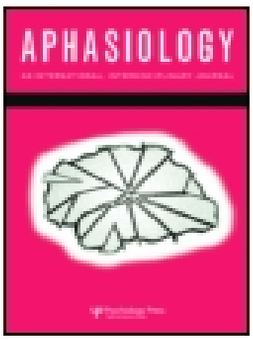

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# An investigation of time reference in production and comprehension in Thai speakers with agrammatic aphasia

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## ABSTRACT

**Background:** It has been demonstrated that reference to the past is difficult for individuals with agrammatic aphasia, leading to the formulation of the PAst DIscourse LInking Hypothesis (PADILIH). Many of the previous studies have focused on Indo-European languages, in which time reference is expressed through verb inflection. The current study examined the PADILIH in Thai, a language that does not use verb inflection but instead uses aspectual markers to refer to time.

**Aims:** We aimed to evaluate the pattern of impairment of time reference in Thai speakers with agrammatic aphasia, by investigating how grammatical reference to past, present, and future was processed.

**Methods and Procedures:** A total of 15 Thai agrammatic speakers and 18 Thai non-brain-damaged (NBD) speakers participated in a sentence production task and an auditory sentence-to-picture matching comprehension task, both of which probed past, present, and future time reference.

**Outcomes and Results:** While the NBD participants performed close to ceiling in both production and comprehension, the agrammatic speakers showed significantly more difficulty in conditions requiring reference to the future in both modalities. In production, however, the agrammatic speakers replaced the target future time reference construction with negation (a construction that can be used as an alternative means for future reference). When responses using negation were counted as correct, the individuals with agrammatic aphasia showed equal impairment across conditions.

**Conclusions:** The results of this study were inconsistent with the PADILIH predictions: Thai agrammatic speakers experienced more vulnerability in reference to the future than the present and the past. This suggested that impairments of time reference may differ depending on the structure of the language. We hypothesized that the problems with producing future time reference in Thai may be influenced by the grammatical status of the future marker. In addition, the use of negation in place of the target word might have been because this negative construction reduces the processing load for Thai agrammatic speakers.

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## Introduction

Agrammatic aphasia is characterized by a difficulty constructing grammatically correct sentences. While the speech of individuals with agrammatic aphasia is non-fluent, effortful, and slow, consisting mainly of content words (Goodglass, 1976), their comprehension is relatively intact. Nevertheless, some studies have shown that comprehension of certain types of sentences; for instance, passive sentences and object clefts are difficult in this population (Burchert et al., 2003). It has also been demonstrated that, relative to agreement inflection and mood inflection, tense inflection is more impaired in agrammatic speakers (Wenzlaff & Clahsen, 2004). These studies have led to the development of a number of different theories of the impairment underlying the problems with tense in agrammatic aphasia (see Friedmann and Grodzinsky (1997) for the Tree Pruning Hypothesis, and Wenzlaff and Clahsen (2005) for the Tense Underspecification Hypothesis).

Bastiaanse (2008), however, observed that in agrammatism not all tenses were equally impaired, but verb forms referring to the past were significantly more difficult than verb forms referring to the present and the future. She proposed that it is not tense that is problematic in agrammatic speakers but time reference, specifically, reference to the past. This led to the formulation of the PAst DIscourse LInking Hypothesis (PADILIH; Bastiaanse et al., 2011). Several cross-linguistic studies have confirmed that both production and comprehension of past time reference are vulnerable in agrammatic speakers (Abuom & Bastiaanse, 2013; Jonkers & De Bruin, 2009; Yarbay Duman & Bastiaanse, 2009). Nonetheless, there are studies that have also found future to be impaired (Nanousi et al., 2006; Koukoulioti & Bastiaanse, 2020; Martinez-Ferreiro & Bastiaanse (2013); Rofes et al., 2014).

In contrast to languages with verb inflections, it has also been demonstrated that in languages with aspectual markers, reference to all time frames is equally impaired, as observed in Chinese (Bastiaanse et al., 2011) and Standard Indonesian (Anjarningsih, 2012). The current study aimed to widen the research base on languages that do not use verb inflection but instead use aspectual markers for time reference. We asked the question whether Thai speakers showed a disproportionate impairment in reference to the past as observed in languages with verb inflections. As Thai uses aspectual markers, might it show the same pattern as in Chinese and Standard Indonesian?

### *Time reference in Thai*

Thai is described as a fixed base word order, Subject-Verb-Object (SVO) language (Sudmuk, 2003). It is an isolating and a non-inflectional language, in which grammatical categories, such as number, aspect, and mood, are not marked by morphological inflection (Prasithrathsint, 2006). Thai does not use verb inflection to express the time frame in which the event happens, but achieves time reference through free grammatical morphemes: aspectual markers.

Aspect can be subclassified into imperfect and perfect. The imperfect aspect indicates that an event is ongoing, while the perfect aspect denotes that an event has been completed. When referring to an event in the present (imperfect/progressive), and the past (perfect), Thai uses the aspectual adverbs *kamlang* and *leaw*, respectively. The progressive aspectual adverb *kamlang* is used to indicate the ongoing nature of an event. Thus, *Chan kamlang kian*: "I am writing" denotes that the writing is currently ongoing. The past

aspectual adverb *leaw* focuses on a finished event. *Chan kian leaw*: "I wrote", therefore, expresses that the writing has happened and ended.

When indicating an event in the future, Thai uses a grammatical morpheme *jaa*, whose grammatical category is controversial. While some linguists treated *jaa* as a time reference marker with a point in time that refers to the future (Supanvanich, 1973), others classified it as an intentive marker expressing intention or willingness, and, thus, as a modal (Sriphen, 1982). Integrating these notions, Kanchanawan (1978) proposed that *jaa* is a non-absolute future marker that both indicates a future event and is an intentive marker; this is similar to Srioutai (2004) who categorized *jaa* as a future-shifting modal. Hence, *Chan jaa kian*: "I will write" denotes that there is a level of intention that the action "writing" will be happening at some time in the future.

Syntactically, aspectual adverbs, which can occur pre-verbally or post-verbally (Table 1), belong to the verb phrase. Thai aspectual adverbs are free-standing morphemes and are used only when the time frame of the discourse context is not clear. According to Grangé (2003, as cited in Anjarningsih, 2012), aspectual adverbs are non-deictic: they can be fully comprehended without additional information as long as the context is clear. Therefore, time frame-wise, aspectual adverbs are referential (Bastiaanse, 2013). They do not link to event time, but are used to indicate how an event relates to its context (i.e., they are used for discourse linking, see more below).

