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Neurolinguistic Studies on the Linguistic Expression of Time Reference in Thai

Siriboonpipattana, Wilasinee

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Neurolinguistic Studies on the Linguistic Expression of Time Reference in Thai

Wilasinee (Kaimook) Siriboonpipattana

The research reported in this thesis has been carried out under the auspices of the Center for Language and Cognition Groningen (CLCG), the Behavioral and Cognitive Neuroscience (BCN) of the University of Groningen, and the International Doctorate for Experimental Approaches to Language And Brain (IDEALAB) of the Universities of Groningen (NL), Newcastle (UK), Potsdam (DE) and Macquarie University, Sydney (AU).

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Neurolinguistic Studies on the Linguistic Expression of Time Reference in Thai

PhD Thesis

to obtain the joint degree of PhD at the
University of Groningen, University of Potsdam, Macquarie University,
and Newcastle University

on the authority of the
Rector Magnificus of the University of Groningen Prof. C. Wijmenga,
President of the University of Potsdam, Prof. O. Günther,
Deputy Vice Chancellor of Macquarie University, Prof. S. Bruce Downton, and
Vice Chancellor of Newcastle University, Prof. Ch. Day.

and in accordance with
the decision by the College of Deans.

This thesis will be defended in public on

Thursday 8 April 2021 at 12.45 hours

by

Wilasinee Siriboonpipattana

born on 4 July 1991

in Ubon Ratchathani, Thailand

Supervisors

Prof. dr. Y.R.M. Bastiaanse

Prof. dr. L. Nickels

Co-supervisor

Dr. S. Popov

Assessment Committee

Prof. dr. D. Howard

Prof. dr. J.P. Koenig

Prof. dr. L.K. Obler

Prof. dr. C.J.W. Zwart

Barb and Lee Malany

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1

General Introduction

OVERVIEW

The concept of time is crucial in everyday communication. Temporal expressions help us to understand when things happen, relative to when we are speaking. For instance, the sentence *Last night, Jimmy talked to his grandmother* shows that the event took place in the past. If *Last night* was to be replaced by *Tomorrow*, the sentence becomes ungrammatical, because the new phrase does not match the time frame specified by the verb *talk*. Time reference has been shown to be affected in individuals with acquired language impairment, such as agrammatic aphasia (e.g., Bastiaanse et al., 2011; Bastiaanse, 2013). Critically, there are many different ways to refer to time; for instance, by morphological markers such as the *-ed* in English and other Indo-European languages, by the use of tone such as in Akan (Tsiwah et al., 2020), and by aspectual markers (the use of free-standing morphemes to indicate different time frames) such as in Thai, the focus of the current dissertation.

1.1 INTRODUCTION

Aphasia, in Greek ‘ἄφατος (áphatos)’ from ‘ἄ- (a-, not)’ and ‘φάσις (phásis, speech)’ meaning ‘no speech’, is an acquired language disorder that affects linguistic abilities: the ability to produce and to comprehend (also to read and to write). It is usually caused by left-lateralized brain damage commonly from strokes, brain tumors, head injuries or dementia. Language severity varies individually: to exemplify, for some individuals, it may affect the ability to retrieve words, while for others, it may affect the ability to construct grammatical sentences, or to understand certain types of sentence (e.g., passive sentences and object clefts). Whether the production or comprehension modalities are affected depends on the size and the lesion site of the brain damage (Grodzinsky, 1990). Aphasia is broadly distinguished based on the characteristics of verbal expressions into non-fluent and fluent types (e.g., Davis, 2007; Goodglass & Kaplan, 1972). The focus of this dissertation is on non-fluent aphasia; specifically, agrammatic aphasia. Agrammatic speech is traditionally characterized by non-fluent speech output, with relatively intact comprehension of single words. Menn and Obler (1990) noted that, cross-linguistically, speech rate and utterance length are means of measurement used to define agrammatism. Compared to non-brain damaged (NBD) speakers, individuals with agrammatic aphasia produce slower speech with more simplified grammatical structures. Their connected speech is reported to consist mainly of content words (i.e., nouns, verbs, adjectives), while function words and grammatical morphemes are often omitted and substituted (e.g., Goodglass & Kaplan, 1972).

Linguistic research in agrammatism has been widely conducted in the past decades, leading to various linguistic theories. Studying the underlying deficits in aphasia is crucial in helping us better understand the nature of language impairments, which consequently, can form the knowledge base that helps maximize the recovery of aphasia by the use of linguistic-based therapies. While most of the previous research has focused on Indo-European languages, the current dissertation concentrates on a language in Southeast Asia, Thai, particularly on the symptoms in spontaneous speech and the linguistic expression of time reference.

This introductory chapter discusses the general background required to understand the three ensuing experimental chapters (Chapter 2-4). Chapter 2 explores narrative and spontaneous speech of Thai speakers with non-fluent aphasia in comparison to the speech of Thai NBD speakers. Chapter 3 investigates the production and comprehension of time reference in Thai agrammatism in relation to the linguistic theory the PAsT DIscourse LIinking Hypothesis (PADILIH; Bastiaanse et al., 2011). While Chapter 2-3 are behavioral studies, Chapter 4 is a neurophysiological study that uses a brain-imaging technique, electroencephalography (EEG) as a method of experimentation. The two latter studies contribute to the linguistic-based knowledge of temporal processing, informing us about how time reference is represented in the human brain.

The unique characteristics of Thai, which will be briefly outlined in this chapter and more thoroughly in the following chapters, motivated the research reported in this dissertation. Our studies present findings from an understudied language, Thai, and provide further evidence on time reference and agrammatism, which largely adds to the body of knowledge in the neurolinguistic literature. In the following sections, first, an overview of the features of Thai germane to the current project are provided. Second, relevant linguistic frameworks, namely, discourse linking, the PADILIH, and the usage-based theory of grammatical status and grammaticalization are delineated. Third, the methodological importance of event-related potentials (ERPs), which are measured by means of EEG, is presented. Finally, the main issues and research questions addressed in the current dissertation are given.

1.2 THE THAI LANGUAGE

Central Thai or Standard Thai, herein referred to as Thai, is the official language of Thailand. It belongs to the Tai-Kra-Dai language family, and is a Subject-Verb-Object (SVO) language (Sudmuk, 2003). Being an isolating or an analytical language, Thai

primarily conveys grammatical relations in sentences by the use of specific words (i.e., free-standing morphemes), rather than inflections (e.g., Thiengburanathum, 2013). Thai is a pro-drop language that permits omissions of subjects and objects in sentences when they can be inferred from the context. For instance, when it is clear that you are having a conversation with the person next to you, there is no need to utter the word *khun*: ‘you’—(*khun*) *pai nhai?*: lit. ‘(you) go where?’ Thus, communication in Thai relies strongly on pragmatics and contextual information. Further, no grammatical categories, such as tense, number, and agreement, are marked on the verb (e.g., Prasithrathsint, 2006).

1. Sunee pai talay **wanee**
 Sunee go beach **today**
 ‘Sunee goes to the beach today.’

2. Sunee kub Suma pai talay **wanee**
 Sunee and Suma go beach **today**
 ‘Sunee and Suma go to the beach today.’

3. Sunee kub Suma pai talay **peekorn**
 Sunee and Suma go beach **year-last**
 ‘Sunee and Suma went to the beach last year.’

4. Sunee *koei* dern pai talay **peekorn**
 Sunee *PERF* walk go beach **year-last**
 ‘Sunee used to go to the beach (by walking) last year.’

To exemplify, sentences (1-4) show that there is one form of the verb in Thai, regardless of the subject pronouns (i.e., sentence (1) for singular; sentence (2) for plural), and tense or time frame (i.e., sentence (2) for present; sentences (3-4) for past). It can be argued that, to claim that aspectual markers in Thai refer to the past, present, or future is linguistically inappropriate, as the temporal meaning in Thai is due to pragmatic factors and its interpretation is out of a discourse context. In this dissertation, however, the term ‘reference to the past, present, or future’ is used throughout as it is more relevant to the theories to follow. Further, the terminology is appropriate (and easier to follow) as the Thai aspectual markers are compared to the Indo-European tense markers, which have been studied widely in the previous studies.

1.2.1 Serial Verbs in Thai

Note that there are two verbs in sentence (4), as indicated by the underlined words. This linguistic phenomenon where a sequence of verbs can be juxtaposed in a single clause is called ‘serial verb construction’ or ‘verb serialization’. It shows that more than one verb can be produced consecutively with no overt conjunction between the verbs (Chuwicha, 1993; Muansuwan, 2002). According to Muansuwan (2002), serial verb constructions include several verb phrases (VP) with fixed position of verbs. There is no consensus as to how many verbs can be connected in a clause / sentence, and the number of verbs varies from language to language (Foley, 2008). Nonetheless, it has been reported in the Thai literature that when there is ‘more than one verb’ or when there are ‘two or more verbs’, a clause / sentence is verb-serialized (Chuwicha, 1993; Muansuwan, 2002; Sudmuk, 2005; Takahashi, 2009; Thepkanjana, 1986; Wilawan, 1993).

1.2.2 Aspectual Markers in Thai

In Thai, no verb inflection is used to express the time frame in which the event happens, but, as illustrated in (1-4), time reference is achieved through aspectual markers—aspectual adverbs (*italicized*), and temporal adverbs (**bold**)—both of which are free grammatical morphemes. Critically, aspectual adverbs are different from temporal adverbs. Aspectual adverbs indicate *how* an event unfolds over time in relation to the discourse, and are classified into perfective (an event has been completed) and imperfective (an event is ongoing) aspect³. The difference between perfective and imperfective Aspect in Thai is comparable to the English simple past (*I fixed it*) and past continuous (*I was fixing it*), respectively. Conversely, temporal adverbs (i.e., *at the moment*, *yesterday*, and *tomorrow*) describe *when* an event is carried out; for example, *yesterday* as a response to the question *When did you visit your parents?*

When they co-occur, the time frame of the aspectual adverb and the temporal adverb must be congruent for a sentence to be grammatical, otherwise, the sentence is incorrect, as shown in (5). In addition, as free-standing morphemes, both aspectual adverbs and temporal adverbs are not obligatory in a sentence when the time frame is clear from the context. Hence, *Sunee pai talay*: lit. ‘Sunee go beach’ is a grammatically and pragmatically correct sentence that can be used to indicate an event happening in the past, present, and future. This ‘omissibility’ characteristic of Thai temporal markers (i.e., aspectual adverbs

3 To avoid repetition, only a brief description is provided here; more detailed descriptions and examples of temporal markers in Thai are given in the chapters where required.

and temporal adverbs) is of interest when thinking about ‘time reference’.

1. Sunee *koei* pai talay ***prungnee**
 Sunee *PERF* go beach ***tomorrow**
 *‘Sunee used to go to the beach tomorrow.’⁴

Another interesting feature of Thai that is relevant to this project is the use of politeness particles. This is discussed further in Chapter 2. This brief introduction to Thai shows that the Thai language is, to a large degree, linguistically different from Indo-European languages. This difference means that it is valuable to examine aphasia in Thai. Given that there are hardly any grammatical morphemes and many words can be omitted in Thai (more about this in the following chapters where relevant), one issue is that it may be challenging to identify Thai agrammatism, as it may have different features to Indo-European Languages. No study has previously attempted to do this in Thai. One of the chapters of this research project, therefore, aimed to explore the nature of Thai agrammatism (Chapter 2). It started by characterizing Thai agrammatism, and comparing the findings to the previously studied languages.

1.3 THEORETICAL FRAMEWORK

The other chapters of this research project focused on the linguistic theories and neurolinguistic background relating to the production and comprehension of time reference in agrammatic aphasia and, specifically, the PADILIH (Chapter 3), and a comparison of time reference in languages with verb inflection and languages with aspectual adverbs (Chapter 4). A summary of the key points of this relevant theoretical background is provided at the end of the section.

1.3.1 Time Reference

It has been shown that agrammatic speakers of Indo-European languages have problems with finite verbs (Bastiaanse & Edwards, 2004). However, the grammatical features of finite verbs (such as tense and agreement) do not exist in Thai. As noted earlier, to refer to different time frames in Thai, aspectual adverbs are employed. This dissertation focuses on one type of problem with verbs in agrammatic speakers, namely, time reference. One of the

⁴ Many of the purported temporal incompatibilities that involve aspect markers are due to pragmatic factors and interpretation of sentences out of a discourse context.

aims is to investigate how grammatical problems with time reference can be determined in Thai. Note that time reference refers to the semantic feature of the event expressed by a verb phrase as a whole, whereas tense refers more precisely to the morphological inflection of the finite verb (Bos & Bastiaanse, 2014).

After a wide-range of studies on agrammatics' performance on verbs, several linguistic theories have been proposed. Friedmann and Grodzinsky (1997) hypothesized that the problems agrammatic speakers have with finite verbs are due to Tense rather than Agreement inflection. According to Friedmann and Grodzinsky (1997), this is related to the difference in the position of the Tense and Agreement nodes in the syntactic tree, with the Tense node being above the Agreement node. Friedmann and Grodzinsky (1997) argued that the functional projections from the Tense node up are inaccessible for agrammatic speakers (when one node is inaccessible, the other nodes above it are inaccessible too); this is known as the Tree Pruning Hypothesis (TPH). Wenzlaff and Clahsen (2004) formed another hypothesis for the problems with Tense inflection, which they called the Tense Underspecification Hypothesis (TUH). The TUH relates the tense problem to the fact that tense carries extra-sentential information in the form of interpretable features of tense (+past) and (-past). In agrammatism, these features are underspecified.

Bastiaanse (2008), however, has argued that it is not tense *per se* that is impaired in agrammatic aphasia, but time reference through verb forms; specifically, reference to the past. This is supported by earlier data from Stavrakaki and Kouvava (2003) who analyzed the spontaneous speech of Greek agrammatic speakers, and reported that the perfective Aspect (that refers to a completed event) was more impaired than the imperfective Aspect (that refers to an ongoing event). Similarly, Yarbay Duman and Bastiaanse (2009) tested Turkish agrammatic speakers, reporting that the production of past time reference morphology was relatively more affected than that of future time reference (see also, Abuom & Bastiaanse, 2013; Jonkers & De Bruin, 2009; Nanousi et al., 2006). Hence, the PADILIH was formulated (Bastiaanse et al., 2011). In the subsequent sections, I describe the theoretical background of the PADILIH.

1.3.1.1 Discourse Linking

One of the influential studies that led to the formulation of the PADILIH was by Avrutin (2000; 2006). Avrutin (2000; 2006) proposed that linguistic structures that are processed by narrow syntax are less problematic for agrammatic speakers to produce and comprehend than those that are processed by discourse syntax. According to him, 'discourse syntax' means that a syntactic element can only be interpreted by linking it

to information outside the sentence. This discourse linking requires more processing resources than narrow syntax. Thus, processing at the level of discourse syntax requires more processing resources and poses additional challenges for agrammatic individuals. Examples of narrow and discourse syntax are given in Table 1.1.

