sweater'

2.2.1.3. The Turkish TART-production: For Turkish the most frequent verb form to refer to the past is the definite past Tense–perfect Aspect. For reference to the present, the present progressive is most common, and for reference to the future, future Tense–imperfect Aspect. Since the infinitive printed above the pictures is not a form that is used in daily life, no neutral condition was included in the Turkish version of the TART. The lexical adverb *az önce:* 'previously' was used to elicit a verb form referring to the past. For reference to the present *imdi:* 'now' and for reference to the future *az sonra*: 'shortly after' were used. For example:

Examiner:	Adam az önce mektup okudu. Adam az önce .....
	the man previously the letter read$_{3sg,past,perf.}$ the man previously.
	'previously the man read a letter, previously the man .....'
Participant:	mektup yazdı
	the letter write$_{3sg,past,perf.}$
	'wrote the letter'

2.2.1.4. Procedure: In the TART-production, practice trials using the verb pair *to read* and *to write* preceded the experimental trials. Each structure was included in these practice trials. The trial sentences were repeated until it was clear that the participant understood the task, in particular that the verb morphology (English, Turkish) or aspectual adverbs or modal verb (Chinese) was critical. If the Chinese participants omitted the aspectual adverb or model verb in the trial items, she/he was explicitly told that these words had to be produced.

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[5]For reasons of clarity, the introducing sentences ("The verbs are 'X' and 'Y'. For this one, I could say…") were omitted from the Chinese and Turkish elicitation procedures.

Responses were scored both quantitatively and qualitatively. A response was considered correct when the required verb form was produced. Because the focus of the study was on time reference, omission of the object was not counted as an error, nor was the use of a semantic paraphasia (an error that occurred infrequently). If the participant produced a verb with incorrect inflection, the substituted inflection was noted. In English, omissions of the inflectional morpheme and omissions of an auxiliary (*wants to* for the neutral form, *is* for present progressive, *will* for the future form) were tallied. In Chinese, omissions of the aspectual adverb were counted even though such an omission results in a grammatical sentence.

2.2.2. TART-comprehension—For comprehension of time reference, the same photos as in the TART-production task were used and the same constructions were tested, except for the neutral condition in Chinese and English. For English, these constructions included the simple past, present progressive and [*will* + infinitive], for Chinese sentences, *le, zai,* or *yao;* for Turkish, definite past Tense–perfective Aspect, present progressive and future Tense– imperfective Aspect. No additional lexical adverbs were used, hence the correct time frame could only be established on the basis of grammatical morphology. All 20 verbs were tested in the three time frames, so the test consisted of 60 items.

Pretesting the Dutch version of the TART showed that choosing from three photos (past, present, future) did not elicit correct responses in a population of non-brain-damaged speakers, because, for some verbs, the photos of the past and future were not easy to distinguish (e.g. *he pushed the trolley* and *he will push the trolley*; these pictures both show a man who is not pushing the trolley). Therefore, it was decided to use a binary choice task, in which both the future and the past were tested using the present Tense picture as a foil. The present was always contrasted with the past, since present and future cannot always be unequivocally distinguished (cf. both *she sharpens the pencil* and *she will sharpen the pencil* may both refer to a photo of a woman sharpening a pencil). The two photos were presented above each other. An example of an item is given in Fig. 2.

2.2.2.1. Procedure: A picture pair was presented to the participant and a sentence with the target inflected form was spoken aloud. The participant was asked to point to the picture that matched the sentence. The test began with 6 examples, 3 with the verb *to read* and 3 with the verb *to write*. The different time frames were contrasted when the participant made an error. None of the participants had problems doing the task, although errors were made. Responses were scored as correct if the participant pointed to the target picture.

3. Results

The non-brain-damaged participants all scored at ceiling. Therefore, their data were not included in further analyses. Because the patient groups were rather small and the scores were not normally distributed, non-parametric testing was performed. Friedman's tests were used for each language to test whether differences between the scores on the time frames were reliable. Subsequently, Wilcoxon tests were applied to test the reliability of the difference between the conditions. For reasons of readability, we only mention the *p*-level in the text. In Appendices (3 and 4) with the individual scores, the exact test statistics are

given. We will first discuss the TART-production data, both quantitatively and qualitatively, and then the results of the TART-comprehension.

3.1. TART-production

3.1.1. Quantitative analysis—In Table 6, the group results on the TART-production are given; the individual data are mentioned in Appendix 3.

These data show that the Chinese and English agrammatic speakers performed relatively well in the neutral condition. In all languages, the agrammatic speakers were impaired in producing the grammatical forms for reference to the past. There was a significant difference between the three time frames for English and Turkish (English $p = 0.040$; Turkish $p = 0.046$), but not for Chinese ($p = 0.928$). Both the English and the Turkish agrammatic speakers performed significantly worse on past than present tense, as expected (English $p = 0.007$; Turkish $p = 0.016$), in line with the results of previous studies on oral production. For Chinese there was no such difference ($p = 0.938$). This was not because reference to the past was not impaired in the Chinese agrammatic speakers: rather, they performed poorly in the present and future conditions. This is probably caused by the fact that aspectual adverbs are not obligatory, contrary to the English and Turkish verb inflection. We will come back to this in Discussion.