Consider the hypothetical situation where you are asked, "What are you doing now?", "What did you do yesterday?", or "What will you do tomorrow?". To answer any of these questions, you could simply say, *Chan kian jodmai*: "I write letter", omitting the aspectual marker. Even though there is no aspectual marker referring to the time frame, this is a pragmatically acceptable and grammatically correct sentence. The omission of the aspectual marker is permissible because the time frame is already referred to in, or co-indexed from, the discourse question. This implies that aspectual markers are only used when the context is not clear. In other words, aspectual markers are always discoursed linked: they are used to link the event to a time frame.

## *Discourse linking, time reference, and the PADILIH*

Avrutin (2006) proposed two levels of syntactic processing: narrow syntax and discourse syntax. Narrow syntax (non-referential elements) can be interpreted when the necessary information is within the sentence. For instance, in "*The girl*$_i$ is washing *herself*$_i$", "*herself*" refers to "*the girl*", forming a binding relation or co-referentiality within the sentence. Discourse syntax (referential elements) is when reference is made to

**Table 1.** Examples of Thai aspectual adverbs used in the current study that refer to present, past, and future. The aspectual markers are italicized.

| | Aspect/Modal | Reference to | Position |
|---|---|---|---|
| *kamlang* kian (is writing) | Imperfect | Present | Pre-verbal |
| kian *leaw* (wrote) | Perfect | Past | Post-verbal |
| *jaa* kian (will write) | Imperfect/Modal | Future | Pre-verbal |

information outside the sentence. For instance, in "*The girl*$_i$ is washing *her*$_j$", "*her*" cannot refer to "*the girl*", but only to another female person outside the context of the sentence. To comprehend who "*her*" refers to, a link to a referent outside the sentence is needed.

Grodzinsky and Reinhart (1993) found that discourse-linked pronouns were harder to process than locally bound reflexives in agrammatic aphasia. Hickok and Avrutin (1996) also reported that which-questions (that are discourse linked) were more difficult to comprehend than who-questions (that do not require discourse linking). According to Avrutin (2006), discourse linking requires more time to process and is also challenging for agrammatic speakers. As tense refers to a point in time that is not a part of the sentence, it should be processed using discourse syntax; hence, tense is difficult in agrammatic aphasia.

Zagona (2003) argued that the notion that discourse linking is required for tense is too broad. She proposed that only past tense is discourse linked. Unlike the present and future, when past tense is processed, there is no simultaneity between evaluation time (speech time) and event time. Since speech time and event time do not coincide, discourse linking has to be used for past time reference. For the present, discourse linking is not needed because the time of speaking and the time of the event coincide. For the future, however, as there is no event occurring yet and it is unsure whether or not the event will take place, nothing can be bound to the sentence; therefore, there is no discourse linking. See Table 2 for a summary.

Taking the ideas of both Avrutin (2006) and Zagona (2003, 2013)), in the PADILIH, Bastiaanse (2013) proposed that reference to the past is difficult because it requires discourse linking and this process is affected in agrammatic aphasia. The PADILIH also posits that discourse linking is not limited to past tense, but is required for all verb forms – both simple (e.g., "wrote") and periphrastic (e.g., "has written", "was writing") – that refer to the past, irrespective of the tense employed. Therefore, in agrammatic speakers, the problems with the past are argued to be due to difficulties with *time reference*, rather than past *tense*. Bastiaanse et al. (2011) found evidence for this account by administering the Test for Assessing Reference of Time (TART; Bastiaanse et al., 2008). In production, two images of different actions with the same time frames were shown side by side (e.g., action – peel, eat; time frame – present). The examiner produced a sentence corresponding to an image on the left, and the first half of the sentence for the image on the right (e.g., "Now, the man is peeling an orange. Now, the man …") for the participant to complete (e.g., "… is eating an orange"). In comprehension, the participant was instructed to point to the image corresponding to the sentence read aloud by the examiner. Bastiaanse et al. (2011) found that past time reference was selectively impaired in both production and comprehension for both Turkish and English speakers with aphasia (see also Jonkers and De Bruin (2009) for Dutch; Yarbay Duman and Bastiaanse (2009) for Turkish).

**Table 2.** Discourse linking and the relationship between speech time and event time for languages with verb inflection.

| | Do speech time and event time coincide? | Are they discourse linked? |
|---|---|---|
| Past | No | Yes |
| Present | Yes | No |
| Future | — (there is no event time at the point of speaking) | No |

However, several studies have reported no significant differences between impairment in reference to the past, present, and future (Fyndanis et al., 2018, 2012; Wenzlaff & Clahsen, 2004). Fyndanis et al. (2012), investigated the ability of two Greek-speaking agrammatic individuals to produce tense and aspect by means of transformational sentence completion tasks: the participants were asked to make a transition from one (sample) time reference (i.e., Tomorrow you will wash your hair) to another time reference on the basis of a temporal adverbial cue (i.e., Yesterday you … [washed your hair]). No dissociation was found between performance for past and future tense (see also Fyndanis et al., 2018).

Other studies have also demonstrated incompatibility with the PADILIH concerning the future. Martínez-Ferreiro and Bastiaanse (2013) examined Catalan and Spanish in both production and comprehension. In production, while Catalan agrammatic participants encountered specific impairment to the past, Spanish agrammatic participants performed equally poorly on the past and future relative to the present. In comprehension, however, the agrammatic speakers encountered difficulty comprehending future time reference in both Spanish and Catalan. Koukoulioti and Bastiaanse (2020) also found a similar pattern concerning reference to the past but also suggested difficulties with the future in Greek agrammatic participants (see also Rofes et al. (2014) for Catalan; and for comprehension, Tsiwah et al. (2020) for Akan).

Turning to languages with aspectual markers, Bastiaanse et al. (2011) also examined Chinese speakers with agrammatic aphasia who showed equal impairment in the production of past, present, and future time reference (with omissions as the majority of errors made). Interestingly, the pattern was different in comprehension: while comprehension of reference to the past was disrupted in all three languages, the future was also impaired relative to the present. Bastiaanse (2013) suggested that as aspectual markers are free grammatical morphemes, they can be omitted when the discourse context is clear. Hence, it is argued that in languages like Chinese, aspectual markers are discourse linked; consequently, if discourse linking is impaired, reference to the past, present, and future should be equally impaired.

Bastiaanse et al. (2011) also noted that it could be the format of the task (of the Chinese study) – *two actions in one time frame* – that promoted omissions. That is, the Chinese participants were first given a priming sentence using a temporal adverb and one verb describing one picture and then had to finish a sentence using the same temporal adverb and a second verb to describe a second picture (e.g., "Here you can say the man just *ate* an orange, and here you can say the man just … [*peeled* an orange]"). With this format, the time frame for the second sentence is clear from the context, and as aspectual markers are not obligatory, they can be omitted.