Pronouns are a well-known example in the theory of narrow and discourse syntax. In sentence (a) *the girl_i* and *herself_i* refer to the same person (i.e., locally bound). In sentence (b) *the girl_i* and *her_j* do not refer to the same person, but *her* refers to another female person outside the context of the sentence. A link to a referent outside the sentence is required to comprehend the sentence. For this, discourse linking is required, making sentences like (b) harder to process than (a). This was earlier reported by agrammatic data: for example, Grodzinsky et al. (1993) found that discourse-linked pronouns were harder to process than locally bound reflexives for individuals with agrammatic aphasia. Similarly, in wh-questions, Hickok and Avrutin (1996) reported that the discourse-linked which-questions were more challenging for individuals with agrammatic aphasia to comprehend than the non-discourse linked who-questions.

Table 1.1 Examples of narrow and discourse syntax.

	Examples	Co-reference?
a. Narrow Syntax	‘The girl _i is washing herself _i ’	Yes
b. Discourse Syntax	‘The girl _i is washing her _j ’	No

Note: Subscripts reflect the referent of the noun / pronoun.

1.3.1.2 The Past Discourse Linking Hypothesis (PADILIH)

Tense refers to a point in time outside the sentence; consequently, tense is processed by discourse syntax (Avrutin, 2000; 2006). Consequently, agrammatic speakers are expected to have problems with tense. Zagana (2003; 2013), however, posited that it is too broad to claim that all tenses are discourse-linked. She proposed that only past tense, as opposed to non-past (present and future) tense, requires discourse linking as the evaluation time (speech time) does not coincide with the event time.

Following on Avrutin (2006) and Zagana’s (2003; 2013) work, Bastiaanse (2013) proposed that rather than a difficulty with past tense, agrammatic speakers have problems with past time reference because discourse linking is required for all verb forms that refer to the past. Thus, the PADILIH predicts that it is not past tense that is troublesome in agrammatism, but all verb forms, irrespective of tense, that refer to the past; for instance,

simple (e.g., *wrote*) and periphrastic (e.g., *has written*, *was writing*) verb forms. The PADILIH has been supported cross-linguistically. Much of this support is from languages that use verb inflection for time reference, for example, Bastiaanse et al. (2011) for English, Turkish (and Chinese), Jonkers and De Bruin (2009) for Dutch, and Yarbay Duman and Bastiaanse (2009) for Turkish. Studies including languages that use aspectual adverbs for time reference, such as Chinese (Bastiaanse et al., 2011), however, reported that the agrammatic speakers showed an equal impairment in the production of past, present, and future time reference. For Standard Indonesian, Anjarningsih (2012) also reported an equal deficit across all time frames.

The concept of discourse linking, the PADILIH, and the fact that marking of event time in Thai (i.e., using aspectual adverbs and temporal adverbs) is not obligatory, are all intertwined, and thus play a significant role in this dissertation. Bastiaanse (2013) proposed that aspectual adverbs are only used when the time frame is not clear from the context; thus, they are used to link the time course of the event to the discourse. This implies that aspectual adverbs are always discourse linked. As a result, an equal deficit in reference to the past, present, and future should be found in Thai speakers with agrammatism. As noted by Bos (2015), much of the previous research on time reference has used the Test for Assessing Reference of Time (TART) developed by Bastiaanse et al., (2008), which has subsequently been adapted to be culturally and socially appropriate to administer in different cultures. For the experiment described in Chapter 3, the TART was, again, modified and used in Thai.

To summarise, to date, it has been claimed that;

- The production of verbs is problematic in agrammatic speakers of Indo-European languages.
- Time reference, which is one facet of the problem with verbs, is impaired in agrammatic aphasia.
- Discourse linking is difficult for agrammatic speakers because it requires more processing resources (Avrutin, 2000; 2006).
- In languages that inflect verbs for time reference, only past time reference is discourse linked; and thus, reference to the past through verb inflection is relatively poor in agrammatic speakers (PADILIH; Bastiaanse et al., 2011).

- Aspectual adverbs in Thai are always discourse linked, regardless of the time frame they refer to. Hence, production and comprehension of aspectual adverbs will be equally impaired for all time frames in Thai agrammatic speakers. (PADILIH; Bastiaanse, 2013).
- The majority of investigations on time reference are on Indo-European languages; there are only a few studies in languages that rely on aspectual adverbs, namely Chinese (Bastiaanse et al., 2011) and Standard Indonesian (Anjarningsih, 2012).

To further add to the knowledge of time reference and agrammatism in the neurolinguistic literature, Chapter 3 replicated the time reference study in Thai, by investigating how time reference is produced and comprehended in Thai speakers with agrammatic aphasia.

1.3.2 The Usage-Based Theory of Grammatical Status and Grammaticalization

Boye and Harder (2012) made a distinction between grammatical and lexical words. Grammatical items are discursively secondary, acting as background information relative to other items / hosts. In other words, they are dependent on the other items. In contrast, lexical items are potentially primary, serving as foreground information. To check for grammatical status, three main criteria are used: focusability, addressability, and modifiability (Boye & Harder, 2012). While grammatical items cannot be focalized, addressed, and modified, lexical items can. Table 1.2 gives examples of how to distinguish grammatical and lexical words based on the aforementioned criteria.

To elaborate, we shall take a closer look at the addressability criterion as an example (see Boye and Harder (2012) for more information). The grammatical and lexical variants of the English word *have* can be distinguished depending on the function taken. In *I have a cat*, the full verb *have* can be addressed by ‘do’ (*Do you have a cat?*), showing that this *have* is a lexical item. In *I have read*, the auxiliary *have* is combined with a full verb: *have* cannot be addressed by do (**Do you have read?*), and thus, is a grammatical word.

Table 1.2 The distinction between grammatical and lexical items.

Examples			Grammatical VS Lexical?
Can the word in italics be focalized?	I like exactly <i>that</i> .	Yes	Lexical
	*I like exactly <i>it</i> .	No	Grammatical
Can the word in italics be addressed?	I <i>have</i> a cat. Do you, really?	Yes	Lexical
	I <i>have</i> read. *Do you, really?	No	Grammatical
Can the word in italics be modified?	It went straight <i>off</i> the road.	Yes	Lexical
	*They live within 10 miles straight <i>of</i> the town.	No	Grammatical

1.3.2.1 The Grammatical-Lexical Distinction in Agrammatism

The usage-based theory of grammatical status and grammaticalization has been supported by neurolinguistic data. As noted above, agrammatic speakers have problems with grammatical words: they often omit and substitute other grammatical words for these items (Goodglass & Kaplan, 1972). Experimental studies have shown, for example, that agrammatic speakers have more difficulty with grammatical than lexical items. For example, Boye and Bastiaanse (2018) compared grammatical and lexical variants of the verb *hebben*: ‘have’ in Dutch agrammatic speakers, and found that they encountered more trouble with the grammatical than the lexical usage (see also Ishkhanyan et al. (2017) for French).

1.3.2.2 Verb Inflections versus Aspectual Adverbs

Based on Boye and Harder (2012), verb tense inflection incorporates grammatical items. For instance, the morphological suffix for past *-ed* and the modal auxiliary *will* serve as background information, and cannot be focalized. The aspectual adverbs used for time reference in Thai, however, are different: they are not suffixes, but are free morphemes. To illustrate, the word *koei* in (6) is a free-standing morpheme. It can be focalized, and can be modified. Note, however, that the semantics of *koei* is quite specific: it refers to an experience in the remote past. Thus, in sentence (7), when *koei* is combined with a temporal adverb *meuxwan* that refers to the recent past (**bold**), the sentence becomes ungrammatical.

- Tim *koei* sue rod

Tim *PERF* remote past buy car

‘Tim purchased a car.’

2. **Meuxwan** Tim **koei* sue rod
Yesterday Tim **PERF*_{remote past} buy car
 *‘Yesterday, Tim purchased a car.’

Hence, unlike Indo-European Tense inflections and auxiliaries which are grammatical, *koei* is lexical. Critically, this does not hold true for all aspectual adverbs in Thai. In terms of the theory of Boye and Harder (2012), we argue that *jaa*, an adverb for future reference which is comparable in meaning to English *will*, is grammatical: it cannot be focalized and cannot be modified. Temporal adverbs, however, are, in Boye and Harder’s (2012) theory, lexical items. This lexical-grammatical distinction of Thai aspectual adverbs and temporal adverbs is an interesting topic for ERP experiment that becomes a crucial point in Chapter 4.

1.4 METHODOLOGICAL BACKGROUND

1.4.1 Behavioral Studies

In this dissertation, both offline and online methodologies were used to tackle the issues of agrammatism and time reference. Chapters 2 and 3 report on behavioral studies with offline tasks. Agrammatic and NBD speakers were asked to respond to questions and describe pictures in a semi-standardized interview session (Chapter 2) and to participate in a sentence production task and an auditory sentence-to-picture matching comprehension task (Chapter 3). In the last experimental chapter (Chapter 4), an online electrophysiological method was employed. Participants’ linguistic performance was measured in real-time by the use of event-related potentials (ERPs).

1.4.2 Event-Related Potentials (ERPs)

Electroencephalography (EEG) is a noninvasive means of measuring brain functioning that records neural electrical activity. By placing electrodes on the scalp, amplifying the signal, and plotting the changes in voltage over a period of time, Hans Berger, in 1924, was able to measure the electrical activity of the human brain, inventing EEG. Although EEG is useful, it is difficult to apply it to isolate individual neurocognitive processes. Later, in 1935, Pauline and Hallowell Davis developed event-related potential (ERP) methodology to extract the processing of a particular event, by averaging across multiple trials and cancelling out unrelated brain processes which cause ‘noise’ in the signal (see Luck, 2005, for more detail). Hence, when small potential changes in the EEG signal are recorded

immediately after the presentation of a sensory stimulus (e.g., in our case, linguistic stimuli in a reading task), we can record specific brain responses (ERPs) to this specific sensory event (Luck, 2005).

Because of the precise temporal resolution of electrophysiological recordings, the ERP technique has proven valuable for tapping into linguistic processes. The current dissertation, thus, used an ERP-paradigm to investigate the processing of time reference by exploring the nature of temporal violations in Thai. Critically, when an aspectual adverb and a temporal adverb do not coincide, a temporal violation occurs. The questions this raises thus are: What are the responses in the human brain to such a sentence? Is there a difference in the way different types of temporal markers (i.e., verb inflection, temporal adverbs, and aspectual markers) are processed? How does the distinction between lexical and grammatical function play a role in the way the human brain computes language? These questions are addressed in Chapter 4.

1.5 THESIS OUTLINE AND RESEARCH QUESTIONS

It has been illustrated that Thai is structurally and morphologically different from English and other Indo-European languages. Unlike in English where verbs are inflected to refer to the time frame of the event, in Thai, no such a morphological process is required. As noted, agrammatic speech has been characterized by slow, effortful speech with short utterances, lacking grammatical morphemes. Suffixes and affixes are often omitted and substituted (Goodglass & Kaplan, 1972); content words are spared (but see Chapter 2 on the use of verbs). In this thesis, I first identify the features of Thai agrammatic speech in Chapter 2, where other relevant characteristics of Thai are also outlined. The agrammatic speakers who participated in the study described in Chapter 2 then took part in the experimental studies, both production and comprehension, on time reference in Chapter 3. The topic of time reference re-emerges in Chapter 4 using ERPs.

The main research questions posed in the three experimental chapters are;

1. How can we characterize agrammatic speech in a language that has no grammatical morphology, like Thai? (Chapter 2)
2. Are specific features of Thai (serial verb constructions and politeness particles) impaired in Thai agrammatic speech? (Chapter 2)

3. What are the patterns of production and comprehension of time reference in agrammatic speakers of Thai, a language that does not use verb inflection but instead uses aspectual markers to refer to time? (Chapter 3)
4. How is temporal information processed by non-brain-damaged speakers in a tenseless language, Thai, when there is a mismatch between the time reference of two temporal markers, namely, aspectual adverbs and temporal lexical adverbs? (Chapter 4)

Finally, in Chapter 5, the results of all the experimental chapters are tied together and discussed, and all of the research questions will be answered.

2

Characteristics of Thai Agrammatic Speech³

3 This chapter has been adapted from: Siriboonpipattana, W., Nickels, L. & Bastiaanse, R. (in review). Characteristics of Thai Agrammatic Speech. *Aphasiology*.

ABSTRACT

Background: Agrammatic speech is characterized by reduced speech rate, reduced utterance length and lack of grammatical complexity, with grammatical morphemes often omitted or substituted. At the word level, verbs have been argued to be particularly vulnerable: agrammatic speakers produce fewer verbs or use a less diverse range of verbs than unimpaired speakers and the use of finite verbs is compromised. However, this description is based on agrammatic narrative speech from languages that express Tense, Aspect and Agreement through verb inflection. To date, a few studies have described narrative speech in a language without verb inflection (e.g., Standard Indonesian). Thai is another language that does not use verb inflection but uses constructions with serial verbs. Another typical feature of Thai, which has not been investigated in agrammatic speakers, is the use of particles to express politeness, although agrammatic speakers of Standard Indonesian have an impaired use of (different) particles but produce the passive construction (which is a way to express politeness) to a normal extent.

Aim: The current study aimed to characterize Thai agrammatic speech and to analyse the use of verbs and polite particles.

Methods: Nine Thai agrammatic and nine non-brain-damaged (NBD) speakers participated in the study. Narrative speech was elicited in a semi-standardized interview and by picture description. First, the presence of general features of agrammatic speech was investigated in Thai: reduced speech rate and utterance length, and lack of grammatical complexity. This was followed by an in-depth analysis of verb and particle production.

Results: As in other languages, Thai agrammatic speakers talked slowly and with short utterances. However, the use of embedded sentences was normal. They produced fewer verbs, more specifically, their production of the serial verb construction was seriously impaired. Remarkably, the use of polite particles was spared, in fact, the agrammatic speakers produced more of these particles than the NBD speakers, although this may have been influenced by the context.

Conclusions: Thai agrammatic speech resembles that of other languages in terms of speech rate and utterance length. Interestingly, the specific features of Thai that were investigated, serial verbs and polite particles, both showed different patterns to normal, and merit further investigation in the future.

2.1 INTRODUCTION

Agrammatic speech is typical in people with Broca's aphasia and is traditionally characterized by nonfluent speech output, with relatively well-preserved comprehension of single words. Research has shown that, relative to non-brain-damaged (NBD) speakers, individuals with agrammatic aphasia produce slow, effortful speech, with simplified grammar. In other words, there is a reduction in the number of words uttered per minute, and complex sentences, such as embeddings and passives, are rarely used (e.g., Saffran et al. (1989), and Thompson et al. (2010) for English; Bastiaanse and Jonkers (1998) for Dutch; Arslan et al. (2016) for Turkish; and Abuom and Bastiaanse (2012) for Swahili-English; but see Anjarningsih et al. (2012) for passives in agrammatic speakers of Standard Indonesian). Connected speech of agrammatic speakers with aphasia consists mainly of content words such as nouns, verbs, and adjectives, whereas function words and grammatical morphemes are often omitted and / or substituted for (Goodglass and Kaplan, 1972).