Although the TART has been developed for group studies, the individual data have been analysed as well (see Appendix 3). For Chinese, no individual differences between past and present were found, the agrammatic speakers perform equally poor in the three conditions. For English and Turkish, all patients (except T7) are worse in the past condition, and this difference is significant in 7/12 English and 2/8 Turkish agrammatic speakers. This is exactly the same pattern as observed by Bastiaanse (2008) for Dutch and Yarbay Duman and Bastiaanse (2009) for Turkish: past is more significantly more difficult than present (Dutch) and future (Turkish) for the group and around 25% of the agrammatic individuals, and for all but one agrammatic speakers the score on past is lower than on present/future, with one exception who shows the opposite pattern.

Four research questions were formulated on the basis of previous studies. The first question was whether reference to the past is also impaired in languages that do not use verb inflection or periphrastic verb forms but aspectual adverbs. Since data from various studies suggest that discourse linking by grammatical morphology is impaired in general, the PADILIH predicts that reference to the past through aspectual adverbs in Chinese is impaired as well. Table 6 shows that Chinese agrammatic speakers produce sentences that do not require a specific time reference (the neutral condition) quite well, but they have problems producing the aspectual adverbs in the experimental conditions, each of which is more difficult than the control condition (neutral – past $p = 0.004$; neutral – present $p = 0.004$; neutral – future $p = 0.006$).

The second question was whether reference to the future was impaired. The PADILIH predicted that this would not be the case. Both in English and in Turkish, the agrammatic speakers performed equally well in the present and future condition and worse in the past than in the future condition; in Chinese, performance in past, present and future was equally

poor[6] (Chinese present–future $p = 0.625$, past–future $p = 0.469$; English present–future $p = 0.25$, past–future $p = 0.014$; Turkish present–future $p = 0.382$, past–future $p = 0.008$).

The third question concerned typological differences between the three languages. As noted above, the Chinese agrammatic speakers perform poorly in referring to the past, present and future, making overall more errors than the agrammatic speakers of the other languages. The question was whether the size of the verb inflection paradigm influences the performance of the agrammatic speakers. Comparison of the English and Turkish agrammatic speakers shows the following results. Both languages use a Tensed verb to refer to the past, but the inflectional paradigm for Turkish is much larger. However, the performances of the English and Turkish agrammatic speakers are comparable (Mann Whitney U, $z = -0.66$, $p = 0.509$) in the past condition. In the other two conditions, the nature of the verb form differs: For both present and future reference, English uses periphrastic forms and Turkish uses Tense inflection. However, again, the performance of the English and Turkish agrammatic speakers is very similar (Mann Whitney U: present: $z = 0.66$, $p = 0.509$; future: $z = -0.15$, $p = 0.881$).

In order to assess the impact of typological differences between the languages on the errors, a qualitative analysis has been performed.

3.1.2. Qualitative analysis—In Table 7 the most frequent errors in the three languages are summarized. The individual scores are presented in Appendix 3.

In Chinese, two error types were most common. Most errors were made because the aspectual adverb was omitted. Omission of this adverb left the sentence grammatical. Some agrammatic speakers made substitution errors. In most cases, the aspectual adverb for past (*le*) or future (*yao*) was substituted by the present marker *zai*.

In English, both substitutions and omissions occurred, but substitutions were more frequent. For present progressive, errors were dominated by incorrect verb inflections, while the correct auxiliary was present (e.g., *is pulls*). For both past and future forms, the most common error was the substitution of present forms (e.g., *is pulling/pulls* for *pulled/will pull*).

In Turkish, two error types were most prominent. Verb inflection was never omitted, but the infinitive inflection (the inflected form that was printed above the picture, but not used in the test) or another inflectional suffix would be substituted for the target inflection. Most errors were made in the past condition and concerned substitutions of the present progressive form, the future and the indefinite past.

3.1.3. Summary of the results on TART-production—All participant groups showed problems producing morphological material associated with time reference. Chinese agrammatic speakers evinced difficulty producing aspectual adverbs, Turkish participants

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[6]Since the non-brain-damaged speakers never omitted the time reference morphemes in Chinese and since none of the agrammatic speakers omitted the morphemes all the time, it was decided to count these omissions as errors. However, even if we only count the substitutions, there is still no difference between the past, present and future conditions.

showed impairment in production of verb inflection and English speakers demonstrated difficulty producing both verb inflection and periphrastic verb forms. However, the pattern found in English and Turkish, that is, greater difficulty with reference to the past than to the present and future, was not found for Chinese. For the Chinese agrammatic speakers all inflection conditions were equally difficult, and sentences with aspectual adverbs were more difficult than sentences with a neutral time frame. The morphological differences between English and Turkish do not play a role: agrammatic speakers of the two languages performed at the same level and exhibited the same pattern. Finally, the error data showed that Turkish agrammatic speakers produce primarily substitution errors, whereas English agrammatic speakers produce predominantly substitution errors, but also omissions of free and bound morphemes.