Anjarningsih (2012) used a modified methodology to investigate time reference in Standard Indonesian, another language with aspectual markers. Using a task where there was *one action in two time frames* (e.g., action – iron; time frames – past and present), Anjarningsih found that the agrammatic speakers performed similarly across all time frames. However, the majority of the errors made were not omissions (as reported in Bastiaanse et al.'s (2011) study on Chinese), but substitutions.

## *The current study*

In light of the methodological issues with the two previous studies in languages with aspectual markers, and their importance for theories of time reference, we conducted

a study in Thai, another language with aspectual markers. We modified the TART to be linguistically and culturally appropriate to languages with aspectual markers and called it the Test for Assessing Reference of Time in a Language with Aspectual Markers (TART-LAM).

The study aimed to investigate the pattern of impairment of time reference in Thai speakers with agrammatic aphasia. In Thai, aspectual adverbs are used to link an event's time to its discourse, they are referential and, thus, always processed by discourse syntax (PADILIH; Bastiaanse, 2013). Therefore, if discourse linking is impaired in Thai agrammatic aphasia, an equally poor performance across conditions – present, past, and future – was hypothesized. While the PADILIH predicts that impairments of time reference should affect production and comprehension similarly, differences across modalities have been observed (e.g., Martínez-Ferreiro & Bastiaanse, 2013). Consequently, in this study, we examined both modalities.

## Materials and method

### *Participants*

A total of 33 native Thai speakers participated in the current study. Six individuals with agrammatic aphasia participated in the production experiment, another six agrammatic individuals participated in the comprehension experiment, and three agrammatic speakers (SP, SM, and JD) participated in both experiments,[1] giving a total of 15 participants with aphasia. Two groups of nine non-brain-damaged (NBD) participants provided control data. The NBD matched the agrammatic speakers for age, gender, handedness, and education. For production, there were four females and five males, aged 26–83 years (mean 53.89) for the agrammatic group, and 23–78 years (mean 52.67) for the NBD group (Appendix 1). For comprehension, there were five females and four males, aged 20–68 years (mean 49.11) for the agrammatic group, and 23–69 years (mean 50.78) for the NBD group (Appendix 2). All participants were right-handed, with over 15 years of education. None of the NBD participants reported any history of neurological, hearing, or vision problems.

The agrammatic speakers were recruited from the Department of Communication Sciences and Disorders, Ramathibodi Hospital, Bangkok, Thailand following classification as "R470: Dysphasia and Aphasia" according to the International Statistical Classification of Diseases and Related Health Problems (ICD-10-TM). They all had aphasia following a single left hemisphere stroke, except participant SP who had suffered a traumatic brain injury (with a left hemisphere lesion). His performance pattern, however, did not deviate from that of the stroke patients. No further details of the lesion localization were available for the agrammatic speakers.

Participants with aphasia were classified as agrammatic based on an interview and a narrative sample (description of a picture of a rural scene). Two judges – a speech therapist and a neurolinguist – listened to the spontaneous speech samples and rated their speech as severely reduced, effortful, with short and simple sentences. In terms of speech fluency, the speech rate (the number of words per minute: wpm) of each agrammatic speaker was outside the range of the NBD (agrammatic speakers, mean 46 wpm; range 32–62; NBD, mean 103.67 wpm; range 81–130). Additionally, their comprehension of single words was relatively spared as measured on the auditory word comprehension subtest of the Thai version of the Boston Diagnostic Aphasia Examination (BDAE), matching the profile of Broca's aphasia.

All participants provided informed consent following the Declaration of Helsinki under the procedure approved by the Committee of Human Rights Related to Research Involving Human Subjects, Ramathibodi Hospital, Mahidol University. They were financially compensated with the equivalent of 15EUR for their participation.

## Materials

Two tasks – a sentence elicitation (with picture description) task and an auditory picture-to-sentence matching task – were administered using materials adapted from the Test for Assessing Reference of Time (TART; Bastiaanse et al., 2008). We redesigned the TART to be suitable for Languages with Aspectual Markers and named the test the TART-LAM. While the TART contrasted two actions of the same time frame (e.g., action – peel, eat; time frame – past), the TART-LAM contrasted one action in three time frames (e.g., action – chop; time frame – future, present, past). The modified TART was designed, first, to ensure that aspectual markers were required to be used (by contrasting different time frames with the same verb, similar to the Anjarningsih, 2012 study) and, second, to ensure that the time frame of each picture was clear (by presenting pictures of all three time frames for each verb, and in a consistent order). To ensure clarity of the time frame, on each trial, three individual colored pictures representing each time frame were presented horizontally in one array in a fixed order of future–present–past (as is common in picture sequencing tasks). The stimuli were presented on a computer screen.

For the production test, to facilitate lexical access, the name of the action was printed in bold centered on top of the three pictures that were presented horizontally. The target item (the picture to be named within the array of three) was highlighted by a colored frame for each action (Figure 1). For the comprehension test, no action name was printed, and there was no highlighted frame.

For the stimuli, there were 24 transitive action verbs (20 experimental and 4 practice items), each depicted in three photographs of different time frames (future–present–past), resulting in 60 experimental and 12 practice items, across three blocks. The order of the time frames was counterbalanced across actions with each action appearing once in each block and the order of the stimuli was pseudo-randomized within a block such that no more than two of the same time frames occurred in succession. See Appendix 3 for the item list.

## Name agreement and clarity of materials

The pictures corresponding to all of the 24 transitive action verbs were checked for name agreement. Ten Thai volunteers (three males, age: mean 33.8 years, range 22–60) were informed that the three pictures were of the same action and that they had to provide one verb corresponding to the action of the pictures. Name agreement was 100%. In addition, the volunteers were asked to rate picture clarity on a 3-point scale with 3 for “clear”, 2 for “not sure”, and 1 for “unclear”. Each volunteer and the first author discussed the pictures that were not rated “clear”, and new photographs were taken accordingly. This process was repeated until all pictures were rated as “clear”.


TARGET-LEFT (FUTURE)

Examiner: 'Could you describe to [listener] the picture on the left by using the word [fold cloth]?'

Participant: ter ***jaa*** pub pah

she ***FUT*** fold cloth

'She *will* fold the clothing.'


TARGET-MIDDLE (PRESENT)

Examiner: 'Could you describe to [listener] the picture in the middle by using the word [fold cloth]?'

Participant: ter ***kamlang*** pub pah

she ***PRES*** fold cloth

'She *is folding* the clothing.'


TARGET-RIGHT (PAST)

Examiner: 'Could you describe to [listener] the picture on the right by using the word [fold cloth]?'

Participant: ter pub pah ***leaw***

she fold cloth ***PAST***

'She *folded* the clothing.'