As noted by Arslan et al. (2016), the narrative and spontaneous speech of individuals with agrammatic aphasia has been examined across languages for several decades. Menn and Obler (1990) published a cross-linguistic source book of agrammatic speech in many different languages, including English, German, French, Italian, Finnish, Chinese and Hebrew. In depth investigations of agrammatic speech in a variety of languages have also been performed (e.g., Italian: Miceli et al., 1989; Dutch: Bastiaanse and Jonkers, 1998; English: Saffran et al., 1989, and Thompson et al., 2010; Turkish: Arslan et al., 2016; Swahili-English bilinguals: Abuom and Bastiaanse, 2012).

However, whilst this previous research has contributed substantially to our understanding of how agrammatic speech manifests itself across a variety of languages, the focus was predominantly on Indo-European languages, with a relative lack of characterization of languages that have different grammatical features; in particular, Asian languages (but see, Packard, 1993 for Chinese; and Anjarningsih et al., 2012 for Standard Indonesian). The current study explored narrative speech of Thai speakers with agrammatic aphasia.

2.1.1 Some Relevant Characteristics of Thai

In this paper, 'Thai' refers to Standard Thai, the official language and language of instruction in government schools and official locations in Thailand. Thai is a language with a fixed Subject-Verb-Object (SVO) word order (Sudmuk, 2003). It is an isolating or an 'analytical' language, a language that primarily uses specific words (i.e., free-standing

morphemes) rather than inflections, to convey grammatical relations in sentences (e.g., Thiengburanathum, 2013). Unlike English or other Indo-European languages that have a combination of grammatical morphemes that can stand alone (such as articles) and those that are bound (inflectional affixes), Thai uses only free-standing morphemes.⁴ For example, while in English plurality on nouns is indicated by the use of affixes *-s/* (e.g., cat—cats), *-z/* (e.g., dog—dogs) or *-Iz/* (e.g., bus—buses), Thai uses additional words *yer*: ‘lot’, as illustrated in (1-2).

- (1) chan sue nungsue
 I buy book
 ‘I buy a book.’
- (2) chan sue nungsue yer
 I buy book lot
 ‘I buy (a lot of) books.’

In general, pronouns in Thai are optional and omissible (pro-drop). Noun phrases, and other phrases, can also be omitted when the meaning is clear from the context and when they are not the focus. If the question is *khun pai nhai ma?*: ‘Where have you been?’, the answer could simply be *sue nungsue*: ‘buy book’, dropping the personal subject pronoun ‘I’. Note that in this case, ‘book’ cannot be dropped as ‘buy’ is a transitive verb that requires an object to complete a sentence. However, when responding to the question *Suda pai ha krai lung lerk ngan?*: ‘Who does Suda meet after work?’, from the complete sentence in (3), below, the subject *Suda*, the string of verbs *dern pai ha*: ‘walk to see’, and the prepositional phrase *lung lerk ngan*: ‘after finishing work’ are omissible, leaving solely the word *mhor*: ‘doctor’. The dropped elements are pragmatically inferable from the preceding question, which emphasized ‘who’, a human direct object of the sentence.

- (3) Suda dern pai ha mhor lung lerk ngan
 Suda walk go see doctor after finish work
 ‘Suda walks to go and see the doctor after finishing work.’

2.1.1.1 Serial Verb Constructions

As illustrated by the underlined words in (3), in Thai, a sequence of verbs can be produced consecutively, syntactically as a verb phrase (VP) that is recursed over another VP

4 This excludes loan words.

(Muansuwan, 2002). This linguistic feature is known as ‘serial verb construction’ and indicates that more than one verb can be juxtaposed in a single clause with no overt conjunction between the verbs (Chuwicha, 1993; Muansuwan, 2002). This phenomenon occurs in many languages, but the number of verbs expressed by serial verb constructions differs from language to language (Foley, 2008). No studies have examined the mean / range of the number of verbs per clause / sentence for serial verb constructions in Thai. Many studies have proposed that when there is more than one verb, then that clause / sentence is verb-serialized (Chuwicha, 1993; Muansuwan, 2002; Sudmuk, 2005; Takahashi, 2009; Thepkanjana, 1986; Wilawan, 1993).

Further, although verb serializations have been widely discussed in the Thai linguistic literature, there is no consensus as to how many types of serial verb constructions there are. While Thepkanjana (1986) classified serial verbs in Thai into seven categories according to the functions of serial verbs, Wilawan (1993) grouped them into two major groups based on the syntactic properties of the first verb in the series. Sudmuk (2005), however, divided the serial verb constructions into eight types “with respect to the restriction of the limited set of verbs that occur in the series.” (p. 9). Although the classification of verb series is controversial, these serialized verbs have common features: according to Takahashi (2009), they “designate a certain substantial event or situation (action, process, change, state, and so on) and share at least one nominal argument, which may or may not be explicitly expressed.” (p. 215)

2.1.1.2 Time Reference

Since Thai does not have inflected verbs, time reference to completed, ongoing and future events is achieved through so-called ‘aspectual adverbs’ (see 4-6). Aspect can be classified as imperfective and perfective. Imperfective aspect indicates that an event is ongoing, and perfective aspect denotes that an event has been finished and is completed. In (4-6), underlined words are aspectual adverbs; italicized words are temporal lexical adverbs.

- (4) *meuxwan* ter du teevee leaw
 yesterday she watch television PERF
 ‘Yesterday, she watched television.’

- (5) *tonnee* ter kamlang du teevee
 now she IMPERF / PROG watch television
 ‘Now, she is watching television.’

- (6) *prungnee* *ter* *jaa* *du* *teevee*
 tomorrow *she* IMPERF *watch* *television*
 ‘Tomorrow, she will watch television.’

Aspectual adverbs are optional and can be omitted when the time frame of the event is clear from the context. In the above examples, the time frame is set by the temporal lexical adverb, so *leaw*, *kamlang* and *jaa* can be left out; however, when they are realized, the sentence is equally grammatical and pragmatically acceptable. The same applies for temporal lexical adverbs. Hence, (*ter*) *du teevee*: ‘(she) watch television’ can be used in response to any of these questions: ‘What is she doing now?’, ‘What did she do yesterday?’, and ‘What will she do tomorrow?’ as the time frame can be inferred from the leading questions.

2.1.1.3 Polite Particles

Particles are lexically meaningful free morphemes added to the end of a clause or a sentence. While English and other Indo-European languages use intonation and prosody to express certain aspects of the meaning of a sentence (e.g., by varying the tone of the voice, the meaning of ‘Come here’ can be changed from a mild entreaty to an authoritative command), Thai uses particles to change the mood of a clause or a sentence: making it softer, more polite, more commanding, or more sarcastic. Here the focus is on particles to express politeness. These particles are the most common particles in Thai and the ones most relevant for the current study. *Khrap* is used by male speakers as in (7), and *kha* is used by female speakers, as in (8).

- (7) *Nguang* *mhai* *khrap?*
 sleepy *right* PART
 ‘Are you sleepy? (uttered politely by a male speaker)’

- (8) *Nguang* *mak* *kha*
 sleepy *very* PART
 ‘Very sleepy (uttered politely by a female speaker)’

According to Prasithrathsint (2001), polite particles are discourse markers that operate at a pragmatic level where they are used to mark politeness in interpersonal communication. They also connote the social status and the gender of the speaker (Prasithrathsint, 2001) and indicate turn-taking (Prasithrathsint, 2001). Bhamoraput (1972) noted that these polite particles are most likely to be used when the social status of the speaker is lower

than that of the addressee (i.e., by those who are inferior, junior, or non-intimate equals), to indicate deference and respect that the speaker wants to show to the addressee. They are also reported to be non-essential elements and do not play a role at the sentence level (Prasithrathsint, 2001).

2.1.2 Aphasiological Background

2.1.2.1 Verbs, Verb Inflection and Time Reference in Agrammatic Speech

Although agrammatic speech is generally characterized by its impoverished grammar, the idea that it consists mainly of content words (see, e.g., Goodglass and Kaplan, 1972) has lately been shown to be only partially correct. For instance, verbs (which are content words) and verb inflections have been reported to be particularly vulnerable (Bastiaanse & Jonkers, 1998; Bastiaanse et al., 2002; Kolk & Heeschen, 1992; Miceli et al., 1989; Saffran et al., 1989; Thompson et al., 2010): in languages that use grammatical morphemes for verb inflections, such as in English (and other Indo-European languages), grammatical morphemes such as the third person singular and past tense endings of verbs are less frequently observed in agrammatic speech than in speech of NBDs.

Many researchers have noted that production of lexical verbs in agrammatic speech is more affected than the production of nouns (Bastiaanse & Jonkers, 1998; Saffran et al., 1989; Thompson et al., 1995). According to Thompson et al. (1995), agrammatic speakers tend to produce verbs that do not have an internal argument (e.g., *to sleep*), or have just one (e.g., *to like [something or someone]*): the more complex the argument structure of the verb, the harder it is for the agrammatic individuals to produce that verb. This has been confirmed for Dutch (Bastiaanse & Jonkers, 1998).

However, some researchers have related the poor production of lexical verbs to the requirement to inflect verbs for tense and agreement. Bastiaanse and Jonkers (1998) investigated a group of Dutch agrammatic speakers and found that verb retrieval and verb inflection had an inverse relationship in this population. In other words, agrammatic speakers who had relatively high verb diversity (i.e., verb retrieval) had poor verb inflection, and those with relatively good verb inflection had reduced verb diversity. This tradeoff was confirmed for Italian (Rossi & Bastiaanse, 2008), and partially confirmed for Turkish (only for direct evidentials; see Arslan et al., 2016) and Swahili-English bilingual agrammatic speakers (Abuom & Bastiaanse, 2012). The overall conclusion from these studies is that it is difficult for agrammatic speakers to both retrieve the name of an event (e.g., verb) and inflect it for tense and agreement.

The question is what happens in languages that have no verb inflection but use aspectual adverbs - grammatical morphemes that are free-standing and optional rather than bound and obligatory. According to Packard (1993), free-standing grammatical morphemes are vulnerable in Mandarin agrammatic speech: they tend to be omitted. This was also shown for Standard Indonesian (Anjarningsih & Bastiaanse, 2011).

Building on this, the linguistic feature Tense, which is used to express event time (past—an event that has taken place; present—an event that is taking place; and future—an event that will take place) seems to be particularly susceptible to impairment. In other words, the semantic notion of time reference, which has to be expressed by grammatical morphology (i.e., the operation that inflects verbs for tense), is affected in agrammatic aphasia (Bastiaanse, 2008; Bastiaanse et al., 2011; Burchert et al., 2005; Clahsen & Ali, 2009; Farqi-Shah & Dickey, 2009; Lee et al., 2008; Wenzlaff & Clahsen, 2004). Stavrakaki and Kouvava (2003), however, found that, aside from tense, aspect was also vulnerable in agrammatism (see also, Nanousi et al., 2006 for Greek). Aspect is different from tense. *Tense* provides information regarding *when* a situation occurs: it sets the time frame of an event (past, present, future), and refers to the location of an event in time (Comrie, 1985). *Aspect* concerns “the internal structure of events, relating a current state with the onset or the end of the state” (Lee, 2008, p. 340). It is used to describe *how* an event is viewed: whether the event is finished (perfect) or still ongoing (imperfect).

Hence, broadly speaking, aspectual adverbs—which are also used to specify the time frame of an event in some languages and are comparable to tense inflection—may also be affected in agrammatic aphasia. In other words, the tradeoff between verb retrieval and inflecting the verb for different time frames, reported by Bastiaanse and Jonkers (1998), is expected for languages that use aspect for time reference. Anjarningsih and Bastiaanse (2011) investigated this in Standard Indonesian, a language that uses aspectual adverbs to situate an event in time. As predicted, an inverse relationship was found between verb retrieval and aspectual adverbs: agrammatic speakers who produced a relatively high diversity of lexical verbs used relatively few aspectual adverbs and *vice versa*.

2.1.2.2 Serial Verb Constructions

Serial verb constructions have not been studied before in agrammatic aphasia. However, Arslan et al. (2016) showed that agrammatic speakers of Turkish—a language that allows multiple verbs in an utterance—NBD speakers produced almost twice as many verbs per utterance than the agrammatic speakers.

2.1.2.3 Particles

Anjarningsih et al. (2012) is the only study that, to our knowledge, has investigated particle production in agrammatic narrative speech. They reported that Standard Indonesian agrammatic speakers produced a low proportion of particles. However, Standard Indonesian particles are different from those in Thai: Standard Indonesian particles function like prepositions and are grammatical words (Anjarningsih et al., 2012), In Thai, particles are used to express politeness, mood, enforcement and are, thus, lexical and pragmatic in nature (McCready, 2014).

Boye & Harder (2012) argued that words and word classes are not necessarily either grammatical or lexical. For example, in English the verb *to have* can have a grammatical function as an auxiliary (*John has written a book*), or a lexical function (*John has a book*). Boye and Bastiaanse (2018) showed that in agrammatic spontaneous speech, the auxiliary *to have* is used less than in typical narrative speech, whereas *to have* with a lexical function is used to a normal extent. A similar difference seems to exist for Standard Indonesian and Thai particles: those in Standard Indonesian have a grammatical function, whereas Thai particles have a lexical function. This may predict that agrammatic speakers of Thai will be relatively less impaired in the production of particles than agrammatic speakers of Standard Indonesian.

2.1.3 The Current Study

The current study aimed to identify the characteristics of Thai agrammatic speech and how they relate to those of other languages. First, we examined whether a group of Thai speakers with aphasia showed the general features of agrammatic speech. We predicted reduced speech rate and utterance length, fewer grammatical sentences that are less complex (i.e. fewer embedded sentences), as has been observed in a wide range of languages. In combination with relatively good comprehension of single words, this confirms a diagnosis of Broca's aphasia / agrammatism.

Second, we focused on some typical grammatical characteristics of Thai. As noted above, verb production in agrammatic aphasia is impaired and this has been related to the need to inflect verbs for agreement and tense (Bastiaanse & Jonkers, 1998 among others). This is interesting in relation to Thai, because of the lack of inflectional morphology for verbs. Therefore, we also explored the relation between verb production and the production of time reference morphology. Previous research has shown that agrammatic speakers have difficulty in retrieving the name of an event (the verb) and indicating the time frame in

which the event happened (inflection for tense and aspect or the use of aspectual adverbs; Bastiaanse & Jonkers, 1998; Rossi & Bastiaanse, 2008; Anjarningsih & Bastiaanse, 2011). Therefore, a tradeoff between verb retrieval and aspectual adverb production in Thai is expected. That is, agrammatic speakers who have relatively good verb production will have relatively poor production of aspectual adverbs and vice versa. Serial verb constructions are also typical for Thai. Given the findings in Turkish (see above; Arslan et al., 2016), the number of verbs per utterance is expected to be decreased in Thai agrammatic speech.

As mentioned above, the production of particles in Standard Indonesian agrammatic speakers was reduced (Anjarningsih et al., 2012). It was argued that particles in Standard Indonesian have a grammatical function. In Thai, however, politeness particles, the most frequently used type of particle, have a lexical / pragmatic function. Therefore, we predict that the production of polite particle in Thai will be spared in agrammatic speakers.