3.2. TART-comprehension

Table 8 presents the results of the TART-comprehension.

The performance in each group is very similar; there is no difference between the overall performance of the three language groups (Kruskal–Wallis: H(2) =4.11, p =0.1281). The differences between the three conditions are significant for each of the languages (Chinese: p =0.0004; English: p =0.0015; Turkish: p =0.0033).

The PADILIH predicts that comprehension of reference to the past, both through verb inflection and through aspectual adverbs, is more impaired that reference to the present and future. The results show that comprehension of past morphology is compromised: the agrammatic participants of the three languages perform strikingly similarly on the past condition (around 70% correct; above chance), which is significantly worse (Chinese: p =0.001; English: p =0.001; Turkish: p =0.008) than their comprehension of present morphology (around 90% correct). For 4/11 Chinese, 5/12 English and 2/8 Turkish agrammatic individuals, past morphology was more difficult to comprehend than present morphology; 2/11 Chinese and 1/8 Turkish agrammatic individuals scored significantly lower on future morphology compared to present morphology.

At the individual level, all agrammatic participants scored lower on past than on present, except for one English agrammatic speaker who scored maximally on both conditions.

Comprehension of future morphology is also affected. For Chinese and English agrammatic speakers, it is significantly worse than present (Chinese p =0.018; English p =0.006), but better than past morphology (Chinese p =0.023; English p =0.024). For the Turkish agrammatic speakers, the future is also more difficult than the present (p =0.023), but the difference between future and past reference just fails to reach significance (p =0.078).

3.3. Summary of the results

Fig. 3 shows an overview of the results.

This figure shows that both production and comprehension of reference to the past through grammatical morphology are impaired, whether this is done through verb inflection, periphrastic verb forms, or aspectual adverbs. Production of reference to the present and

future is relatively spared in English, with its periphrastic verb forms, and Turkish, with its complex finite verbs. The performance patterns in these two typologically different languages are comparable. In both languages the errors are predominantly the substitutions of the grammatical morpheme, but in English omissions occur as well. In Chinese, most errors are omissions of the aspectual adverb, but substitutions are made as well.

The patterns of performance on the comprehension test are very similar in the three languages. Comprehension of past morphology is worse than comprehension of present morphology, the latter being close to ceiling. Comprehension of future morphology is impaired as well, though not to the same extent as past morphology in Chinese and English. Future morphology in Turkish is only marginally better than past morphology.

4. Discussion

In both production and comprehension, grammatical morphology referring to the past is affected in the three languages. For English and Turkish, the past is more impaired than the present in production and comprehension. For Chinese, the past is more impaired than the present in comprehension, but in production, performance is equally low in both conditions. Comprehension of future morphology falls between past and present: worse than present in all three languages, but better than past in Chinese and English.

The production results replicate earlier findings reported by Bastiaanse (2008), who found that for (Dutch) agrammatic speakers, production of grammatical morphology to refer to the past was more difficult than grammatical morphology to refer to the present, for both Tensed verbs and periphrastic verb forms. The data are also in line with the findings of Yarbay Duman and Bastiaanse (2009), who demonstrated that for Turkish agrammatic speakers, finite verbs inflected for past Tense/perfective Aspect were more difficult to produce than finite verbs inflected for future Tense/imperfective Aspect. Both studies found a similar pattern with respect to individual performance as was seen in the current study: all agrammatic speakers score lower on past than present (Bastiaanse, 2008) and future (Yarbay Duman & Bastiaanse, 2009), and these differences are significant for some of the individual results. Finally, the current results are also in-line with findings from studies that were not originally directed at the difference between reference to past and present; reanalysis of data from these studies showed that past was selectively impaired (Faroqi–Shah & Thompson, 2007; Lee et al., 2008; Nanousi et al., 2006; Simonsen & Lind, 2002; Stavrakaki & Kouvava, 2003).

First, we will discuss the Chinese production results, which are different from the English and Turkish data, as well as from data of previous studies. Subsequently, the quantitative and qualitative differences in performances across the three languages are discussed for production. Next, the performance on production and comprehension will be compared. Finally, we will argue that there is a central underlying disorder in reference to the past in agrammatic aphasia, as predicted by the PADILIH and we will present some issues that still have to be sorted out.