**Figure 1.** An example stimulus item of the production test. The action is *"fold cloth"*. Left: to elicit time reference to the future; middle: to elicit time reference to the present; right: to elicit time reference to the past.

## Procedure

### Production

The procedure was designed in order to ensure that the context necessitated the use of the aspectual marker. Hence, as displayed in Figure 2, there were three people in the room; the participant (P) and the examiner (E), who sat on the same side of the table, and a listener (L), who was seated on the other side of the table. The participant was instructed to describe the highlighted item in the array to the listener, who could not see the stimulus. As an aspectual marker is an optional element in a sentence when the time frame is clear from the context, it is believed that by blinding the conversational partner to the pictures, participants should produce as much information as needed for the conversational partner to fully comprehend the sentence. Thus, in this case, the use of time reference is obligatory. To make the setting as realistic as possible, the listener was actively involved in the experiment by noting down the participant's responses.

### Comprehension

The participant was presented with an array of three pictures of the same action and was asked to indicate the picture that corresponded to the sentence produced by the examiner. Only one sentence was provided (indicating one time frame) before the next

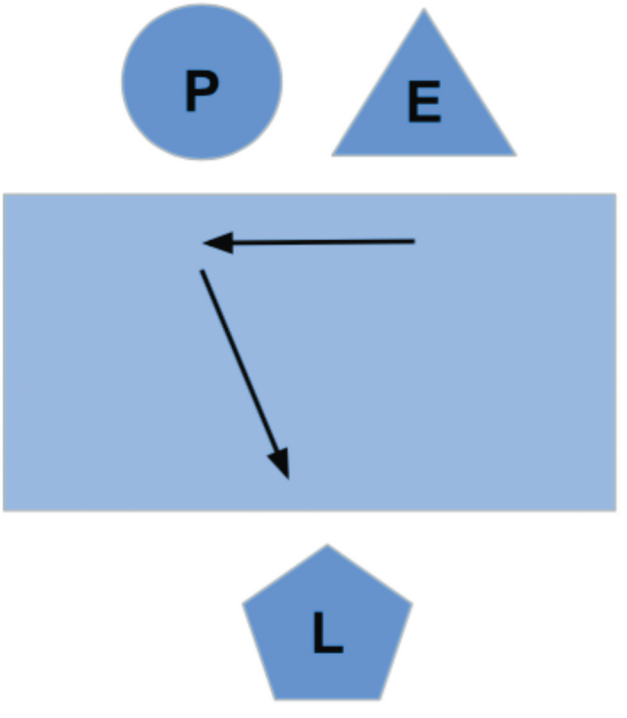


**Figure 2.** Experimental setup. "P" represents a participant; "E" represents an examiner; and "L" represents a listener who cannot see the computer screen. The arrows indicate the direction of conversation.

**Figure 3.** An example stimulus item of the comprehension test. The action is "chop fruit". The three contrasting time frames are (from left to right); future 'She *jaa* chop fruit (She will chop fruit), present "She *kamlang* chop fruit (She is chopping fruit)", and past "She chop fruit *leaw* (She chopped fruit)".

array was presented (Figure 3). All arrays were displayed once before they were repeated twice more, with the two remaining target sentences/time frames.

For both tasks, during the 12 practice items, the feedback was given and questions could be asked. The practice items were repeated until it was clear that the participant understood the task. During the experimental session, no feedback or questions were allowed. There was no time limit. To minimize fatigue, participants were offered a break after 15–20 items. The two tasks were administered in different sessions separated by approximately 2 months. For participants who performed both experiments, the production task was administered first. The administration took 45-min for production and 30-min for comprehension.

## *Scoring*

For both tests, a simple binary score of correct and incorrect was employed for quantitative analysis. Only the final response was scored for self-corrected trials. For production, a correct score was given when participants produced the target aspectual markers: *"jaa"* for the future, *"kamlang"* for the present, and *"leaw"* for the past. Production errors were classified as substitution, omission, or negation of the aspectual adverb (no other error types occurred).

## *Statistical analysis*

The performance of the agrammatic speakers was analyzed both at the group and at the individual level. Because of the small number of participants, non-parametric tests were used for statistical analysis. For the group analysis, three tests were performed: Mann–Whitney test for between-group comparison of the NBD and the agrammatic speakers, Friedman's test for within-group comparison across conditions, and Wilcoxon Signed-Ranks test for pairwise analysis between conditions. For comprehension, Bayesian Paired

Samples T-Tests were additionally conducted to examine the strength of the evidence for the observed pattern between the pairs of conditions.

For the individual analysis, Cochran's Q test was performed to examine whether there was an effect of condition for each participant, and for those participants who showed a significant effect, McNemar's test was performed between pairs of conditions. All pairwise analyses (Wilcoxon Signed-Ranks test, McNemar's test) were Bonferroni corrected for multiple comparisons.

All of the statistical analyses were conducted in SPSS 24.0, except Bayesian Paired Samples T-Tests that were performed using JASP (JASP Team, 2020).

## Results

### *Production: group analysis*

The overall accuracy for production on the TART-LAM is shown in Figure 4 (see also Table 3).

Between-group comparisons showed that the agrammatic speakers performed significantly worse than the NBD in all conditions (Mann Whitney test; past $U = 9.000$, $z = -3.170$, $p$(1-tailed) = .004; present $U = .000$, $z = -3.825$, $p$(1-tailed) <.001; future $U = 2.000$, $z = -3.576$, $p$(1-tailed) <.001).

While there was no main effect of condition for the NBD who performed close to ceiling across time frames (Friedman's test; $\chi2(2) = 2$, $p = .368$), there was a significant difference between the three time frames for the agrammatic speakers: Friedman's test; $\chi2(2) = 8.970$, $p = .011$.

For the group of agrammatic speakers, pairwise analysis revealed no significant difference between present and past conditions, or between past and future conditions (Wilcoxon Signed-Ranks test (2-tailed, $p$ values, Bonferroni corrected); past – present $T = 23.50$, $z = -.774$, $p = 1.137$; past – future $T = 32.50$, $z = -2.035$, $p = .126$). However, the future condition was significantly worse than the present (present – future $T = 36.00$, $z = -2.552$, $p = .033$).

### *Production: individual analysis*

Six of the nine participants showed no significant difference in accuracy across the three conditions (Table 3; Cochran's Q test; all Q's <4.909; all $p$'s >.086). The effect of the condition was statistically significant in three participants: SP, SM, and NN. For all three participants, further pairwise analysis was performed. A significant difference between the future and past, with the future being less accurate than the past, was observed in SP and SM. For SP, the future was also significantly worse than the present. No statistically significant differences were found between the present and past for any of the participants, nor were there any significant pairwise differences between any time frame for NN.