2.2 METHODS

2.2.1 Participants

Nine individuals with non-fluent aphasia (5 males, aged 26-83 years, mean 53.89 years) and nine NBD speakers (5 males, aged 23-78 years, mean 52.67 years) matched for age, gender, handedness, and education participated in the study. All participants were native speakers of Thai and right-handed. The agrammatic speakers were recruited from the Department of Communication Sciences and Disorders, Faculty of Medicine, 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 one participant (A2) who had suffered traumatic brain injury (his performance pattern did not deviate from that of the stroke patients). No further details of the lesion localization were available for the agrammatic speakers, as it was not possible to obtain the scans from the previous hospital from which the participants were transferred.

The participants with aphasia were all identified as having a profile consistent with agrammatic aphasia by a speech therapist at Ramathibodi Hospital and a neurolinguist. Their speech was non-fluent and effortful; articulation was relatively spared: all aphasic speakers were intelligible. Further, the auditory word comprehension subtest of the Thai version of the Boston Diagnostic Aphasia Examination (BDAE; Goodglass & Kaplan, 1972) adapted to Thai was administered and revealed that their comprehension of single

Table 2.1 Demographic data for the agrammatic (A1-A9) and non-brain-damaged (N1-N9) speakers.

	age (years)	gender	years of education	years post-onset	% correct auditory comprehension
A1	26	m	19	3	100
A2	50	f	21	5	100
A3	60	f	19	3	97.58
A4	30	m	19	3	100
A5	59	m	19	2	100
A6	55	f	19	1	95.16
A7	73	m	15	4	100
A8	49	f	15	3	93.55
A9	83	m	15	5	97.60
mean	53.89	--	17.89	3.22	98.21
N1	23	m	19	-	100
N2	50	f	15	-	100
N3	58	f	19	-	100
N4	29	m	19	-	100
N5	58	m	19	-	100
N6	54	f	21	-	100
N7	69	m	15	-	100
N8	55	f	19	-	100
N9	78	m	15	-	100
mean	52.67	--	17.89	--	100
range	23-78	--	15-21	--	100

Note: m = male; f = female.

words (nouns, verbs, colors, shapes, letters, and numbers) was relatively spared, thus their language characteristics matched the profile of Broca's aphasia. The demographic details of the participants and their BDAE scores are displayed in Table 2.1.

Each participant gave informed consent following the Declaration of Helsinki under the procedure approved by the Committee of Human Rights Related to Research Involving Human Subjects, Faculty of Medicine, Ramathibodi Hospital, Mahidol University (MURA2018/34). They were financially compensated the equivalent of 15 Euro for their participation. All data are available and are provided in Tables 2.1-2.5.

2.2.2 Materials & Procedure

We explored naturalistic speech production elicited by means of picture description and a spontaneous speech interview. Following Olness' (2006) method for elicitation of narrative speech, participants were instructed to describe a black and white picture of a Thai rural scene provided and used standardly by the Ramathibodi Hospital⁵. The commonly-used 'cookie theft' picture (Goodglass & Kaplan, 1972) was not culturally or linguistically appropriate for Thai individuals. For spontaneous speech, a semi-standardized interview was conducted asking for information about the past (illness), present (hobby / family), and future (plans). There were two questions in each category. Question (i) was always raised first. If further prompting was required, the participants were asked question (ii). These questions were adjusted from Abuom and Bastiaanse (2012) and Anjarningsih et al. (2012), among others. The questions were;

- a. *Picture description:*
 - i. Can you tell me what is happening in this picture? / Can you create a story with a beginning, a middle and an end about what happened in the picture?
- b. *Reference to the past:*
 - i. Can you tell me about how your speech problems started (agrammatic speakers) / about your last illness (for NBD speakers)?
 - ii. Can you tell me about what happened when you had your stroke (agrammatic speakers) / about your last illness (for NBD speakers)?
- c. *Reference to the present:*
 - i. Can you tell me how you spend your free time?
 - ii. Can you tell me something about your family?

⁵ The picture illustrates children playing in a field, and adults doing agricultural work.

d. *Reference to the future:*

- i. Can you tell me what will you do next?
- ii. Can you tell me what your plan is after this hospital visit?

For participants with aphasia, the samples were obtained in a quiet room at the Department of Communication Sciences and Disorders, Faculty of Medicine, Ramathibodi Hospital, Mahidol University. The first author administered the experiment in the presence of a speech therapist. For NBD participants, the samples were obtained by phone. In both cases, the entire session was audio-recorded and orthographically transcribed by the first author.

2.2.3 Data Analysis

Although a sample size of 300 words is generally considered to be reliable for spontaneous speech analysis for languages such as English, Italian, and Dutch (Brookshire & Nicholas, 1994), for a language such as Thai that does not have articles and drops many elements, such as subject and object pronouns and aspectual adverbs, a sample size of 200 words is comparable and appropriate (Arslan et al., 2016; Abuom & Bastiaanse, 2012). The 200-word samples were extracted with an equal balance from the picture description and the three questions with reference to the past, present, and future.

The author segmented the speech samples into utterances. Another Thai native speaker with a background in Thai linguistics checked the transcription and the segmentation into utterances for accuracy. An utterance was defined as a unit that expresses a proposition, and / or includes a predicate and an explicit or implied subject. Disagreements between the two judges on the transcription or the analysis of an utterance were discussed and resolved by consensus.

To answer the first research question, we first analyzed *general characteristics* of agrammatic speech that have been found to be reduced in studies of other languages, to ensure that the non-fluent speech was truly agrammatic. This, in combination with the high scores on the BDAE test for auditory word comprehension (see Table 2.1), supported the diagnosis of agrammatic Broca's aphasia. For this, the following grammatical variables were analyzed:

- *Mean length of utterances (MLU)*: the number of words per utterance
- *Speech rate*: words per minute
- *Grammaticality*: percentage of grammatical sentences
- *Embedded sentences*: percentage of utterances that include at least one embedding

The second research question addressed the *production of lexical verbs* and *time reference* elements. The following variables were used:

- *Number and diversity of verbs*: the number of lexical verbs and the number of different verbs were tallied. Thai does not distinguish between non-finite and finite verbs as all verbs are free-standing morphemes.
- *Serial Verbs*: the mean number of verbs per utterance for every utterance that contained at least one verb (Mean number of Verbs per Utterance: MVU).⁶
- *Number of aspectual adverbs*: aspectual adverbs used to mark the temporal location of the event with respect to the past, present, and future were counted.

The final research question was related to the production of *particles*. For this, the following variable were used:

- *Polite particles*: percentage of utterances with a polite particle.

2.2.4 Statistical Analysis

For comparison between the agrammatic and NBD speakers, we examined performance both at the group and at the individual level. Since the groups were small, for the between-group comparisons, we used the non-parametric Mann-Whitney U (MWU) test, with a significance level set at $p = .05$. The individual scores of the agrammatic speakers were compared to the range of the NBDs for each variable. If all agrammatic speakers fell outside the normal range, there was considered to be strong evidence that a variable was affected by agrammatism.

2.3 RESULTS

2.3.1 General Characteristics of Agrammatic Features

In Table 2.2, the results of the grammatical analysis are given. The MLU of the agrammatic speakers was lower than that of NBDs (MWU: $z = -3.510$, $p < 0.001$). All agrammatic speakers scored outside the range of the NBDs. In addition, the agrammatic speakers produced significantly fewer words per minute than the NBD speakers (MWU: $z = -3.582$, $p < 0.001$). Again, all agrammatic speakers scored outside the normal range. In sum, the agrammatic speakers produced utterances that were half as long and took double the time to produce compared to the NBD individuals.

⁶ Note that all utterances that contained more than one verb were serial verb constructions.

The percentage of grammatical sentences produced by the agrammatic speakers was also lower than that of the NBD (MWU: $z = -3.136$, $p < .0001$) and all agrammatic speakers were outside the range of the NBDs, except A2. There was no difference in the percentage of embedded sentences between the two groups (MWU: $z = -1.572$, $p = 0.136$), with many of the NBD and agrammatic speakers not producing any embedded sentences at all.

2.3.2 Verb Production

The production of verbs, and variables for serial verbs for both groups of participants are shown in Table 2.3. The analysis of verb production showed that, as a group, agrammatic speakers produced significantly fewer verbs than NBD speakers⁷ (Verb tokens: MWU: $z = -2.474$, $p = 0.011$). All but A1 and A6 scored within the normal range. In regards to verb diversity, there was no difference between the agrammatic and the NBD speakers (Verb types: MWU: $z = -1.197$, $p = 0.258$). Most of the agrammatic speakers scored within the normal range. Together this means that, overall, the agrammatic speakers produced fewer verbs, but the amount of information they provided with the few verbs they produced was similar to that of the NBDs.

2.3.3 Aspectual Adverbs

Table 2.4 shows the production of aspectual adverbs by both groups. The number of aspectual adverbs produced by the NBD speakers was unexpectedly low; the same was true for the agrammatic speakers. Given the number of NBD speakers (and agrammatic speakers) who did not produce any aspectual adverbs, we did not perform statistics.

2.3.4 Serial Verbs

Table 2.3 gives the data for the serial verbs. The agrammatic speakers produced significantly fewer verbs per utterance compared to the NBD speakers (MWU: $z = -3.532$, $p < 0.001$). All agrammatic speakers scored above the normal range.

2.3.5 Particles

The production of polite particles is given in Table 2.5. Interestingly, the agrammatic speakers produced more significantly polite particles than the NBDs, (MWU: $z = -2.870$,

⁷ Since the total number of verbs is different between the groups, calculation of the Type Token Ratio is not justified, unlike our practice in other studies (see, e.g. Bastiaanse & Jonkers 1998; Abuom & Bastiaanse, 2012).

$p = 0.004$), and also have a higher percentage of utterances with polite particles (MWU: $z = 1.98$, $p = 0.047$). Numerically, all but two (A3; A4) agrammatic speakers produced more polite particles than any of the NBDs, and two (A2; A6) produced a higher proportion of utterances with polite particles.

2.4 DISCUSSION

The current study aimed to identify the features of narrative and spontaneous speech in Thai agrammatic speakers by addressing three points: the general characteristics of Thai agrammatism; the use of verbs and aspectual adverbs for time reference; and the use of particles. The three topics will be discussed below.

2.4.1 General Characteristics of Thai Agrammatism

Our data show that the basic characteristics of Thai agrammatic speech do indeed resemble the general features of agrammatic profiles in other languages, including, for example English (Saffran et al., 1989; Thompson et al., 2010); Dutch (Bastiaanse & Jonkers, 1998); Turkish (Arslan et al., 2016); and Standard Indonesian (Anjarningsih et al., 2012). As in these languages, the Thai agrammatic speakers studied here produced shorter utterances than the NBD speakers. Their speech was also slow compared to the NBD speakers. Most of their utterances described a simple event with, for instance, an agent performing a single action (e.g. *haa mhor*: lit. ‘(I) see doctor’), or a feeling that was experienced (e.g. *mun jeb*: lit. ‘it hurt’).⁸ While, overall, the ability to produce grammatical sentences was impaired in the agrammatic speakers, the percentage of grammatical sentences in one participant (A2) was very high. However, many of the sentences A2 produced were short and simple; her relatively long MLU was due to the fact that she added a polite particle to almost every utterance (in more than 90% of the cases).

8 Recall that Thai is a pro-drop language; in this case, the personal subject pronoun *chan*: ‘I’ was dropped, which is entirely acceptable.

Table 2.2 The individual and group results for the grammatical variables.

	MLU	speech rate (wpm)	% grammatical sentences	% embedded sentences
A1	3.39	38	66.67	0
A2	4.49	47	92.31	2.56
A3	5.06	47	71.88	6.25
A4	5.18	61	39.39	0
A5	4.74	39	47.06	0
A6	3.78	44	55.56	0
A7	4.62	32	69.23	2.56
A8	5.34	62	68.42	5.26
A9	4.37	44	55.26	0
mean	4.55	46	62.86	1.85
N1	8.9	116	80.00	5.00
N2	9.37	81	94.74	26.32
N3	5.63	121	87.5	3.13
N4	10.47	130	94.74	10.53
N5	10.39	125	100.00	27.78
N6	11.17	96	88.89	11.11
N7	9.58	81	89.47	0
N8	6.25	94	90.63	0
N9	7.9	89	96.00	0
mean	8.85	103.67	91.33	9.32
range	5.63-11.17	81-130	80-100	0-27.78

Note: **bold**: outside the range of the NBD speakers.

Table 2.3 Individual and group results for the production of verb types, verb token and the mean number of verbs per utterance that contain a verb.

	verb tokens	verb type	mean number of verbs per utterance
A1	22	14	1.38
A2	47	27	1.57
A3	37	16	1.48
A4	48	30	1.78
A5	39	21	1.86
A6	34	26	1.42
A7	44	28	1.33
A8	49	18	1.44
A9	51	17	1.82
mean	41.22	21.89	1.56
N1	56	24	2.95
N2	62	21	3.26
N3	55	21	1.90
N4	36	20	2.00
N5	57	33	3.17
N6	42	25	2.33
N7	59	27	3.11
N8	75	35	2.50
N9	51	27	2.22
mean	54.78	25.89	2.60
range	36-75	20-35	1.90-3.26

Note: **bold**: outside the range of the NBD speakers.

Table 2.4 The individual and group results of the numbers of aspectual adverbs used by the agrammatic speakers and the NBD speakers.

	aspectual adverbs			
	past	present	future	total
A1	0	0	0	0
A2	4	3	0	7
A3	1	7	0	8
A4	2	4	3	9
A5	2	0	3	5
A6	0	0	0	0
A7	0	4	0	4
A8	0	1	1	2
A8	0	3	0	3
mean	1	2.44	0.78	4.22
N1	0	0	0	0
N2	1	6	0	7
N3	0	2	0	2
N4	0	0	0	0
N5	2	0	0	2
N6	3	0	2	5
N7	2	2	0	4
N8	2	0	3	5
N9	0	4	0	4
mean	1.11	1.56	0.56	3.22
range	0-3	0-6	0-3	0-7

Table 2.5 The number of polite particles and the percentage of polite particles per utterance produced by the agrammatic and NBD speakers.

	# polite particles	% polite particles per utterance
A1	10	27.78
A2	36	92.31
A3	6	18.75
A4	2	6.06
A5	10	29.41
A6	20	55.56
A7	11	28.21
A8	19	50
A9	11	28.95
mean	13.89	37.45
N1	3	15
N2	2	10.53
N3	5	15.63
N4	8	42.11
N5	0	0
N6	9	50
N7	0	0
N8	1	3.13
N9	5	20
mean	3.67	17.38
range	0-9	0-50

Note: **bold**: outside the range of the NBD speakers.

In terms of sentence complexity, again, we saw evidence of grammatical impairment in the group of agrammatic speakers. Five of the nine did not produce one single embedding. However, some of the NBDs also failed to produce embedded sentences. It is well-known that in some languages, embedded sentences are used less frequently than in others. For example, in the cross-linguistic study of Bastiaanse et al. (1996), the English and Hungarian NBDs used a large number of embedded sentences, whereas many of the Dutch NBDs did not produce any at all. It appears that Thai is like Dutch in this respect: not every healthy speaker uses many embedded sentences.