4.1. The Chinese production data

The Chinese agrammatic speakers performed very poorly on the production test: they scored worse than the non-brain-damaged control participants, with equally poor performance in each of the three conditions. No selective deficit for reference to the past could be observed. Since their performance on the comprehension task was almost identical to the performance of the English and Turkish agrammatic speakers, we assume that the underlying disorder (problems with reference to the past) is similar for the agrammatic speakers of the three languages. The TART-production is apparently not appropriate for testing agrammatic speakers in a language that uses free-standing aspectual adverbs instead of verb inflection. Let us look again at the example item for reference to the present:

Examiner:	zhenusheng xianzai *zai* zhe yifu zhenusheng xianzai
	woman now ASP fold sweater woman now
	'Now the woman is folding the sweater. Now the woman .....'
Participant:	[*zai* tan yifu]
	[ASP iron sweater]
	'is ironing the sweater'

Notice that in these sentences two words are used to refer to the present, the lexical adverb *xianzai*: '*now*' and the aspectual adverb *zai*. In English and Turkish the word *now*/ *imdi* is obligatory combined with present Tense of the finite verb, and omission or substitution of the verb inflection results in an ungrammatical sentence. In Chinese, however, the Aspectual adverb is redundant in combination with *xianzai*, because *xianzai* already means that the time of speaking and the event time coincide. Thus, omission of the aspectual adverb leaves a perfectly grammatical sentence. The non-brain-damaged speakers of Chinese have no problems producing the aspectual adverb (*zai*) in combination with the temporal lexical adverb (*xianzai*), despite the fact that it is not mandatory. Considering that the agrammatic Chinese speakers have language problems, it is not surprising that they omit grammatical morphemes that are not in an obligatory environment, like the aspectual adverbs. This means that we have to find another way to test the production of time reference morphology in Chinese agrammatic aphasia. It is clear, though, that these agrammatic speakers have problems with reference to the past. Their error pattern on the comprehension test is identical to that of the English and Turkish agrammatic speakers: grammatical morphology referring to the past is more difficult to comprehend than grammatical morphology referring to the present.

4.2. Comparison of the production data across languages

It was shown that the morphological structure of a language does not influence agrammatic speakers' performance. Whether free (Chinese), bound (Turkish) or both types (English) of grammatical morphemes are used, this does not influence patients' performance, at least not for comprehension. Performance patterns are the same for the three languages: past < present, past   future and future < present.

The production scores of the English and Turkish speakers are similar as well, although English uses both free (future) and bound (past) morphemes and combinations (present) and Turkish speakers only have bound morphemes. Chinese agrammatic speakers are also impaired in the production of past morphology, but they are also poor on the present and future conditions. We argued above that this is probably caused by the fact that when the aspectual adverbs are omitted, the sentences are grammatical and still contain a temporal lexical adverb to denote the time frame.

Three theories that make different predictions for performance across languages were discussed in Introduction. According to Bates et al. (1987), classes of grammatical morphemes that have many members are less prone to errors than classes that have only a few members. This account predicts that the Turkish agrammatic speakers would perform better than the English agrammatic speakers, because the Turkish verb inflection paradigm is much larger than the corresponding English paradigm. Menn and Obler (1990) suggest the opposite, that is, the larger the paradigm, the more it is prone to errors. Leaving the Chinese data apart for reasons mentioned in the previous paragraph, and taking only the English and Turkish data into account, it is clear that both theories make wrong predictions. The performance of the agrammatic speakers of English (with its very simple verb inflection paradigm) and Turkish (with its complex paradigm) on the TART-production is very similar: the levels of performance are the same in all three conditions (past < present =future).

Bastiaanse et al. (2003) argued that it is not the size of the inflectional paradigm, but rather the function of the inflection, that determines error patterns. In both English and Turkish, this function is the same: reference to a time frame relative to the moment of speaking. Therefore, similar performance across languages is predicted, as found in the current study.

The pattern of omissions and substitutions of grammatical morphemes partially supports Grodzinsky's (1990) hypothesis. His theory that omissions of inflection occur when the result is a word and substitutions occur when omission results in a nonword correctly predicts the omissions in Chinese (although some substitutions are produced as well) and the substitutions in Turkish. However, for English, Grodzinsky (1990) predicts omissions (of both free and bound morphemes), but the agrammatic speakers mainly produce substitutions. However, Grodzinsky's claim is based on observation made in narrative speech. Apparently, on a test that is focused on the production of inflected verbs in which the participants are primed with inflected verbs, more substitution emerge, in which majority of incorrect answers are time reference errors. Notice that both the omissions and substitutions resulted in ungrammatical sentences, but in existing words.

4.3. Production and comprehension compared

Both the level and the pattern of performance on the comprehension task are more or less the same for these three typologically very different languages. Reference to the past is significantly more impaired than reference to the present. For production in English and Turkish, the data show a corresponding pattern: Reference to the past is more impaired than reference to the present. As mentioned above, the data on the Chinese production test probably reflect a lower performance overall, because the use of a temporal lexical adverb in

the sentence allows omission of the aspectual adverb. The comprehension data from Chinese, however, show exactly the same pattern as those in English and Turkish, implying that in Chinese agrammatism there is a selective deficit in reference to the past as well. Therefore, we assume an underlying deficit in reference to the past through grammatical morphology in agrammatic aphasia, which causes problems in both production and comprehension of verb inflections and aspectual adverbs.

The comprehension data for reference to past and present are compatible with the findings of Faroqi–Shah and Dickey (2009), who found that agrammatic speakers were slower in processing non-present-Tense sentences, and with the data of Jonkers and Bruin (2009), who reported that comprehension of past Tense verbs was worse than comprehension of present Tense verbs. However, the current data show that this is not due to past *Tense*, but rather to the fact that the verb forms used in their experiments referred to the past. Chinese speakers show similar comprehension impairments, whereas their marker for reference to the past ('*le*') is not in the Tense node.