### *Production: error analysis*

The three types of non-target responses that occurred were substitution, omission, and negation. Substitution was defined as a replacement of the target aspectual marker with another aspectual marker that referred to a different time frame (e.g., "he *FUT* fold cloth"

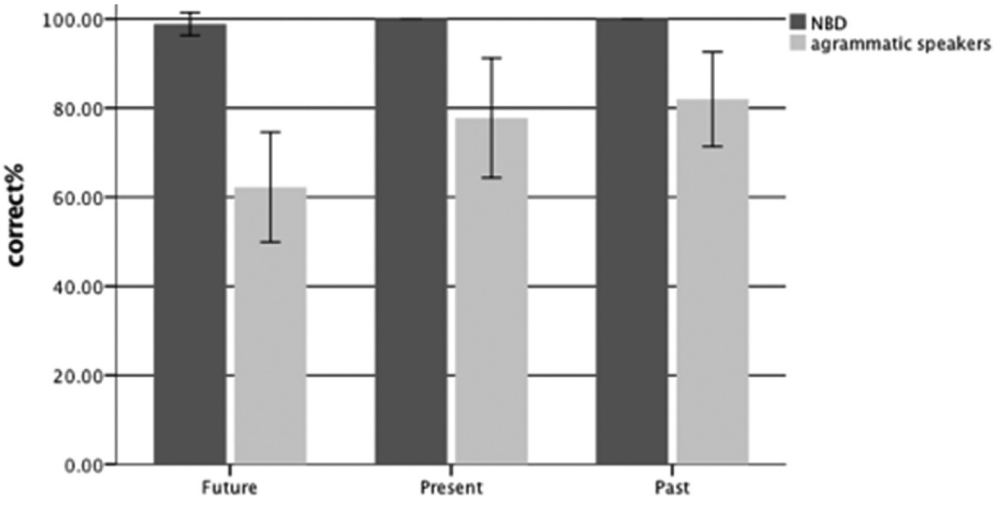


**Figure 4.** Percentage correct of the TART-LAM production of the future, present, and past for non-brain-damaged participants (NBD) and agrammatic speakers, with all errors counted as incorrect (error bars represent 95% confidence intervals).

for "he *PRES* fold cloth"). Omission occurred when the aspectual marker was omitted (e.g., "he fold cloth" for "he *FUT* fold cloth"). Negation referred to the use of negation in place of the aspectual marker (e.g., "he *NEG* fold cloth" for "he *FUT* fold cloth"; see below for the sentence example).

***Target – Future***

ter ***jaa*** pub pah
she ***FUT*** fold cloth

"She *will* fold the clothing."

***Response – Negation***

ter ***yangmai*** pub pah
she ***NEG*** fold cloth

"She *hasn't yet* folded the clothing."

The translation of the negation *yangmai* in Thai is equivalent to the English usage of "not yet" to define an event that has not happened or has not been performed up to the present time, but might occur in the future.

In our data, substitution and omission errors were most frequent across the three time frames. The negation errors, however, were observed solely in the future condition and were produced by 7 out of 9 participants. The three participants who manifested selective impairment with the future did not produce more negation errors than the other participants (for the three participants: range 2–7, and for the other six participants: range 1–8; Table 3).

Since the negation errors did not occur across conditions, they were not included in the overall error analysis. Substitution errors were as prevalent as omission errors (Wilcoxon Signed-Ranks test, $p$ value Bonferroni corrected; $T = 13.00$, $z = -1.129$, $p = .777$).

**Table 3.** Production: Individual and group performance and statistics for the participants with agrammatic aphasia on the TART-LAM. Error types are classified per condition under "Incorrect".

| | Future (20) | | | | Present (20) | | | | Past (20) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Incorrect | | | | Incorrect | | | | Incorrect | | | Cochrane's Q | | McNemar's (2-tailed)[a] | | |
| Participant (n = 9) | Correct | Subs. | Omis. | Neg. | Correct | Subs. | Omis. | Neg. | Correct | Subs. | Omis. | Neg. | Q (2 df) | P | Future & Present | Future & Past | Present & Past |
| SP | 9 | 5 | 3 | 3 | 18 | 1 | 1 | - | 20 | - | - | - | 17.167 | < 0.001* | 0.036* | 0.003* | 1.500 |
| SM | 10 | 5 | 3 | 2 | 17 | 3 | - | - | 20 | - | - | - | 12.154 | 0.002* | 0.276 | 0.006* | 0.750 |
| NN | 8 | - | 5 | 7 | 8 | 5 | 7 | - | 14 | 4 | 2 | - | 7.200 | 0.027* | 3.000 | 0.093 | 0.093 |
| PL | 17 | - | 3 | - | 19 | 1 | - | - | 18 | - | 2 | - | 1.000 | 0.607 | | | |
| SN | 15 | 4 | 1 | - | 18 | 1 | 1 | - | 12 | 8 | - | - | 4.909 | 0.086 | | | |
| CL | 14 | 1 | - | 5 | 16 | 4 | - | - | 14 | 3 | 3 | - | 0.800 | 0.670 | | | |
| WC | 15 | 2 | - | 3 | 17 | 3 | - | - | 18 | 2 | - | - | 2.000 | 0.368 | | | |
| JD | 14 | 1 | 4 | 1 | 15 | 1 | 4 | - | 15 | 4 | 1 | - | 0.182 | 0.913 | | | |
| UN | 10 | 1 | 1 | 8 | 12 | 7 | 1 | - | 15 | - | 5 | - | 2.714 | 0.257 | | | |
| Mean | 12.44 | 2.11 | 2.22 | 2.89 | 15.56 | 2.89 | 1.56 | - | 16.22 | 2.33 | 1.44 | - | | | | | |
| SD | 3.21 | 2.03 | 1.79 | 3.1 | 3.5 | 2.15 | 2.4 | - | 2.86 | 2.74 | 1.74 | - | | | | | |
| % | 62.22% | 10.56% | 11.11% | 16.11% | 77.78% | 14.44% | 7.78% | - | 81.11% | 11.67% | 7.22% | - | | | | | |

The abbreviations 'Subs.' stands for Substitution, 'Omis.' for Omission, and 'Neg.' for Negation. McNemar's pairwise comparisons were not performed on participants whose Cochrane's Q test was not shown to be significant. Asterisk (*) marked significant results. [a]Bonferroni corrected *p*-value reported. Holm-Bonferroni correction provides the same outcome.

Giving further consideration to the negation responses to the future time reference condition, *yangmai* was sometimes produced in place of the target response *jaa*. Despite this form not being produced by any of the NBD speakers in this task, this is an acceptable alternative way of referencing the future in Thai. For this reason, we performed a second "lax" analysis, where the negation was treated as a correct response for future time reference in addition to the target future marker *jaa*. The other scores remain unchanged.