2.4.2 Production of Verbs and Time Reference

The number of verbs in the agrammatic speakers was lower than that of the NBD speakers. This has been reported for other languages previously (e.g., Saffran et al., 1989; Thompson et al., 1995 for English; Miceli et al., 1989 for Italian). In other languages, such a difference is not found (Bastiaanse & Jonkers, 1998 for Dutch; Abuom & Bastiaanse, 2012 for Swahili and English; Anjarningsih et al., 2012 for Indonesian). Having observed the current data for Thai, it can be seen that only two agrammatic speakers fall outside the normal range, showing that no decisive conclusion on the production of verb tokens can be drawn. However, when the production of serial verbs is considered, the difference in verb use becomes clear: NBD speakers produce more serial verbs than agrammatic speakers. Clearly, there is simplified use of verbs by these Thai agrammatic speakers (we return to this below).

In both groups, the production of aspectual adverbs was very low. It seems that the way the narrative speech was elicited did not evoke explicit use of aspectual adverbs. In this respect, the results diverge from the findings in Standard Indonesian agrammatic speech: Anjarningsih and Bastiaanse (2011), who, when the same questions were used for eliciting spontaneous speech, found a trade-off between the diversity of verbs and aspectual adverbs, which was interpreted as a problem in expressing the name of the event and the time frame in which the event happened (Bastiaanse, 2013). This pattern was not observed in the current Thai data.

However, there is an interesting phenomenon with respect to verb retrieval: the number of verbs was low, not because there are many utterances without a verb (this number was similar in both groups), but rather because the Thai agrammatic speakers appeared to find it hard to express complex events using serial verb constructions. This supports the findings of Arslan et al. (2016) who reported a reduced number of verbs per utterance in Turkish agrammatic speech. Critically, however, unlike in Turkish, verbs in Thai are

complex in that more than one verb can be combined in a single clause. This can be seen in the NBD speakers who produced sentences with as many as three verbs (e.g., *klub pai haa mhor*: lit. ‘return go see doctor’ for ‘I went back there to see a doctor’). In contrast, the agrammatic speakers usually used only one single verb (e.g., *ha mhor*: lit. ‘see doctor’).

Serial verb constructions can be subcategorized into many types (Thepkanjana, 1986; Sudmuk, 2005; Wilawan, 1993), for example, to describe that the events occur simultaneously (e.g., *khao nung kin kao*: lit. ‘he sit eat rice’); to describe the order of an event (e.g., *khao reep dern ma ha chan*: lit. ‘he hurry walk come find me’; or to show how an event is a consequence of the previous action (e.g., *khao leun lom pen prae*: lit ‘he slip fall become wounded’). These constructions are grammatically complex, that is, the verbs have to be used in the right order to express which verb modifies the other. Even though agrammatic speakers seem to be relatively unimpaired in their use of verbs, combining the verbs into a meaningful concatenation is apparently too complex.

2.4.3 Production of Particles

Surprisingly, the agrammatic speakers produced more particles than NBDs. This finding diverges from that of Anjarningsih et al. (2012) who reported an impairment in the production of particles in Standard Indonesian agrammatic speech. However, the Indonesian particles, as argued above, have a grammatical function, whereas Thai particles have a lexical function. According to Boye and Harder (2012), and supported by Boye and Bastiaanse (2018), the same word class can have different functions across languages (e.g., Standard Indonesian and Thai particles) and within languages (as shown by the data from Boye and Bastiaanse (2018) on the grammatical and lexical function of *to have* in Dutch).

Critically, however, the relative increase in polite particles in Thai agrammatic speakers may have been because of social hierarchy. The experimental setting for the agrammatic speakers was at the hospital as part of their follow-up medical appointments. Prior to testing, we asked if they were willing to participate in the semi-standard interview as part of a research project, and that this interview would be conducted by the first author but under the supervision of the participant’s speech therapist. Hierarchy in Thai is important; educated people and clinicians are highly-respected. In this context, the social status of the agrammatic speakers (i.e., patients) is lower than that of the interviewers (i.e., a neurolinguist and a speech therapist), hence, pragmatically, their use of polite particles not only signifies politeness, but also implies that they should converse in a way that is appropriate to their status (Bhamoraput, 1972; Prasithrathsint, 2001). In contrast, the

NBD speakers were of equal (or possibly higher) status than the conversational partner: the first author acted as an interviewer, and the NBD speakers were participating as a favor. In addition, the fact that the interviewer was younger than the majority of the NBD speakers is likely to explain the low number of polite particles (by the NBD speakers). As noted by Bhamoraput (1972), polite particles are less likely used if the speakers are superior to or more senior than the addressee. Interestingly the fact that pragmatic constraints may interfere with grammatical complexity has been reported before: Anjarningsih et al. (2012) and Jap et al. (2016) reported that the passive construction in Standard Indonesian is relatively spared, even though the passive in Standard Indonesian is as complex as that of English. In Standard Indonesian, the passive is a polite form and, thus, production of these constructions is not affected, just like particles in Thai. It is possible that politeness may protect grammar, or at least, agrammatic speakers prefer to obey the politeness rules.

2.5 CLINICAL IMPLICATIONS AND FUTURE DIRECTIONS

The current study focused on the characteristic features of Thai agrammatic speech. We showed that agrammatism in Thai can easily be identified by slow speech with short utterances that are not always grammatical. The data also showed that Thai agrammatic speakers have a problem with verbs, and specifically, they cannot express complex events using serial verbs, which restricts their ability in daily communication. It may be useful to focus on these constructions during therapy, as they are very typical for Thai and often used by non-brain-damaged speakers. Of course, our findings are limited given that we only examined spontaneous speech in a small sample of one type of aphasia, but we hope that this is the beginning of a serious search for the features of language impairment in Thai people with aphasia which in turn will lead to the development of improved diagnostic assessment and directions for treatment.

3

An Investigation of Time Reference in Production and Comprehension in Thai Agrammatic Aphasia³

3 This chapter has been adapted from: Siriboonpipattana, W., Nickels, L., & Bastiaanse, R. (2020). An investigation of time reference in production and comprehension in Thai speakers with agrammatic aphasia. *Aphasiology*, 1–22. <https://doi.org/10.1080/02687038.2020.1781777>

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's 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.

3.1 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 P*ast* D*iscourse* L*inking* 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 (Jonkers & De Bruin, 2009; Yarbey Duman & Bastiaanse, 2009; Abuom & Bastiaanse, 2013). 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?

3.1.1 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 (Supavanich, 1973), others classified it as an intensive 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 intensive 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 3.1), 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, 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).

Table 3.1 Examples of Thai aspectual adverbs (italicized) used in the current study that refer to present, past, and future.

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

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.

3.1.2 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_j*’, ‘*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 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 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 present, discourse linking is not needed because the time of speaking and the time of the event coincide. For 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 3.2 for a summary.

Table 3.2 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

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 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).

However, several studies have reported no significant differences between impairment in reference to the past, present and future (Fyndanis et al., 2012; Fyndanis et al., 2018; 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 past and future relative to present. In comprehension, however, the agrammatic speakers encountered difficulty comprehending future time reference in both Spanish and Catalan. Koukouloti 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, 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).

3.1.3 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 and Bastiaanse, 2013). Consequently, in this study, we examined both modalities.

3.2 MATERIALS AND METHOD

3.2.1 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 experiments⁴, giving a total of 15 participants with

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

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 4 females and 5 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 5 females and 4 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 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 the equivalent of 15EUR for their participation.

3.2.2 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 3.1). For the comprehension test, no action name was printed, and there was no highlighted frame.

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 3.1 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.

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-randomised within a block such that no more than two of the same time frames occurred in succession. See Appendix 3 for the item list.

3.2.3 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 (3 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’.

3.2.4 Procedure

3.2.4.1 Production

Figure 3.2 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.

The procedure was designed in order to ensure that the context necessitated the use of the aspectual marker. Hence, as displayed in Figure 3.2, 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 strongly preferred. To make the setting as realistic as possible, the listener was actively involved in the experiment by noting down the participant's responses.

3.2.4.2 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 array was presented (Figure 3.3). All arrays were displayed once before they were repeated twice more, with the two remaining target sentences / time frames.

Figure 3.3 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)'.

For both tasks, during the 12 practice items, 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 two months. For participants who performed both experiments, the production task

was administered first. Administration took 45-min for production, and 30-min for comprehension.

3.2.5 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 future, ‘*kamlang*’ for present, and ‘*leaw*’ for past. Production errors were classified as substitution, omission, or negation of the aspectual adverb (no other error types occurred).

3.2.6 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).

3.3 RESULTS

3.3.1 Production: Group Analysis

The overall accuracy for production on the TART-LAM is shown in Figure 3.4 (see also Table 3.3).

Figure 3.4 Percentage correct of the TART-LAM production of 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).

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

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

For the group of agrammatic speakers, pairwise analysis revealed no significant difference between present and past conditions, or between past and future (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 $T = 36.00$, $z = -2.552$, $p = .033$).

3.3.2 Production: Individual Analysis

Six of the nine participants showed no significant difference in accuracy across the three conditions (Table 3.3; Cochran's Q test; all Q 's < 4.909 ; all p 's $> .086$). The effect of condition was statistically significant in three participants: SP, SM, and NN. For all three participants, further pairwise analysis was performed. A significant difference between future and past, with future being less accurate than past, was observed in SP and SM. For SP, future was also significantly worse than present. No statistically significant differences were found between present and past for any of the participants, nor were there any significant pairwise differences between any time frame for NN.

3.3.3 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’ 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	<i>jaa</i>	pub	pah
she	<i>FUT</i>	fold	cloth

‘She *will* fold the clothing.’

Response - Negation

ter	<i>yangmai</i>	pub	pah
she	<i>NEG</i>	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 3.3).

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); $T = 13.00$, $z = -1.129$, $p = .777$).

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

Table 3.3 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”.

Participant (n = 9)	Future (20)				Present (20)				Past (20)			Cochrane's Q		McNemar's (2-tailed) ^a		
	Correct	Incorrect			Correct	Incorrect			Correct	Incorrect		Q (2 df)	P	Future & Present	Future & Past	Present & Past
		Subs.	Omis.	Neg.		Subs.	Omis.	Neg.		Subs.	Omis.					
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%	-	-			

Note: 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. *Bonferroni corrected *p*-value reported. Holm-Bonferroni correction provides the same outcome.

'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.

3.3.4 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 were those displayed in Table 3.3. The sole difference in this analysis was the future condition for the agrammatic speakers, where negation errors were recalculated as correct (Figure 3.5).

Figure 3.5 Percentage correct of the TART-LAM production of 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).

Agrammatic speakers remained significantly worse than NBD in all conditions (Mann-Whitney; past $U = 9.000$, $z = -3.170$, $p(1\text{-tailed}) = .004$; present $U = .000$, $z = -3.825$, $p(1\text{-tailed}) < .001$; future $U = .000$, $z = -3.748$, $p(1\text{-tailed}) < .001$). 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 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 reference for SP and SM (both, future 12/20, past 20/20, $p = .024$), SP no longer showed a significant difference between future and present (future 12/20, present 18/20, $p = .327$). NN once again showed no significant differences between conditions.

3.3.5 Comprehension: Group Analysis

Figure 3.6 Percentage correct of the TART-LAM comprehension of future, present, and past of NBD and the agrammatic speakers, with 95% confidence interval.

As can be seen in Figure 3.6 (see also Table 3.4), 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 $U = 18.000$, $z = -2.519$, $p(1\text{-tailed}) = .050$; present $U = 9.000$, $z = -3.174$, $p(1\text{-tailed}) = .004$; future $U = 4.500$, $z = -3.516$, $p(1\text{-tailed}) < .001$).

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

3.3.6 Comprehension: Individual Analysis

At an individual level (Table 3.4), none of the agrammatic speakers showed a significant difference across conditions (all Q 's < 4.571; all p 's < .607). Note that the 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.

Table 3.4 Comprehension: Individual and group performance and statistics of the participants with agrammatic aphasia on the TART-LAM.

	Future (20)	Present (20)	Past (20)	Cochrane's Q	
				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		

3.4 DISCUSSION

3.4.1 Time Reference Deficit in Thai

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 were equally impaired.

The asymmetry between future and present was not predicted. According to Zagana (2013), future is a subtype of present; they are both categorized as non-past. Following Zagana, the PADILIH differentiates between past and non-past (i.e., present and future) and predicts that 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 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 (Koukouliti & 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 Zagana (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 future, they do not (i.e., there is no event available for which such a relationship can be established; Table 3.2). Building on this proposal, Koukouliti 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 present and past. More specifically, 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 future is more impaired than past, with SP also being more impaired on future than on 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.

3.4.2 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 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 uses of 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.

3.5 CONCLUSIONS

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).

4

Time Reference Violation in a *Tenseless* Language: An ERP Study on Thai

ABSTRACT

Background: Languages around the world have different ways to express the time frame of an event. In English, for example, the verb is inflected to refer to the past and present (*she walked; she walks*). In Indo-European languages, when a lexical temporal adverb (e.g., *yesterday, now*) is used, there must be congruency between the time frame of the adverb and the inflection of the verb. If the time frames do not agree (**yesterday I walk*), the sentence is ungrammatical. ERP studies on Indo-European languages show that an ungrammatical verb form in sentences like these elicits a P600, sometimes preceded by a LAN, which is suggested to reflect the processing of temporal disagreement.

Methods: In languages like Thai, verbs are not inflected and an optional free-standing (aspectual) adverb is used to refer to the event time. The current study investigated time reference violations in Thai. Two sentence types were used: (1) sentences with a temporal lexical adverb followed by an incongruent aspectual adverb; (2) sentences with an aspectual adverb followed by an incongruent temporal lexical adverb.

Results: The results showed that both violations elicited an N400, but in the case of an aspectual adverb followed by a temporal lexical adverb, this N400 was followed by a P600.

Conclusions: These results suggested that in Thai, time reference has a stronger lexical-semantic component as reflected in the N400, but that in sentences in which an aspectual adverb is followed by a temporal lexical adverb, sentential (discourse) reanalysis is needed.

4.1 INTRODUCTION

In languages with obligatory Tense marking, optional deictic expressions of time must align semantically with the Tense markers. In English, for instance, an optional temporal adverb such as *yesterday* must align with the temporal meaning expressed by a Tense suffix: *Yesterday, he cooked spaghetti*. The same applies in the case of reference to the present or the future: *Now, he is cooking spaghetti*, and *Tomorrow, he will cook spaghetti*.

**Tomorrow, he cooked spaghetti*, therefore, illustrates a temporal mismatch between the temporal adverb and the verb inflection. Linguistically, this violation can be perceived at the semantic level and repaired at the morphological level (Baggio, 2008). The incongruency between the semantics of *cooked* (which locates an event in the past) and that of the temporal adverb *tomorrow* (which refers to the future) is problematic when processing the sentence. That is, *tomorrow* constrains the set of suffixes that is appropriate for the stem *cook-* in this context. *Tomorrow, he cooked* contains a violation of the semantics set by the temporal adverb *tomorrow* through the use of an improper inflectional morpheme, resulting in a grammatical violation.