The results of the future condition are less clear. The performance of the English and Turkish agrammatic speakers on the production task and the performances in all three languages on the comprehension task are very similar, meaning that the status of the morpheme does not play a role, except in Chinese production where it can be omitted without making the sentence ungrammatical. The lack of clarity stems from the finding that on the production task, reference to the future is only very mildly impaired and not worse than reference to the present, whereas on the comprehension task all language groups score significantly lower on the future condition than on the present condition (but they still perform better on the present than past condition). It is not exactly clear why comprehension of future morphology is impaired only in comprehension. However, despite the results of the statistical tests, it is not the case that comprehension of grammatical morphology referring to the future is seriously impaired: the mean score across languages for comprehension in the future condition is 85% correct, which is considerably higher than the 68% correct in the past condition.

We therefore conclude that the current data suggest that reference to the past is selectively impaired in both production and comprehension of agrammatic speakers across the three languages, although an alternative task is needed to test production in Chinese and other languages that use aspectual adverbs rather than verb inflection to express reference to a time frame.

4.4. Other accounts of the data

Several hypotheses have been proposed to explain the problems with Tense and Aspect. Theories that relate the problems to a specific node in the syntactic tree, such as the Tree Pruning Hypothesis (Friedmann & Grodzinsky, 1997), cannot be correct because the present study shows that (a) time reference through grammatical morphology is also impaired in Chinese which does not feature Tense or Aspect as a bound morpheme, and (b) Tensed verbs referring to the present and future are relatively well preserved. Theories that relate the problems to the interpretable features of Tense and/or Aspect (Burchert et al., 2005; Nanousi et al., 2006; Wenzlaff & Clahsen, 2004, 2005) or to the diacritical features of Tenseand/or

Aspect (Faroqi–Shah& Dickey, 2009; Faroqi–Shah & Thompson, 2007; Lee et al., 2008) are much preferred, since they relate the problems with time reference through grammatical morphology to the morphosemantic interface. We think this is the right idea: tense morphology is difficult because semantic information about the moment of the event relative to the moment of speaking must be encoded or decoded grammatically. However, there are two problems with these theories. First, the difficulties of the agrammatic speakers are not restricted to the Tense and/or Aspect node, but extend to the encoding and decoding of all bound and free grammatical morphemes expressing the time of the event. Second, these theories do not explain why reference to the past is particularly vulnerable.

In short, all these theories have a scope that is to narrow. They address Tense and/or Aspect and not time reference. A broader scope is needed to account for the data and the PADILIH offers this scope. Moreover, since the PADILIH is based on other constructions that are selectively affected in agrammatic aphasia (problems with the comprehension of pronouns and discourse linked *wh*-questions), we can speculate on a more general underlying impairment in agrammatic Broca's aphasia.

4.5. The PADILIH and Broca's area

The PADILIH was formulated to capture data from a number of studies that demonstrated that agrammatic speakers encounter problems with reference to the past. The current study largely supports the PADILIH, but it also raises an interesting new question. If the competition between narrow syntax and discourse linking is indeed the underlying problem in agrammatic aphasia, as suggested by Avrutin (2006), then it is to be expected that there is a correlation between the ability to produce and comprehend reference to the past, pronouns and *which*-questions. This is a project that we are currently running.

Although we do not have information about lesion sites for the present group of agrammatic individuals, it is safe to assume that in this group, Broca's area did not function properly. They were all diagnosed as suffering from Broca's aphasia with well-established tests and their speech was characterized as non-fluent and telegraphic by both the referring speech therapist and the experimenter. Broca's area is essential for syntactic computation. According to Avrutin (2000, 2006) and Piñango (2001) damage to Broca's area results in competition between narrow syntax discourse linking (Avrutin) or 'slow syntax' (Piñango), both implying that only syntactic operations requiring minimal resources can be properly computed, whereas more complex operations are impaired. Discourse linking is such a complex syntactic operation that requires more processing resources than, for example, binding. In case of discourse linking, an extrasentential relation has to be established. For reference to the past, the relation between the time of speech and the time of the event, needs to be computed and expressed through grammatical morphology. If this is the correct explanation, individuals with fluent aphasia should not show the selective deficit for reference to the past, because in this population Broca's area is spared. This is indeed what we have found: fluent aphasic speakers encounter serious problems on both TART-production and TART-comprehension, but the three time frames are equally impaired (Bos, Brederoo, & Bastiaanse, 2011). We, therefore, agree with Avrutin (2000, 2006) and Piñango

(2001) that damage to Broca's area affects the abilities of the agrammatic individuals to apply proper discourse linking, both in production and in comprehension.