### *Production: reanalysis (accepting negation errors as correct)*

The same statistical tests for group and individuals were computed. The accuracy of the agrammatic speakers on the present and the past time frames is displayed in Table 3. The sole difference in this analysis was the future condition for the agrammatic speakers, where negation errors were recalculated as correct (Figure 5).

Agrammatic speakers remained significantly worse than NBD in all conditions (Mann–Whitney; past $U = 9.000$, $z = -3.170$, $p$(1-tailed) = .004; present $U = .000$, $z = -3.825$, $p$ (1-tailed) <.001; future $U = .000$, $z = -3.748$, $p$(1-tailed) <.001). However, with the revised coding, there was now no main effect of condition for the agrammatic speakers (Friedman's Test; $\chi 2(2) = .194$, $p = .908$). Nor were there any significant pairwise differences between the future, present, and past (Wilcoxon Signed-Ranks test, $p$ values, Bonferroni corrected; past – present $T = 23.50$, $z = -.774$, $p = 1.317$; past – future $T = 14.50$, $z = -.085$, $p = 2.796$; present – future $T = 17.00$, $z = -.140$, $p = 2.664$); the participants with agrammatic aphasia performed similarly across the three time frames.

For individual analysis, the effect of condition was shown to be statistically significant in the same three participants: SP (Q = 10.4; $p = .006$), SM (Q = 8.909; $p = .012$), and NN (Q = 8.6; $p = .014$), but with different pairwise dissociations (McNemar's test, Bonferroni corrected). While future time reference continued to be significantly worse than past time

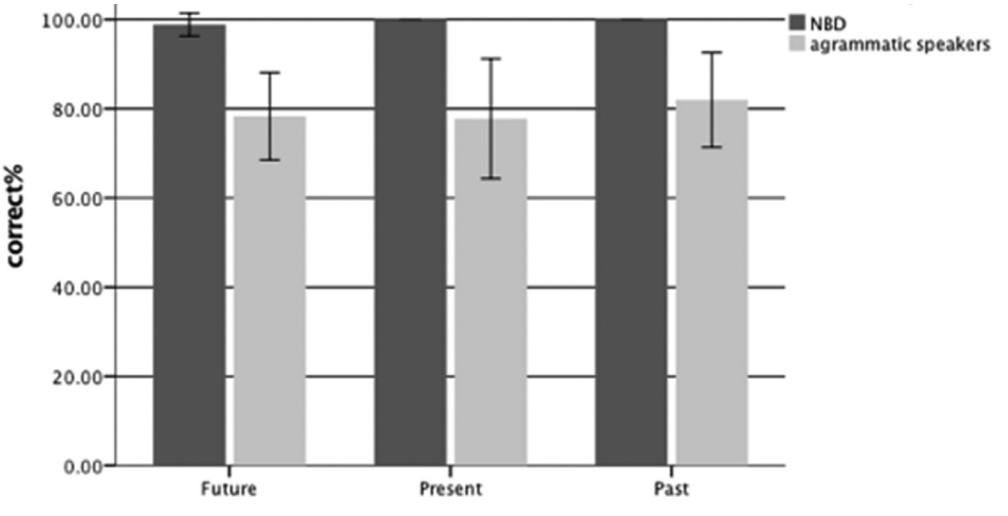


**Figure 5.** Percentage correct of the TART-LAM production of the future, present, and past for non-brain-damaged participants (NBD) and agrammatic speakers, with negation errors counted as correct (error bars represent 95% confidence interval).

reference for SP and SM (both, future 12/20, past 20/20, $p$ = .024), SP no longer showed a significant difference between the future and present (future 12/20, present 18/20, $p$ = .327). NN once again showed no significant differences between conditions.

### *Comprehension: group analysis*

As can be seen in Figure 6 (see also Table 4), the NBD participants performed at ceiling with no errors in any condition and the agrammatic speakers performed significantly more poorly in all time reference conditions, although the past condition was only marginally significant (Mann–Whitney Tests; past $U$ = 18.000, $z$ = −2.519, $p$(1-tailed) = .050; present $U$ = 9.000, $z$ = −3.174, $p$(1-tailed) = .004; future $U$ = 4.500, $z$ = −3.516, $p$ (1-tailed) <.001).

Within-group analysis, for the agrammatic speakers, revealed that there was a significant difference between the three time frames (Friedman's Test $\chi 2(2)$ = 7.786, $p$ = .020). Pairwise analyses showed no significant difference between the past and present (Wilcoxon Signed Rank Test, $p$ values, Bonferroni corrected; $T$ = 12.00, $z$ = −.317, $p$ = 2.253), but present was significantly more accurate than future ($T$ = 28.00, $z$ = −2.414, $p$ = .048). However, while the past was numerically more accurate than future, this did not reach significance ($T$ = 24.50, $z$ = −1.811, $p$ = .210).

Additionally, considering that the number of participants was small, we computed Bayesian Paired Samples T-Tests to obtain an estimate of the strength of the evidence for a difference (or lack of difference) between conditions. Recall that our null hypothesis ($H_0$) was that there was no difference between the two conditions, while the alternative hypothesis ($H_1$) was that there was a difference between the two conditions. Using Jeffreys (1961) terminology, the results indicated strong evidence for a difference ($H_1$)

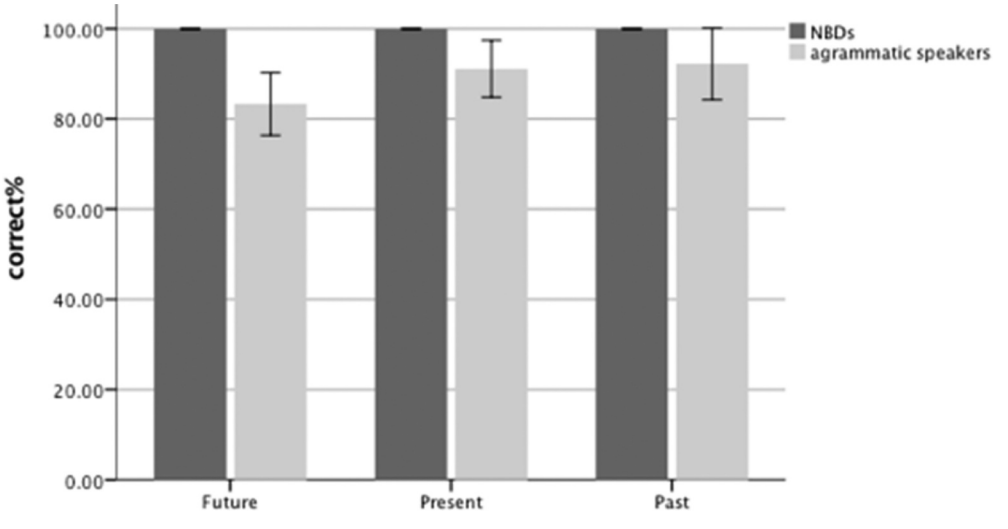


**Figure 6.** Percentage correct of the TART-LAM comprehension of the future, present, and past of NBD and the agrammatic speakers, with 95% confidence interval.