This interaction between semantics and grammar is characteristic of Indo-European languages, and an interesting focus for ERP studies, some of which have been performed: one for English (Steinhauer & Ullman, 2002) and three for Dutch (Baggio, 2008; Bos et al., 2013; Dragoy et al., 2012). However, other languages have different ways to specify event time. In Thai, for example, tense marking does not exist. To specify the time frame of the event, so-called ‘aspectual adverbs’ are used. We will first discuss time reference in Indo-European languages and Thai, as well as in Chinese, followed by the scarce literature on ERP studies of time reference.

4.1.1 Time reference in Indo-European Languages

Broadly speaking, deictic Tense points to a moment in time, relative to the time of speaking where the event is expressed (Harder, 1996). Tense, thus, differs from Aspect which indicates whether the event is viewed as a whole—perfective aspect—or with respect to its internal structure—imperfective aspect (e.g., Lee, 2008). In Indo-European languages, both Tense and Aspect are marked on the verb. For instance, English simple past (*They ran from coast to coast*) vs. present progressive (*They are running from coast to coast*) represents both an aspectual and a temporal contrast, with progressive forms representing imperfective aspect, and simple forms representing perfective aspect. While both Tense and Aspect markers relate to verbs, they take many different forms. For example, English

uses an inflectional affix to express past tense (*He signed the letter yesterday*), whereas German uses the present perfect (*Er hat den Brief gestern unterschrieben*: lit. ‘Yesterday he has signed a letter’); in Dutch, both ways are possible and used equally often.

4.1.2 Time Reference in Thai

Thai is a non-inflectional (isolating) language in which categories such as number, case, tense, aspect, and mood are not marked by morphological means (Prasithrathsint, 2006). To express information regarding deictic event time, Thai uses temporal adverbs and aspectual adverbs.

Critically, *temporal adverbs* (e.g., *yesterday*, *now*, *tomorrow*) designate a point in time after, simultaneously with, or prior to the speech event. These adverbs contribute to the temporal interpretation of the sentence in which they occur (Demirdache & Uribe-Etxebarria, 2004). Furthermore, temporal adverbs answer the question *when*, for example, the word *yesterday* in response to the question *When did you bake the bread?*

Aspectual adverbs “concern the internal structure of events, relating a current state with the onset or the end of the state” (Lee, 2008, p. 340). They indicate whether the event is viewed as a whole (perfective aspect) or with respect to its internal structure (imperfective aspect). Aspectual adverbs are used to describe *how* an event is viewed or unfolds over time in relevance to the discourse. Syntactically, the aspectual adverb modifies the Verb Phrase it precedes. It is possible to have more than one aspectual adverb before the verb and / or after the verb (Koenig & Muansuwan, 2005). Here, we focus on preverbal aspectual adverbs.

As free-standing morphemes, both temporal adverbs and aspectual adverbs are optional and can be dropped when the deictic time is clear from the discourse. For example, the answer to the question *Prungnee khun jaa tam arai?*: lit. ‘Tomorrow you will do what?’ can be *kian jodmai*: lit. ‘write letter’. Despite not having any temporal markers, the response is adequate because the preceding question already specifies deictic time. The presence (or absence) of temporal and aspectual adverbs in Thai relies heavily on pragmatics and contextual information.

When aspectual adverbs (*italics*) are used together with temporal adverbs (**bold**), they must be congruent for a sentence to be acceptable (1).¹¹ A past temporal adverb and a non-

11 For a discussion on the difference between ‘ungrammatical’ and ‘unacceptable’ see Leivada and Westergaard (2020).

past (e.g., present or future) aspectual adverb or *vice versa* cannot co-occur in the same context without resulting in a violation (2).

- (1) **Prungnee** Chan *jaa* kian jodmai
Tomorrow I *IMPERF* write letter
 ‘Tomorrow, I will write a letter at home.’
- (2) **Prungnee** Chan **koei* kian jodmai
Tomorrow I **PERF*_{remote past} write letter
 *‘Tomorrow, I used to write a letter.’

In the current ERP experiment, we use one aspectual adverb referring to the past (*koei*) and one referring to the future (*jaa*). *Koei* can only be used preverbally and no intervening elements are allowed, except another aspectual adverb. The semantics of *koei* is quite specific: it refers to an experience in the remote past. A sentence such as in (3) is unacceptable, because *koei* cannot be combined with *meuxwan*: ‘yesterday’.

- (3) **Meuxwan** Chan **koei* kian jodmai
Yesterday I **PERF*_{remote past} write letter
 *‘Yesterday I used to write a letter.’

Jaa, like *koei*, is grammatically restricted in that it can only be used preverbally without an intervening element. It is comparable in meaning to English *will*.

While the positions of the aspectual adverbs *jaa* and *koei* are fixed, those of temporal adverbs are not. In (1-3), the temporal adverb is at the beginning of the sentence, while in (4) it follows the Verb Phrase.

- (4) Chan *jaa* kian jodmai **prungnee** tee baan
 I *IMPERF* write letter **tomorrow** at home
 ‘I will write a letter, tomorrow, at home’

4.1.3 Time Reference through Verb Inflection and Aspectual Adverbs Compared

As noted above, deictic time reference is a semantic notion that is expressed through grammatical morphology in Indo-European languages and through aspectual adverbs in Thai. Boye and Harder (2012) argued that the lexical-grammatical distinction should

not be based on theoretical linguistic notions such as function versus content words or open- versus closed-class verbs. They outlined a usage-based theory in which grammatical items (morphemes, words, more or less schematic constructions) are defined as items that are conventionalized, hence entrenched as carriers of background information. In contrast, lexical items are defined as items that have the potential to express foreground information. It follows that grammatical items can be identified as items that cannot, under normal circumstances, be focalized, addressed or modified, and are dependent on a host in relation to which they express background information. Based on this, a distinction can be made, for example, between a grammatical and a lexical variant of the English verb *have*. Grammatical, auxiliary *have* requires combination with a full verb, and cannot be addressed by means of *do* (5). In contrast, the lexical, full-verbal variant of *have* can appear as the only verb in a clause, and can be addressed by means of *do* (6).

(5) The boy has purchased a book. *So does the girl.

(6) The boy has a book. So does the girl.

The theory is supported by both psycholinguistic and neurolinguistic data. For example, it has been shown that individuals with agrammatic aphasia (a grammatical impairment after brain damage) have more problems producing verbs classified as ‘grammatical’ than verbs classified as ‘lexical’ (Boye & Bastiaanse, 2018). Similar results have been reported for French agrammatic speakers (Ishkhanyan et al., 2017). *Je*: ‘I’ and *me*: ‘me’ are grammatical (they cannot be focalized in a cleft construction) and are harder to produce for agrammatic speakers than *moi*: ‘me’, which is classified as lexical (it can be focalized in a cleft construction).

Based on Boye and Harder (2012), Indo-European Tense inflections and auxiliaries can be considered to be grammatical. For instance, they are clearly non-focalizable (except in metalinguistic contexts). Thai aspectual adverb, *jaa* is also, we argue, grammatical: it cannot stand alone, and it cannot be focalized or modified by negation. Notice that *jaa* has been interpreted as a modal verb by some Thai linguists (Kanchanawan, 1978; Srioutai, 2004). Other aspectual adverbs can stand alone and express primary information. These adverbs are lexical. Thai *koei* is a case in point: it can stand alone as an answer to a question, and it can be focalized and modified through negation, as in *mai koei*: ‘not used to’. Thai temporal adverbs are always exclusively lexical items.

The heterogeneous status of temporal and aspectual expressions with respect to the lexical-grammatical distinction makes time reference an interesting topic for experiments

examining electrophysiological responses using Event-Related Potentials (ERP), because lexical and grammatical violations typically elicit different ERP responses. Several studies have been performed in English, Dutch, and Mandarin Chinese. The current study in Thai will contribute to the knowledge on processing of time reference by testing violations of time reference by both aspectual and temporal adverbs.

4.1.4 ERP Studies on Time reference Violations

4.1.4.1 ERP Components and Their Interpretation: N400, LAN, and P600

The N400 is a negative ERP deflection that peaks around 400 ms after stimulus onset in centro-parietal scalp regions. Kutas and Hillyard (1980) first reported an N400 when comparing instances of semantically plausible and semantically anomalous sentences (e.g., *He spread the warm bread with butter / *socks*).

The Left Anterior Negativity (LAN) is a negative deflection detected in the left anterior scalp region, and is argued to represent an automatic response to morphosyntactic anomalies (Gunter et al., 2000; Hahne & Friederici, 1999; Neville et al., 1991). The P600, a positive response starting approximately 500 ms post stimulus onset, is usually interpreted as reflecting repair and reanalysis (Friederici et al., 1993; Friederici & Frisch, 2000; Hahne & Friederici, 2002; Osterhout & Holcomb, 1992). The biphasic pattern of LAN-P600 has been observed in a number of studies involving morphosyntactic violations (Friederici et al., 1993; Hagoort et al., 1999).

Fodor and Ferreira (1998) argued that the exact nature of the mechanisms underlying syntactic repair and reanalysis of the P600 was controversial and required refinement. Exploring scalp distributions, Hagoort et al. (1999) suggested that a posterior P600 is associated with the processing of ungrammatical sentences, whereas a frontal P600 reflects an attempt to compute (reanalyze) non-preferred sentences (Hagoort et al., 1999; Osterhout & Holcomb, 1992; Van Berkum et al., 1999). It has also been suggested that posteriorly distributed positivity is related to syntactic repair of ungrammatical continuations, and frontally distributed positivity involves not only revision processes for ambiguous sentences but also indicates an increase in sentence complexity (Friederici et al., 2002; Kaan & Swaab, 2003; Kolk & Chwilla, 2007). According to the *perceptual monitoring account* (Kolk & Chwilla, 2007; Van de Meerendonk et al., 2010), the P600 reflects a discrepancy between expected and perceived stimuli. If the discrepancy is mild, the constraint is easily resolved, leading to an N400. However, if the discrepancy is large, it becomes more difficult to fix, initiating a reanalysis process, resulting in a P600. Two

further studies on disagreement processing have shown that there is a direct relationship between the complexity of repair / reanalysis and the size of the P600 effect (Popov & Bastiaanse, 2018; Popov et al., 2020). In addition, the P600 has also been shown to reflect the integration of lexical information with the contextual semantic representation (Brouwer et al., 2012; Kuperberg et al., 2003).

4.1.4.2 Time Reference Violation in Indo-European Languages

Using ERPs, Steinhauer and Ullman (2002) compared grammatical sentences to sentences with a tense violation (e.g., *Yesterday, I sailed* / **sail Diane's boat to Boston*). Compared to acceptable sentences, anomalous sentences evoked a left anterior negativity (LAN) in the 300-500 ms time range after the verb onset, followed by a centro-posterior positivity (P600) from 600-900 ms. Steinhauer and Ullman (2002) suggested that the presence of the LAN-P600 elicited in their study indicated that tense violations were perceived as morphosyntactic and not semantic or pragmatic violations.

Baggio (2008) used a similar design for a study in Dutch and also found a LAN followed by a centro-posterior P600 when a past temporal adverb was violated by a verb in present tense. However, he argued that “it is the mismatch between the semantic features of the adverb and the verb that determines that tense is used incorrectly” (p. 37), which means that the temporal mismatch has a semantic basis, but still elicits the LAN and P600. Importantly, in both Steinhauer and Ullman (2002) and Baggio (2008), the critical word (the verb) differed across conditions: since both studies used the same temporal adverb (*yesterday* in the example above), they measured ERPs on different verb forms (*sailed* / **sail*).

Dragoy et al., (2012) also studied time reference violations in Dutch and in both directions: a temporal adverb referring to the past followed by a verb form referring to the present, or a temporal adverb referring to the present followed by a verb form referring to the past. They varied the temporal adverbs across conditions and, critically, measured ERPs on the same verb form (*the waiter who just* / **now the pepper grind* [...]). Sentences with temporal adverbs referring to the past followed by a present verb form elicited a P600, which was broadly distributed in the centro-posterior region, as in Baggio (2008) and Steinhauer and Ullman (2002). When a temporal adverb referring to the present was followed by a past verb form, no ERP effect was found. In a follow up study (Bos et al., 2013), periphrastic verb forms were used: present perfect, that includes a present tense auxiliary in combination with a past participle (*the waiter who just* / **now has_{PRES} grind the pepper* [...]) to refer to the past, and future imperfect, that includes a present tense auxiliary in combination with an infinitive (*the waiter who soon* / **just will_{PRES} grind the pepper* [...]) to refer to the

non-past (i.e., future). The results of Dragoy et al. (2012) were confirmed: a past temporal adverb that is violated by a non-past verb form elicits a P600, but the opposite (a non-past temporal adverb followed by a past verb form) elicits no ERP component. The reason for a lack of effect when the non-past temporal adverb is followed by a past verb form was explained by the fact that although these constructions are generally unacceptable (as shown by behavioral test results), they are allowed in certain narrative contexts ('and now / soon Cinderella fell asleep').

On the basis of the ERP studies conducted in Dutch and English, we can conclude that when a non-past verb form violates the time frame set by past temporal adverb, a P600 is elicited. In the two studies where the critical word was not the same in both conditions, a LAN preceded the P600. In the two studies in which a non-past temporal adverb was violated by a past verb form, no ERP effects were elicited. Even though Baggio (2008), Dragoy et al. (2012), and Bos et al. (2013) all agree that tense / time reference morphology encodes semantic information, their ERP results are consistent with findings on (dis) agreement, which in general indicate morphosyntactic processing (see Molinaro et al., 2011).

4.1.4.3 Time Reference Violations in Mandarin Chinese

Little is known about processing of time reference violations at the neurophysiological level in languages that do not use morphological marking for time reference, except for Mandarin Chinese (Qiu & Zhou, 2012; Zhang & Zhang, 2008). Qiu and Zhou (2012) used the aspectual adverb *jiangyao* to refer to the future, and the aspectual adverb *cengjing* and the aspectual particle *-guo* to refer to the past.¹² They included temporal adverbial phrases referring to the past violated by an aspectual adverb referring to the future (*last month the UN *jiangyao_{FUT} dispatch a special investigation unit*) and the other way around (*next month the UN *cengjing_{PAST} dispatch a special investigation unit; next month the UN dispatch-*guo_{PAST} a special investigation unit*). Importantly, the critical words were similar across conditions. They found that a violation of agreement between the temporal adverbial phrase referring to the future and the aspectual particle *-guo* elicited a centroparietal P600, similar to the findings in Indo-European languages that use morphological marking for time reference (Baggio, 2008; Bos et al., 2013; Dragoy et al., 201; Steinhauer & Ullman, 2012).

12 In their paper, Qiu and Zhou (2012) categorized *jiangyao* and *cengjing* as temporal adverbs. However, in our terminology, temporal adverbs describe when the event is carried out (e.g., *yesterday*, *now* and *tomorrow*), and aspectual adverbs describe whether the event is completed, ongoing, or will be going on. Here, therefore, we refer to them as aspectual adverbs.