The PADILIH needs to be tested on a wide range of languages. For this, the TART can be used, but it should be modified to test grammatical morphology in languages like Chinese and Indonesian with their free morphemes of time reference. Another issue is whether the time reference problems are restricted to grammatical morphemes, or should be extended to lexical adverbs used for time reference ('now', 'just', 'soon'). Some recent data from Indonesian suggest that comprehension of lexical adverbs referring to the past is impaired as well, as found by Anjarningsih, Haryadi-Soebadi, Gofir, and Bastiaanse (in press). Also, data from Abuom, Obler, and Bastiaanse (2011) showed that in bilingual agrammatic speakers, both languages may not be equally affected: English-Swahili bilingual speakers were selectively impaired in producing past Tense in English, but not in Swahili, which has a very complex verb inflection paradigm. The current study revealed that English and Turkish agrammatic speakers performed at the same level, but it is unclear whether the aphasia in the two groups was equally severe. Data from bilingual agrammatic speakers from typologically different languages may thus prove very revealing.

To conclude, our study showed that grammatical morphology used for time reference is affected in both comprehension and production in agrammatic aphasia, irrespective of how time reference is expressed in a language, whether through verb inflection, periphrastic verb forms or aspectual adverbs. The comprehension data and the English and Turkish production data demonstrate a clear and selective impairment for grammatical morphemes that are use to refer to the past. It is suggested that this is due to the fact that reference to the past requires discourse linking, whereas reference to the present and future does not. Discourse linking requires additional sources (Avrutin, 2000; Piñango, 2001) and is notoriously difficult for individuals with agrammatic aphasia.

Acknowledgments

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Appendix 1

Demographics and scores on the BDAE word comprehension (%) of the agrammatic speakers.

	Gender	Age	Handedness	Months post-onset	Etiology	BDAE
Chinese						
C01	M	42	Right	127	LCVA	94
C02	M	22	Right	96	TBI	98
C03	M	50	Right	97	LCVA	98
C04	M	41	Right	180	LCVA	90
C05	M	55	Right	92	LCVA	85
C06	M	65	Right	204	LCVA	50
C07	M	33	Ambidextrous	125	LCVA	100
C08	M	55	Right	156	LCVA	88
C09	F	52	Right	120	LCVA	86
C10	M	50	Right	177	LCVA	100
C11	M	51	Right	212	LCVA	100
English						
E1	M	52	Right	59	LCVA	100
E2	M	47	Right	55	LCVA	100
E3	M	64	Left	220	LCVA	100
E4	F	48	Right	23	LCVA	98
E5	M	53	Right	108	LCVA	100

	Gender	Age	Handedness	Months post-onset	Etiology	BDAE
E6	F	60	Right	61	LCVA	98
E7	M	53	Right	43	RCVA	97
E8	M	68	Right	180	TBI	100
E9	F	74	Right	36	LCVA	100
E10	M	54	Right	39	LCVA	92
E11	M	58	Right	226	LCVA	95
E12	M	37	Left	34	LCVA	100
Turkish						
T1	M	68	Right	2	LCVA	90
T2	M	54	Right	5	LCVA	84
T3	F	49	Right	84	LCVA	88
T4	F	43	Right	4	LCVA	91
T5	M	68	Right	1	LCVA	65
T6	F	39	Right	7	LCVA	65
T7	M	65	Right	12	LCVA	NA
T8	M	59	Right	2	LCVA	92

Appendix 2

The verb pairs used in the *Test for Assessing Reference of Time (TART;* Bastiaanse et al., 2008).

Examples

to read – to write the letter

Test items

to paint – to draw a square

to tear – to glue the paper

to pour – to drink the milk

to eat – to peel the apple

to push – to pull the trolley

to sharpen – to break the pencil

to knit – to sew the cloth

to empty – to fill the folder

to mop – to sweep the floor

to iron – to fold the sweater

Appendix 3

Individual performances and statistics on TART-production. Maximum is 20 for each category (bold =score significantly different from present (Fisher's exact tests); Chinese patient # 9 was not tested on this part; the Turkish version had no neutral condition). Sub =substitution, om =omission, inf =infinitive.

	Neutral	Past				Present				Future			
	Correct	Correct	Sub	Om	Other	Correct	Sub	Om	Other	Correct	Sub	Om	Other
Chinese													
C1	20	1	0	19	0	1	0	19	0	1	0	19	0
C2	20	12	0	8	0	6	0	14	0	6	0	14	0
C3	19	13	4	3	0	13	4	3	0	18	0	2	0
C4	18	0	0	20	0	1	0	19	0	0	1	20	0
C5	20	10	2	8	0	7	12	1	0	16	1	3	0
C6	20	2	0	18	0	0	0	20	0	0	0	20	0
C7	16	16	2	3	0	20	0	0	0	20	0	0	0
C8	17	5	5	10	0	8	0	11	0	8	1	12	0
C10	20	0	0	20	0	0	0	20	0	0	0	20	0
C11	11	5	1	14	0	6	3	11	0	4	1	15	0
English													
E1	16	**13**	7	0	0	19	1	0	0	19	1	0	0
E2	17	18	2	0	0	16	4	0	0	20	0	0	0
E3	19	**3**	9	8	0	13	7	0	0	12	7	1	0
E4	3	**12**	7	1	0	19	1	0	0	12	8	0	0
E5	20	12	4	4	0	18	2	0	0	19	1	0	0
E6	19	6	7	6	1	4	5	11	0	7	3	7	3
E7	20	14	5	1	0	19	1	0	0	19	1	0	0
E8	3	**4**	15	1	0	12	7	1	0	4	16	0	0
E9	16	**6**	14	0	0	20	0	0	0	19	1	0	0
E10	18	17	3	0	0	16	3	1	0	13	7	0	0
E11	16	**12**	8	0	0	20	0	0	0	20	0	0	0
E12	4	**2**	11	7	0	12	5	3	0	3	10	6	1