**Table 4.** Comprehension: Individual and group performance and statistics of the participants with agrammatic aphasia on the TART-LAM.

| | | | | Cochrane's Q | |
|---|---|---|---|---|---|
| | Future (20) | Present (20) | Past (20) | Q (2 df) | P |
| SP | 20 | 20 | 20 | N/A | |
| JD | 15 | 19 | 19 | 4.571 | .102 |
| TW | 15 | 15 | 19 | 4.571 | .102 |
| PS | 18 | 19 | 15 | 3.25 | .197 |
| PP | 17 | 18 | 20 | 2.8 | .247 |
| SM | 17 | 19 | 20 | 3.5 | .174 |
| MN | 15 | 17 | 15 | 1 | .607 |
| SS | 15 | 17 | 18 | 2 | .368 |
| WT | 18 | 20 | 20 | 4 | .135 |
| Mean | 16.67 | 18.22 | 18.44 | | |
| SD | 1.8 | 1.64 | 2.07 | | |
| % | 83.33% | 91.11% | 92.22% | | |

between present and future ($BF_{10}$ = 10.369), but only anecdotal evidence for either $H_1$ or $H_0$ for the present and past ($BF_{10}$ = 0.334) and between the past and future ($BF_{10}$ = 1.783).

### *Comprehension: individual analysis*

At an individual level (Table 4), none of the agrammatic speakers showed a significant difference across conditions (all Q's <4.571; all *p*'s <.607). Note that Cochran's Q Test could not be performed on participant SP whose performance was at ceiling in every time frame. No significant difference was found between pairs of conditions.

## Discussion

This study investigated the pattern of impairment of time reference in Thai speakers with agrammatic aphasia. The PADILIH predicts that agrammatic performance should be similarly affected for both production and comprehension. To test this prediction, we administered a sentence elicitation task and a spoken sentence to picture matching task with both agrammatic and non-brain-damaged (NBD) Thai speakers.

The Thai individuals with agrammatic aphasia performed significantly more poorly than the NBD participants (who performed at ceiling) in both production and comprehension and in every time reference condition. However, in addition, the agrammatic speakers showed significantly more difficulty in processing reference to the future compared to the present in both tasks than reference to the past or present, which was equally impaired.

The asymmetry between the future and present was not predicted. According to Zagona (2013), the future is a subtype of the present; they are both categorized as non-past. Following Zagona, the PADILIH differentiates between the past and non-past (i.e., present and future) and predicts that the past is selectively impaired in languages with verb inflections. In languages with aspectual markers, however, the PADILIH predicts that all time frames are equally impaired because all aspectual markers are discourse linked (i.e., linking the event to the discourse). As can be seen, our data did not fully support the PADILIH for comprehension: comprehension of the future is more impaired than comprehension of the present. For production, the PADILIH correctly predicts the results but

only when the production of *yang mai*: "not yet" in place of the target word *jaa* is considered to be correct.

Nevertheless, our study was not the first to have found this. As mentioned in the Introduction, impairment of reference to the future through verb inflection compared to the present was repeatedly found for production in Greek (Koukoulioti & Bastiaanse, 2020; Nanousi et al., 2006), and for comprehension in Spanish-Catalan (Martínez-Ferreiro & Bastiaanse, 2013). Based on these data, the future-present dissociation appears to be independent of language type. Based on Zagona (2003), Martínez-Ferreiro and Bastiaanse (2013) postulated that the problem with future time reference is related to the (non)simultaneity between speech time and event time. While for the present, speech time and event time coincide, for the future, they do not (i.e., there is no event available for which such a relationship can be established; Table 2). Building on this proposal, Koukoulioti and Bastiaanse (2020) suggested that the difficulty with future was related to the fact that there is no truth-value on the state of the world at the time of an utterance that refers to the future, but this has to be inferred, and it is this that affects the production of the specific verb forms. The Thai agrammatic speakers may prefer to use negation construction as, contrary to the target future time reference *jaa*, negation has an assigned truth-value at the time of utterance.

Alternatively, we posit that reference to the future in Thai may be impaired because of its grammatical role, one that is different from that of the present and past. More specifically, the future is the sole time reference marking that is classified as a modal (Kanchanawan, 1978; Srioutai, 2004). It could, therefore, be speculated that it is the status of *jaa* as a modal that is the cause of the difficulty.

Bastiaanse and Jonkers (1998) investigated the use of modals in individuals with agrammatic aphasia in Dutch, but found no impairment in the production of modals relative to other verbs. However, Boye and Bastiaanse (2018) examined modals in greater detail, contrasting "grammatical" and "lexical" use of modal verbs in Dutch. Modals were classified as grammatical when they were combined with a lexical verb (*de man wil een nieuwe broek kopen:* "the man wants to buy new trousers") and as lexical when they were the main verb of the sentence (*de man wil een nieuwe broek:* "the man wants new trousers"). Agrammatic speakers showed more severe impairment when modals were used as grammatical verbs than when they were used as full lexical verbs. Given that *jaa* is a grammatical modal, Boye and Bastiaanse's results suggested that this may indeed have been the source of our Thai agrammatic speakers' problems with the future.

Critically, however, at the individual level, in production, only two participants, SP and SM, did show that the future is more impaired than the past, with SP also being more impaired on the future than on the present. No significant differences were found between conditions for the comprehension experiment at an individual level most likely because of a lack of power given that participants performed relatively well on the task.

### *What happened to the production of reference to the future?*

Recall that in our production study, two analyses were conducted. The first analysis was a strict analysis where any non-target production was counted as incorrect. In the second, lax, analysis, negation errors were recounted as correct. Importantly, negation errors were

produced only in the future condition, and only by the agrammatic speakers and not by the NBD participants. Rather than using the target word *jaa*, participants instead said *yangmai*: "not yet". This response type has not been reported in the previous studies related to time reference. Although not employed by NBD individuals in this task, the use of *yangmai* to refer to the future is acceptable and grammatical in Thai. Hence, we suggested that the negation construction was not, in fact, an error, but rather an alternative way of referencing the future employed by the agrammatic speakers.