In the case of disagreement between the temporal adverb followed by an aspectual adverb, Qiu and Zhou (2012) also observed a posterior P600 effect, but this was preceded by an N400.¹³ This N400 is not unexpected, because aspectual adverbs are semantically enriched words (Ma & Wang, 2004) and, following Boye and Hader (2012), are lexical items. Consequently, the N400 elicited during the processing of aspectual adverbs was interpreted by Qiu and Zhou (2012) as indicating lexical and semantic aspects of temporal processing in Mandarin Chinese. The N400-P600 effect was found both when future temporal adverbs were violated by past aspectual adverbs and when past temporal adverbs were violated by future aspectual adverbs. Table 4.1 summarises the results of ERP-studies of time reference violations.

4.1.4.4 Summary of Time Reference Violation Studies

In sum, based on the previous literature the following observations can be made:

- in Indo-European languages, LAN is only elicited when the critical word is different across conditions (e.g. ‘*yesterday, I sailed ...*’ and ‘**yesterday, I sail ...*’) (Steinhauer & Ullman, 2002; Baggio, 2008);
- in Indo-European languages, a P600 is elicited when a past temporal adverb is violated by a non-past verb form, but not when a non-past temporal adverb is violated by a past verb form (Dragoy et al., 2012; Bos et al., 2013);
- violation of Mandarin Chinese aspectual adverbs elicits an N400, followed by a P600; interestingly, this holds both for a past temporal adverb that is violated by a future aspectual adverb and for a future temporal adverb followed by a past aspectual adverb (Qiu & Zhou, 2012).

These results are in line with the theory of Boye and Harder (2012). As noted, in this theory, Indo-European inflectional and auxiliary time expressions are clearly grammatical. The violation of the Indo-European tense category leads to structural repair reflected in the P600 effect. A parallel can be drawn between tense violation processing and (nominal) number disagreement processing. Both categories (i.e., tense and number) are semantically rooted (temporal information and numerosity). However, both categories are expressed grammatically (i.e., inflectional morphology) in Indo-European languages. In a study on Dutch by Popov and Bastiaanse (2018), determiner-noun number disagreement led

13 This N400 was only found after they replicated the experiment without the *-guo* condition.

to a P600 response, interpreted as reflecting structural repair and reanalysis. In the same study, violation of grammatical gender which, unlike number, is not a semantic feature (it is unrelated to natural gender and is immutable), also led to a P600 response. Popov and Bastiaanse concluded that when a feature is coded grammatically, the ERP response reflects only the registration and the repair of the mismatch at the formal (feature) level. It does not reflect the violation of the semantic information underlying the formally realized feature, such as numerosity. Or, at least, such violation does not result in the N400 effect. This explanation overlaps very much with Baggio's (2008) explanation that time reference violations are semantic violations which nonetheless elicit a P600 effect.

The lack of a P600 effect in the two studies on Dutch when a future temporal adverb is followed by a past verb form is explained by the fact that this combination is acceptable in some environments (although not in the sentences that were tested). According to Sun and Boye (2019), the Mandarin Chinese experiential particle *-guo*, as tested by Qiu and Zhou (2012), is grammatical and when there is an incongruency with the time frame set by a temporal adverb, a P600 is elicited. The Mandarin Chinese aspectual adverbs *cengjing* and *jiangyao* are lexical, as argued above. This is also reflected in the data: violation of a time frame set by an incongruity between a temporal adverb and an aspectual adverb elicits an N400 followed by the P600. The incongruity is not that of simple lexical semantics, rather, it encompasses a violation of an entire time frame, as set by the preceding context (temporal adverb), which is violated by an aspectual adverb. Such a violation is firstly registered at the semantic level (N400) and due to its complexity and involvement of elements with grammatical(ized) features (i.e., aspectual adverbs), it needs to be repaired, resulting in the P600.

Table 4.1 Summary of the components reported in studies to time reference violations.

Language	Violation	past-*non past	similar word?
Mandarin Chinese (Qiu & Zhou, 2012)	Past _{ADV} *Fut _{ASP}	N400-P600	+
English (Steinhauer & Ullman, 2002)	Past _{ADV} *Pres _{TENSE}	LAN-P600	-
Dutch (Baggio, 2008)	Past _{ADV} *Pres _{TENSE}	LAN-P600	-
Dutch (Dragoy et al., 2012)	Past _{ADV} *Pres _{TENSE}	P600	+
Dutch (Bos et al., 2013)	Past _{ADV} *Fut _{AUX+INF}	P600	+
		nonpast-*past	
Mandarin Chinese (Qiu & Zhou, 2012)	Fut _{ADV} *Past _{ASP}	N400-P600	+
	Fut _{ADV} *Past _{PART}	P600	+
Dutch (Dragoy et al., 2012)	Fut _{ADV} *Past _{TENSE}	-	+
Dutch (Bos et al., 2013)	Fut _{ADV} *Past _{AUX+PARTIC}	-	+

Note: Past_{ADV} = past temporal adverb; Fut_{ASP} = future aspectual adverb; Pres_{TENSE} = present tense; Fut_{AUX+INF} = Future by auxiliary and infinitive; Fut_{ADV} = future temporal adverb; Past_{ASP} = past aspectual adverb; Past_{PART} = past particle; Past_{AUX+PARTIC} = past by auxiliary and participle.

The results of the discussed studies clearly reflect the different nature of time reference in Indo-European languages and Mandarin Chinese. The aim of the current study on Thai is to further explore this difference.

4.1.5 The Current Study

For the current study, we tested two violation types. First, the violation of a time frame set by a future temporal adverb by a past aspectual adverb (*koei*) that, in terms of the theory of Boye and Harder (2012), has a lexical function (see 7-8). Chinese *chengjing* refers to an experience that occurs once or twice in the past. Thai *koei* is more similar to English ‘used to’ and can only refer to the remote past: it cannot be combined, for example, with ‘just’ or ‘yesterday’. Therefore, we argue that this aspectual adverb is semantically more enriched than the Mandarin Chinese equivalent:

(7) *Past temporal adverb + past aspectual adverb*

Peekorn	por	koei	tam arhan india
Last year	father	PAST	do food Indian

‘Last year, father used to make Indian food’

(8) *Future temporal adverbs + *past aspectual adverb*

Prungnee	por	*koei	tam arhan india
Tomorrow	father	*PAST	do food Indian

*‘Tomorrow, father used to make Indian food.’

Second, we included a condition in which a time frame set by an aspectual adverb is violated by a temporal adverb (9-10).

(9) *Future aspectual adverb + future temporal adverb*

Por	jaa	tam arhan india	prungnee
Father	FUT	do food Indian	tomorrow

‘Father will make Indian food tomorrow’

(10) *Past aspectual adverb + future temporal adverb*

Por	koei	tam arhan india	*prungnee
Father	PAST	do food Indian	*tomorrow

*‘Father used to make Indian food tomorrow’

We formulated the following research questions:

1. How are temporal violations processed in a ‘tenseless’ language, such as Thai?
2. Is temporal violation processed (and repaired) in a different way depending on whether the violation is caused by a lexical or an aspectual adverb?

Regarding the first research question, we expect that the temporal violation is registered as a semantic violation, thus eliciting the N400. Unlike in Indo-European languages, time reference in Thai is not formally encoded as inflectional morphology, the violation of which is akin to disagreement processing known to elicit the P600. The temporal violation in Thai is indeed at the temporal level (i.e., semantic / conceptual level) without any interfering formal cues, which means that no P600 is expected in relation to temporal processing. This expectation is in line with the findings on Mandarin Chinese (Qiu & Zhou, 2012).

The novel element of our study is that we varied the kind of temporal violation. In one condition an introductory temporal adverb is violated by a later aspectual adverb, whereas in the other condition, the aspectual adverb is violated by the upcoming temporal adverb. The aspectual adverb (*koei*) used in this study, albeit considered a lexical item according to Boye and Harder’s (2012) criteria, shows more grammaticalized properties compared to the temporal adverb (*prungnee*). We expect that the violation of both will elicit the N400, as this is a temporal violation. However, we expect these two kinds of violations to differ in terms of repair and reanalysis due to their different levels of grammaticalization. We assume that the temporal adverb is semantically ‘richer’, whereas the aspectual adverb is grammaticalized to an extent, as argued above. As a consequence, once the temporal adverb is violated by the aspectual adverb, the repair process is fairly simple – the parser assumes that the correct reading is that of the temporal adverb (semantically richer) and it only needs to repair or delete the aspectual adverb. In this way, the original temporal context of the sentence, established by the temporal adverb, is retained. Consequently, the P600 effect, which is understood to reflect repair and reanalysis, is expected to be small or altogether absent.

Similarly, when the aspectual adverb is violated by the temporal adverb, the parser assumes again that the correct time frame is given by the temporal adverb. In this case, the parser has to repair and reanalyze the whole sentential temporal set-up which was established by the aspectual adverb. We expect that such complex repair and reanalysis will be reflected in a (larger) P600 effect.

4.2 EXPERIMENTAL PROCEDURE

4.2.1 Participants

Forty native speakers of Thai participated in this study. Data from nine participants were excluded: three performed poorly (<87.5% correct) on the acceptability judgement task, one was ambidextrous, and for another two, technical issues resulted in unusable output files.¹⁴ Additionally, EEG data from three participants were excluded due to excessive artefacts. In total, data from thirty-one participants remained (6 males, mean age 31.16, age range 25-45). All participants were recruited in Sydney, Australia. The participants reported normal or corrected-to-normal vision, no history of alcohol or drug abuse, and no diagnosed neurological impairments, psychiatric or speech / language disorders. They were all right-handed as confirmed by their results on the Edinburgh Handedness Inventory (Veale, 2014). Participants provided informed consent according to the Declaration of Helsinki under a procedure approved by the Human Research Ethics committee at Macquarie University, Sydney, Australia and were financially compensated 25-35 AUD for their participation in the experiment depending on the length of session.

4.2.2 Materials

Of the 240 sentences used in the present study, 160 were experimental and 80 were filler sentences. The experimental sentences were divided into four conditions (see Table 4.2). Two conditions comprised sentences with temporal adverbs preceding the aspectual adverbs (TempFirst; $n = 80$). The other two conditions included sentences with aspectual adverbs preceding the temporal adverbs (AspFirst; $n = 80$). The difference between the two sentence types was the position of the temporal adverb that was in the first position in the TempFirst conditions and in the penultimate position in the AspFirst conditions.

Both sentence types (TempFirst and AspFirst) were presented in acceptable and unacceptable conditions. Thus, the four experimental conditions were TempFirst acceptable ($n = 40$), TempFirst unacceptable ($n = 40$), AspFirst acceptable ($n = 40$), and AspFirst unacceptable ($n = 40$).

14 The participant indicated that she was right-handed, and used her right-handed to sign our consent form. After completing the experiment, she, however, used her left-hand to sign the financial compensation paper.

Table 4.2 Examples of the four experimental conditions.

Condition	temporal adverb	aspectual adverb	temporal adverb	Example				
1. TempFirst Acceptable	Past	Past		peekorn year-ago	por father	koei PAST	tam arhan india do food india	tee suan lang baan at garden behind home
				A year ago (last year), father used to make Indian food at his backyard.				
2. TempFirst Unacceptable	Future	*Past		prungnee, tomorrow,	por father	*koei *PAST	tam arhan india do food india	tee suan lang baan at garden behind home
				*Tomorrow, father used to make Indian food at his backyard.				
3. AspFirst Acceptable		Future	Future	por father	jaa FUT	tam ar-han india do food india	prungnee tomorrow	tee suan lang baan at garden behind home
				Father will make Indian food, tomorrow, at his backyard.				
4. AspFirst Unacceptable		Past	*Future	por father	koei PAST	tam ar-han india do food india	*prungnee *tomorrow	tee suan lang baan at garden behind home
				*Father used to make Indian food, tomorrow, at his backyard.				

Note: TempFirst = temporal adverb first; AspFirst = aspectual adverb first.

The TempFirst conditions were constructed using an aspectual adverb that referred to the past, preceded by a congruent past temporal adverb in the acceptable sentences, and incongruent future temporal adverb in the unacceptable sentences. The AspFirst conditions were constructed using a temporal adverb that referred to the future, preceded by a congruent future aspectual adverb in acceptable sentences and an incongruent past aspectual adverb in unacceptable sentences.

The 80 filler sentences comprised 40 acceptable and 40 unacceptable sentences with word order violations (switching of the verb and the second noun phrase). Note that half of the filler sentences were also constructed with a temporal adverb in the penultimate position in order to resemble the structure of experimental sentences as much as possible.

In order to avoid the exposure of the participant to the acceptable and unacceptable version of the same sentence, and to minimize repetition, the 240 sentences were divided into 2 lists, 120 sentences each, in a Latin Square design by taking 20 sentences from each experimental condition ($n = 80$), and 5 sentences from each filler type ($n = 40$). Each participant only saw each sentence in either the acceptable or unacceptable condition, with sentence allocation to acceptable / unacceptable counterbalanced across participants.

4.2.3 Acceptability Ratings of the Materials

All of the 240 experimental and filler sentences were evaluated for acceptability prior to the start of the experiment, using an online survey (via 'Google Forms'). Participants had to make a binary decision as to whether a sentence was correct or not using their native speaker intuition. Thirty native speakers of Thai (6 male, mean age 29.07, age range 21-41) participated in the acceptability rating task. Sentences were included in the experiment if there was agreement of at least 80% (i.e., 80% of all participants agreed that the sentence was grammatical).

Of the 240 items, 21 items did not reach the inclusion threshold. These sentences were later modified by 3 native speakers of Thai, and assessed by another 15 Thai volunteers (male 6, mean age 27.71, age range 22-61) using the same procedure. All 21 modified sentences exceeded the 80% criterion. The mean acceptability rating across the final set of 240 sentences was 93.67%: TempFirst acceptable 91.03% (SD = 0.07); TempFirst unacceptable 96.83% (SD = 0.05); AspFirst acceptable 90.83% (SD = 0.07); AspFirst unacceptable 93.17% (SD = 0.06); filler acceptable 97.33% (SD = 0.05); filler unacceptable 92.83% (SD = 0.07).

4.2.4 Procedure

The experiment was programmed and presented using E-Prime 3.0 (Psychology Software Tools, Inc., 2016). Participants were seated approximately 80 cm from a computer screen. The experiment started with written instructions that had been previously explained orally by the examiner. Sentences were presented visually, word by word, using Times New Roman (Thai), size 40, appearing in white centered on the computer screen with a black background. At the beginning of each sentence, a fixation cross appeared for 500 ms. Each word was displayed for 350 ms, followed by a blank screen for 350 ms. At the end of each sentence, a question mark “?” appeared prompting an acceptability judgement task. Participants were instructed to read each sentence and to indicate whether the sentence was acceptable / unacceptable by pressing the key coloured green on the keyboard (letter Q) for acceptable, and the key coloured red on the keyboard (letter P) for unacceptable. The question mark disappeared as soon as the button was pressed, or automatically after 3s. The fixation cross preceding the next sentence appeared immediately after the response (or time out).

To ensure that participants understood the task, they were given a practice session with 6 practice sentences. The experimental session consisted of 3 blocks. Each block lasted 8-10 minutes, depending on participants' response latencies. Participants were given a break after each block, and they could resume whenever ready. The total length of the experiment was 25-30 minutes per participant.