	Neutral	Past			Present				Future			
	Correct	Sub	Inf	Other	Correct	Sub	Inf	Other	Correct	Sub	Inf	Other
Turkish												
T1	**6**	11	3	0	17	0	3	0	17	1	2	0
T2	4	13	3	0	9	5	6	0	7	4	8	1
T3	11	7	2	0	15	5	0	0	18	2	0	0
T4	**10**	5	5	0	20	0	0	0	15	3	2	0
T5	11	6	3	0	16	4	0	0	18	0	2	0
T6	10	9	1	0	16	4	0	0	18	2	0	0

	Neutral	Past			Present				Future			
	Correct	**Sub**	**Inf**	**Other**	**Correct**	**Sub**	**Inf**	**Other**	**Correct**	**Sub**	**Inf**	**Other**
T7	6	6	0	8	4	8	0	8	17	0	1	2
T8	13	2	5	0	18	1	1	0	18	2	0	0

Chinese: neutral-past $W =45$, $p =0.004$; neutral-present $W =53$, $p =0.004$; neutral-future $W =50$, $p =0.006$. past–present–future: $\chi^2(2) =0.15$, $p =0.928$. past–present $W =1$; $p =0.938$; past–future $W =-9$ $p =0.469$; present–future $W =-4$, $p =0.625$.

English: neutral-past $W =52$, $p =0.042$; neutral-present $W =-20$, $p =0.470$; neutral-future $W =1$, $p =0.970$. past–present–future: $\chi^2(2) =6.29$, $p =0.040$.past–present $W =-66$, $p =0.007$; past–future $W =-47$, $p =0.014$; present–future $W =20$, $p =0.25$.

Turkish: past–present–future: $\chi^2(2) =10.75$, $p =0.046$.past–present $W =-34$; $p =0.016$; past–future $W =-36$ $p =0.008$; present–future $W =-14$; $p =0.382$.

Appendix 4

Individual performances and statistics on TART-comprehension (bold =score significantly different from present (Fisher's exact tests); maximum is 20 for each category).

	Past	Present	Future
Chinese			
C1	16	19	17
C2	17	20	18
C3	18	19	17
C4	**12**	19	**13**
C5	**13**	20	**13**
C6	13	17	13
C7	**15**	20	19
C8	**8**	16	15
C9	13	16	19
C10	15	19	15
C11	10	15	14
English			
E1	19	20	19
E2	19	20	18
E3	**13**	19	20
E4	**13**	20	18
E5	17	20	16
E6	17	19	19
E7	**2**	20	17
E8	**10**	20	16
E9	16	19	19
E10	20	20	18
E11	18	20	19
E12	**6**	20	19
Turkish			
T1	14	18	19

	Past	Present	Future
T2	17	20	**15**
T3	16	18	17
T4	17	20	18
T5	**12**	20	18
T6	**12**	20	16
T7	16	20	19
T8	16	20	16

Chinese: past–present–future: $\chi^2(2) = 15.86$, $p = 0.0004$. past–present $W = -65$, $p = 0.001$; past–future $W = -31$; $p = 0.023$; present–future $W = 52$; $p = 0.018$.

English: past–present–future: $\chi^2(2) = 13.04$, $p = 0.002$. past–present $W = -66$; $p = 0.001$; past–future $W = -49$; $p = 0.024$; present–future $W = 50$ $p = 0.006$.

Turkish: past–present–future: $\chi^2(2) = 11.44$, $p = 0.003$. past–present $W = -36$, $p = 0.008$; past–future $W = -22$; $p = 0.078$; present–future $W = 32$; $p = 0.023$.

Fig. 1.
An example of TART-production. For elicitation of the correct time frame, see text.