After reclassifying the negation errors as correct, there was no longer a significant difference across conditions for the agrammatic speakers as a group, nor was there an asymmetry between the future and present. No particular time frame was observed to be impaired. These findings support the PADILIH that predicts an equal deficit in time references in languages with aspectual markers. Despite the methodological differences, the revised data are in line with Bastiaanse et al. (2011) for Chinese and Anjarningsih (2012) for Standard Indonesian. The results advance the idea of Avrutin (2006) and the PADILIH: if discourse linking is compromised in agrammatism (Avrutin, 2006), and all time reference is discourse linked in languages that use non-obligatory aspectual adverbs (Bastiaanse et al., 2011), time reference should be equally impaired in all time frames.

The use of the negative phrase, nevertheless, raises an interesting question: why did the Thai agrammatic speakers use negation *yangmai* rather than the future marking *jaa*? According to Friedmann and Grodzinsky (1997), negation is difficult for people with agrammatism because it has its origin in the impaired part of the syntactic tree (see the Tree Pruning Hypothesis, Friedmann & Grodzinsky, 1997 for more details). Contrary to Friedmann and Grodzinsky (1997), however, Rispens et al. (2001) found that negation was not difficult in every language. They explored production (and comprehension) of negative sentences using sentence-anagram tests in three languages: English, Dutch, and Norwegian. Based on the syntactic tree, the internal structure of the negative phrase is language dependent, and is differentiated, based on grammatical constraints, into either a functional head (if it is related to verb movement; e.g., English) or a specifier (if it does not relate to verb movement; e.g., Dutch, Norwegian). Rispens et al. (2001) found that it was more difficult for people with aphasia to construct negative sentences when the negation word was a functional head than when it was a specifier. Put simply, negation was found to be more difficult for English agrammatic speakers than Dutch or Norwegian agrammatic speakers.

According to Visonyangoon (2000) and Jenks (2013), the internal structure of the negation phrase in Thai is, like in Dutch and Norwegian, a specifier, accounting for the fact that Thai agrammatic speakers were able to use *yangmai*. The results of our experiment, therefore, suggest that in Thai, the negative phrase may require less processing load than the use of modals, and, therefore, is less impaired. Hence, we believe that when Thai agrammatic speakers are unable to produce the modal for future time reference, they can instead use the negative phrase.

In sum, our Thai agrammatic speakers were less vulnerable in reference to the past and the present compared to the future in both production and comprehension. The problems with producing future time reference can then be explained by the grammatical status of the future marker, that is, unlike present and past markers, a modal. Additionally, the use of negation in place of the future aspectual marker in agrammatism might be because the negative structure results in a reduced processing load compared to the use of the modal.

However, further research is needed to examine to what extent future time reference is impaired, and to explore how negation is processed in individuals with agrammatic aphasia. It would also be desirable to replicate these results with further Thai speakers with aphasia and ensure that the results are robust to slight methodological changes (e.g., ordering of pictures).

## Note

1. Unfortunately, as testing for production and comprehension occurred two months apart, the majority of participants were not available for both testing sessions.

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No potential conflict of interest was reported by the authors.

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## *Appendix 1*

Production: Demographic details of the agrammatic speakers, and their scores (% correct) on the test for word auditory comprehension (Thai BDAE) in Thai. Demographic details of the non-brain-damaged participants are displayed at a group level only.

| | Age (years) | Gender | Handedness | Education (years) | Years post-onset | BDAE comprehension (%) |
|---|---|---|---|---|---|---|
| **Agrammatic speakers** | | | | | | |
| SP | 26 | M | R | 19 | 3 | 100 |
| SM | 50 | F | R | 21 | 5 | 100 |
| NN | 60 | F | R | 19 | 3 | 97.58 |
| PL | 30 | M | R | 19 | 3 | 100 |
| SN | 59 | M | R | 19 | 2 | 100 |
| CL | 55 | F | R | 19 | 1 | 95.16 |
| WC | 73 | M | R | 15 | 4 | 100 |
| JD | 49 | F | R | 15 | 3 | 93.55 |
| UN | 83 | M | R | 15 | 5 | 97.6 |
| Mean (SD) | **53.89 (18.25)** | – | – | **17.89 (2.26)** | **3.22 (1.30)** | **98.21 (2.45)** |
| **Non-brain damaged participants** | | | | | | |
| Mean (SD) | **52.67 (17.39)** | **4 F's, 5 M's** | **all R's** | **17.89 (2.26)** | – | **100 (0)** |

## Appendix 2

Comprehension: Demographic details of the agrammatic speakers, and their scores (% correct) on the test for word auditory comprehension (Thai BDAE) in Thai. Demographic details of the non-brain-damaged participants are displayed at a group level only.

| | Age (years) | Gender | Handed- ness | Education (years) | Years post-onset | BDAE comprehension (%) |
|---|---|---|---|---|---|---|
| **Agrammatic speakers** | | | | | | |
| SP | 26 | M | R | 19 | 3 | 100 |
| JD | 49 | F | R | 15 | 3 | 93.55 |
| TW | 47 | F | R | 19 | 2 | 92.74 |
| PS | 68 | F | R | 17 | 1 | 100 |
| PP | 20 | M | R | 14 | 4 | 100 |
| SM | 50 | F | R | 21 | 5 | 100 |
| MN | 67 | F | R | 10 | 2 | 100 |
| SS | 63 | M | R | 19 | 4 | 95.16 |
| WT | 52 | M | R | 21 | 1 | 98.39 |
| Mean (SD) | **49.11 (16.83)** | – | – | **17.22 (3.63)** | **2.78 (13.9)** | **97.76 (3.07)** |
| **Non-brain damaged participants** | | | | | | |
| Mean (SD) | **50.78 (15.05)** | **5 F's, 4 M's** | **all R's** | **17.11 (2.93)** | – | **100 (0)** |

## Appendix 3

Verbs and nouns (actions) used in the Test for Assessing of Reference of Time in Language with Aspectual Markers (modified from the TART; Bastiaanse et al., 2008).

| Thai | | Literal Translation | |
|---|---|---|---|
| Verb | Noun | Verb | Noun |
| tam | prae | do | wound |
| kwad | puen | sweep | floor |
| tad | leb | cut | nail |
| duem | nom | drink | milk |
| kian | nangsue | write | note |
| tang | naa | dress | face |
| tood | kai | fry | egg |
| sai | sue | put on | shirtwear |
| mud | pom | tie | hair |
| lang | naa | wash | face |
| lhao | dinsor | sharp | pencil |
| pub | pah | fold | cloth |
| lang | jaan | clean | dish |
| rabaai | sii | paint | color |
| hun | polamai | chop | fruit |
| jud | krapao | pack | suitcase |
| waad | loop | draw | picture |
| tork | kai | crack | egg |
| perd | jodmai | open | letter |
| prang | fun | brush | teeth |