Fig. 2.
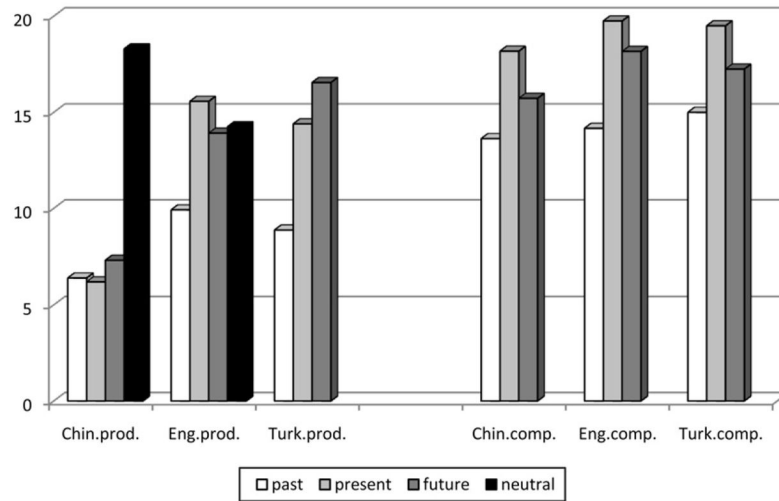An example of TART-comprehension. The target sentence is: 'the man is drinking milk'.

Fig. 3.
The mean numbers of correct responses on TART-production (left) and TART-comprehension (right) per language for the agrammatic speakers. The maximum score is 20 per condition, both in production and comprehension.

Table 1

Examples of English finite verbs and periphrastic verb forms that refer to past, present and future. Finite verbs are italics.

	Tense	Reference to
writes	Present	Present
is writing	Present	Present
can write	Present	Present
wrote	Past	Past
has written	Present	Past
has been writing	Present	Past
was writing	Past	Past
will/shall write	Present	Future
would/should write	Past	Future

Table 2

Examples of Turkish verbs that refer to past, present and future. All are finite, 3rd person singular (a form which has a ø-suffix for agreement) with the exception of 'yazaca ı', which is a (non-finite) participle. The italic morphemes are the time reference inflections.

	Tense/Aspect	Reference to
yazıyor [is writing]	Present imperfect	Present
yazdı [wrote]	Past perfect	Past
yazacak [will write]	Future imperfect	Future
yazaca ı [to be written]		Future

Table 3

Examples of Chinese aspectual adverbs that refer to past, present and future. The aspectual adverbs are italics.

	Aspect/Modal	**Reference to**
zai xie [is writing]	Dynamic imperfective/progressive	Present
xie *zhe* [is writing]	Static imperfective/durative	Present
xie *le* [wrote]	Perfective	Past
xie *guo* [once wrote]	Experiential perfective	Past
yao xie [will write]	Modal	Future
hui xie [is going to write]	Modal	Future

Table 4

Overview of the intact and impaired Tense and Aspect morphology in oral production tasks.

Authors	Language	Intact	Impaired
Stavrakaki & Kouvava	Greek	Present tense	Past tense
		Imperfect	Perfect, perfective
Simonsen & Lind	Norwegian	Present	Past
Nanousi et al.	Greek	Imperfect	Perfect, perfective
Bastiaanse	Dutch	Simple present	Simple past
		Present progressive	Present perfect
Lee et al.	English	Present progressive	Present perfect
		Simple present	Simple past

Table 5

Demographic data and BDAE word comprehension scores (% correct) of the agrammatic speakers. Means and (ranges) are given.

Language (*n*)	Age	Gender	Months post-onset	BDAE
Chinese (11)	49.9 (22–65)	10 male	137.4 (92–212)	89.9 (50–100)
English (12)	55.7 (37–74)	9 male	90.3 (23–226)	98.3 (92–100)
Turkish (8)	55.6 (39–68)	5 male	14.6 (1–84)	82.15 (65–92)

Table 6

The mean number correct on the TART-production (maximum = 20 per category). Between brackets are the ranges. $N = 10$ for Chinese[a], 12 for English and 8 for Turkish.

	Neutral	Past	Present	Future
Chinese	18.30 (13–20)	6.40 (0–16)	6.20 (0–20)	7.30 (0–20)
English	14.25 (3–20)	9.92 (2–18)	15.67 (4–20)	13.92 (3–20)
Turkish	–	8.87 (4–13)	14.38 (4–20)	16.55 (7–19)

[a]One Chinese agrammatic speaker only did the comprehension task. Therefore, the production task included 10 Chinese agrammatic speakers.

Table 7

Mean number of errors produced by types on the TART-production by the three aphasic groups. Omis. =omission; subs. =substitution, inf. =infinitive. For Chinese *n* =10; for English *n* =12; for Turkish *n* =8. Maximum possible number of errors per time frame is 20.

	Chinese			English			Turkish		
	omis.	subst.	other	omis.	subs.	other	infin.	subs.	other
Past	11.4	1.4	–	2.42	7.75	0.08	2.75	7.38	1.00
Present	11.8	1.9	–	1.33	3.00	0.00	1.25	3.38	1.00
Future	12.5	3.0	–	1.17	4.58	0.33	1.88	1.75	0.38

Table 8

The mean number correct on the TART-comprehension (maximum =20 per category). Between brackets are the ranges. N =11 for Chinese, 12 for English and 8 for Turkish.

	Past	**Present**	**Future**
Chinese	13.64 (8–18)	18.18 (15–20)	15.73 (13–19)
English	14.17 (6–20)	19.75 (19–20)	18.17 (16–20)
Turkish	15.00 (12–17)	19.50 (18–20)	17.00 (15–19)