4.2.5 EEG Recordings and Data Analysis

Continuous EEG activity was recorded from 64 electrode channels using an ActiveTwo Biosemi system (BioSemi B.V., Amsterdam, the Netherlands). BioSemi pin-type active Ag/AgCl electrodes were mounted in a BioSemi headcap and positioned according to the extended International 10-20 system. Common Mode Sense (CMS) active electrode and Driven Right Leg (DRL) passive electrode were used as ground electrodes. Two additional mastoid electrodes were placed bilaterally and served as offline referencing channels. All data signals were sampled at 1024 Hz.

MATLAB (R2019b, MathWorks, Inc) was used for offline EEG data processing using two MATLAB toolboxes, Fieldtrip (fieldtrip-20191028, Oostenveld et al., 2011) and EEGLAB (eeglab2019_0 v14.1.2, Delorme & Makeig, 2004) for artifact rejection and plotting.

After acquisition, the data were downsampled to 128 Hz and bandpassed with a butterworth filter (highpass filter of 1 Hz and a lowpass filter of 30 Hz). Noisy channels were identified using the findNoisyChannels function from the Prep toolbox (Bigdely-Shamlo et al., 2015), then spherically interpolated. Noisy channels and eye artifacts were cleaned using an automated Independent Component Analysis (ICA; Pion-Tonachini et al., 2019) method in EEGLAB. The continuous EEG signal was segmented into epochs from 200 ms before the stimulus onset (trigger marked on the critical word) to 1000 ms post-target onset. Prestimulus time was used for baseline correction.

Cluster-based permutation testing (Maris & Oostenveld, 2007) was used to test for statistically significant differences between conditions (dependent samples *t*-test of acceptable versus unacceptable sentences). The cluster alpha level used for grouping data samples (channel-time pairs) into clusters was set at .05. The Monte Carlo approximation of *p*-values was applied to identify significant clusters.

4.3 RESULTS

4.3.1 Behavioral Data

To be included in the analysis, participants had to have an accuracy of at least 87.5% (i.e., at least 105/120 items correct). Average accuracy of the 31 participants was 94.84% (average number errors = 6; SD = 4.4). For each of the conditions, mean performance was: TempFirst acceptable 95.97% (SD = 1.01); TempFirst unacceptable 94.03% (SD = 1.38);

AspFirst acceptable 93.55% (SD = 1.35); AspFirst unacceptable 93.87% (SD = 1.38); filler acceptable 97.26% (SD = 0.93); filler unacceptable 94.35% (SD = 1.36).

4.3.2 Electrophysiological Data

Acceptable and unacceptable sentences were compared at the onset of the aspectual adverbs and the onset of the temporal adverbs. Following Baggio's (2008) analysis procedure, mean amplitude values in each condition in time bins of 100 ms were taken as an input for the cluster-based permutation test (Maris & Oostenveld, 2007). Based on our hypothesis and the latency range reported in most time reference studies, two time-bins starting from 300 ms to 500 ms were selected for negativity of the N400 effect, and four time-bins starting from 500 ms to 900 ms were chosen for positivity and late positivity of the P600 effect. Output for each time bin was a cluster of electrodes where there was a significant difference (negative or positive) between the conditions (TempFirst—acceptable versus unacceptable; AspFirst—acceptable versus unacceptable).

4.3.2.1 Violations at the Aspectual Adverbs (TempFirst Conditions)

When the timeframe of the event was set by temporal adverbs and was violated by aspectual adverbs, the cluster-based permutation test revealed a significant difference between the acceptable and unacceptable conditions in the 300-400 ms and 400-500 ms latency range (Figure 4.1). Visual inspection of ERP waveforms revealed a negative shift that was larger for violations at the aspectual adverbs.

While the difference was most pronounced over the left-lateralized centro-posterior electrode sites ($p = .036$, $t = -23.49$, $SD = .006$) involving up to 10 electrodes (T7, TP7, CP5, CP3, CP1, P1, P3, P5, P7 and P9) for the latency range between 300 and 400 ms, it was spread largely over the centro-posterior electrode sites ($p = .006$, $t = -81.72$, $SD = .002$) involving up to 34 electrodes (C3, CP5, CP3, CP1, P1, P3, P5, P7, P9, PO7, O1, Iz, Oz, POz, Pz, CPz, FC4, FC2, Cz, C2, C4, C6, T8, TP8, CP6, CP4, CP2, P2, P4, P6, P8, P10, PO8, O2) between 400 and 500 ms. Almost all of the negative electrode sites in the 300-400 ms latency range were persistently negative into the latter time bin, 400-500 ms, where a broader distribution was found. This effect exhibited the timing and topographical distribution typical of an N400.

No effects were found in the P600 time window (500-900 ms).

Figure 4.1 Panel A: Grand-average ERPs for the acceptable and unacceptable conditions from frontal, central, and parietal electrode sites time locked to the onset of the aspectual adverbs. Panel B: The topographic maps display the mean amplitude difference between the ERPs evoked by the **aspectual adverbs** in correct and violated sentences. Asterisks indicate electrode clusters at which the mean amplitude difference between the two conditions is significant. Note that the topographical map scales differ across time windows in order to better illustrate the amplitude difference between the acceptable and unacceptable conditions in each time window.

4.3.2.2 Violations at the Temporal Adverbs (AspFirst Conditions)

When the time frame of the event was set by aspectual adverbs and was violated by temporal adverbs, the cluster-based permutation analysis revealed two clusters with significant differences between the acceptable and unacceptable condition when the contrast occurred at the temporal adverb (Figure 4.2). The first significant difference was a negative centro-posterior cluster, stronger in the left hemisphere, in the 400-500 ms time bin ($p = .006$, $t = -108.47$, $SD = .002$), with the following 39 significant electrode sites: FC5, FC3, FC1, C1, C3, C5, TP7, CP5, CP3, CP1, P3, P5, P7, P9, PO7, PO3, O1, Iz, Oz, POz, Pz, CPz, Cz, C2, C4, C6, T8, TP8, CP6, CP4, CP2, P2, P4, P6, P8, P10, PO8, PO4, O2. A visual inspection of the ERP waveform revealed a negative deflection, larger for violated temporal adverbs. Similar to the mismatch occurring at the aspectual adverbs, this effect was interpreted as an instance of N400.

The second significant difference was a positive cluster in the 600-700 ms time bin ($p = .003$, $t = 147.77$, $SD = .002$). In this latency range, the difference was most pronounced over fronto-central electrode sites, also stronger in the left hemisphere, with 49 electrode sites being significant (AF7, AF3, F1, F3, F5, F7, FT7, FC5, FC3, FC1, C1, C3, C5, T7, TP7, CP5, CP3, CP1, P1, P3, PO3, Pz, CPz, AF4, AFz, Fz, F2, F4, F6, FT8, FC6, FC4, FC2, FCz, Cz, C2, C4, C6, T8, TP8, CP6, CP4, CP2, P2, P4, P6, P8, P10, PO4). Visual inspection indicated a positive shift, larger for incongruent sentences. This effect bore resemblance to P600.

4.3.2.3 Interaction Effect

Additionally, we tested for an interaction effect using cluster-based permutation test (using t-test on difference waveforms) with the following within-subject factors: acceptability (2 levels: acceptable versus unacceptable) and sentence types (2 levels: aspectual adverbs versus temporal adverbs) to determine if there were differences between the differences. The test showed statistically significant difference for the latency range between 600-700 ms ($p = .03$, $t = -23.72$, $SD = .006$) at 10 electrode sites (Pz, FCz, Cz, C2, CP6, CP4, CP2, P2, P4, P6), indicating that the differences within differences was statistically significant in this *a priori* set time window.

Figure 4.2 Panel A: Grand-average ERPs for the acceptable and unacceptable conditions from frontal, central, and parietal electrode sites time locked to the onset of the temporal adverbs. Panel B: The topographic maps display the mean amplitude difference between the ERPs evoked by the **temporal adverbs** in correct and violated sentences. Asterisks indicate electrode clusters at which the mean amplitude difference between the two conditions is significant. Note that the topographical map scales differ across time windows in order to better illustrate the amplitude difference between the acceptable and unacceptable conditions in each time window.

4.4 DISCUSSION

To investigate how temporal information is processed in languages that use aspectual markers rather than verb inflection for time reference, we examined the processing of time reference in Thai using ERPs. We observed different ERP results to those typically found in Indo-European languages. When the time frame of the event was set by a temporal adverb and violated by an aspectual adverb, an N400 was detected. When the time frame of the event was set by an aspectual adverb and violated by a temporal adverb, an N400 followed by a P600 was elicited. Table 4.3 summarizes the relevant findings in the literature and our findings, and below we address the interpretation of each of the ERP components in turn.

Table 4.3 Summary of the components in studies to time reference violations.

Language	Violation	past-*non past	similar word?
Mandarin Chinese (Qiu & Zhou, 2012)	Past _{ADV} *Fut _{ASP}	N400-P600	+
Thai (this study)	Past _{ASP} *Fut _{LEX}	N400-P600	+
English (Steinhauer & Ullman, 2002)	Past _{ADV} *Pres _{TENSE}	LAN-P600	-
Dutch (Baggio, 2008)	Past _{ADV} *Pres _{TENSE}	LAN-P600	-
Dutch (Dragoy et al., 2012)	Past _{ADV} *Pres _{TENSE}	P600	+
Dutch (Bos et al., 2013)	Past _{ADV} *Fut _{AUX+INF}	P600	+
		nonpast-*past	
Mandarin Chinese (Qiu & Zhou, 2012)	Fut _{ADV} *Past _{ASP}	N400-P600	+
	Fut _{ADV} *Past _{PART}	P600	+
Thai (this study)	Fut _{LEX} *Past _{ASP}	N400	
Dutch (Dragoy et al., 2012)	Fut _{ADV} *Past _{TENSE}	-	+
Dutch (Bos et al., 2013)	Fut _{ADV} *Past _{AUX+PARTIC}	-	+

Note: Past_{ADV} = past temporal adverb; Fut_{ASP} = future aspectual adverb; Pres_{TENSE} = present tense; Fut_{AUX+INF} = Future by auxiliary and infinitive; Fut_{ADV} = future temporal adverb; Past_{ASP} = past aspectual adverb; Past_{PART} = past particle; Past_{AUX+PARTIC} = past by auxiliary and participle; similar word?: ERPs measured at similar words across conditions.

4.4.1 N400

The time reference violation by both aspectual adverbs and temporal adverbs elicited an N400 effect. For both sentence types, the negative cluster was similarly distributed along the scalp in the centro-parietal region. We suggest that the processing of temporal markers, all free-standing morphemes in Thai, relies at least to some extent on semantic information regardless of the nature of the violation (i.e., at an aspectual adverb, or at a temporal adverb). What we found contrasts with the previous findings in languages that inflect verbs for time reference that have instead reported P600 (Baggio, 2008; Bos et al., 2013; Dragoy et al., 2012; Steinhauer & Ullman, 2002;), sometimes preceded by a LAN (Baggio, 2008; Steinhauer & Ullman, 2002). Consequently, our observation of N400

suggests that temporal information is differently processed depending on the linguistic devices used for expressing time reference.

In languages that use verb inflection for time reference, the reported P600 is proposed to reflect the fact that morphological markings are grammaticalized on the verb stems to which they attach (the morphological perspective; Baggio, 2008). To reiterate, when sentences in which a temporal adverb sets a time frame, such as *yesterday* in ‘*Yesterday, he cooks spaghetti*’ are processed, this constrains the suffix that the stem *cook-* can adopt (i.e., the suffix *-ed*). When *cook_s* is encountered with a suffix that is incompatible with the previous time frame, a failed check for agreement occurs. The crucial word here is *agreement*, which can be registered at two levels: semantic and morphosyntactic. Semantically, the mismatch between *yesterday* and *cook_s* represents temporal disagreement, since the temporal adverb conveys a past meaning, and the morpheme *-s* indicates present tense semantics. Still, since the temporal semantics of the verb morpheme is encoded in an inflectional suffix, we do not talk anymore about temporal but rather tense (dis)agreement. In this respect, the tense feature is similar to the number feature or semantic gender, in that it has a semantic basis, but is expressed through morphosyntactic means. The consequence is that the violation of such agreement triggers structural repair (and reanalysis) of the offending tense morpheme, reflected in the centro-posterior P600 effect (Friederici et al., 1993; Hagoort et al., 1999).

Unlike Indo-European languages, Thai does not use any morphosyntactic means for encoding temporal information. Rather, it uses temporal and aspectual adverbs, both of which fall within the lexical spectrum. Unlike temporal adverbs, aspectual adverbs (or at least *koei*) may have some grammaticalized properties (e.g., fixed position). However, their characteristics are still overwhelmingly those of lexical elements according to the criteria proposed by Boye and Harder (2012). Since temporal disagreement does not involve any grammatical elements, it is highly unlikely that it would trigger structural repair and reanalysis and the subsequent P600 effect. Instead, the disagreement in Thai, regardless of whether it is registered on the temporal or aspectual adverb, creates a mismatch at the semantic or discourse level, and increases the difficulty of integrating the offending adverb into the already established time frame. This results in the N400 effect on the disagreeing adverb.

4.4.2 P600

In addition to an N400 effect, when the event’s time frame was set by an aspectual adverb and violated by a temporal adverb, a P600, which was prominent in the anterior and central regions, was elicited.

Some previous studies have shown a biphasic response with both LAN and P600 effects (Baggio, 2008; Steinhauer & Ullman, 2002). The pattern was interpreted as indicating morphosyntactic processing, with the LAN representing the check for “satisfiability of a set of temporal constraints” (Baggio, 2008, p. 51). In other studies pertinent to temporal processing, the P600 was detected in isolation without the presence of a LAN effect (Bos et al., 2013; Dragoy et al., 2012; Qiu & Zhou, 2012). The current study fell into the latter group: a P600 was observed for the mismatching temporal adverbs with no LAN in either condition. Nonetheless, in terms of scalp distribution, while the previous studies observed a posterior P600, our study revealed a more central and anterior P600.

It may, at first, seem counterintuitive that the P600 was evoked only for violations at the temporal adverb and not at the aspectual adverb, given that both are semantically-rich free-standing morphemes that encode temporal information, and that also elicited the N400. However, despite being classified as lexical items according to Boye and Harder’s criteria (2012), aspectual adverbs (e.g., *koei*) are elements that have certain grammatical characteristics – they are part of the verb phrase, which is seen through their relatively fixed position in relation to the verb. In addition, aspectual adverbs differ from temporal adverbs at the semantic level. Temporal adverbs tend to carry more semantic information, that is, more precise temporal information than aspectual adverbs. For example, the temporal adverb *meuxwan* ‘yesterday’ places an event in the past, in the period of 24h before last midnight. The past aspectual adverb *jaa*, however, indicates that something happened in the future, without any further specification. For sentences in which the time reference of temporal adverbs was violated by that of the aspectual adverbs, it is likely that participants considered the temporal adverb to indicate the ‘correct’ time frame, as this is the more informative element having richer temporal semantics. Participants, therefore, simply needed to repair the target item (i.e., the aspectual adverb). The most likely and possibly the only repair scenario is the omission of the offending aspectual adverb, as the necessary temporal information has already been conveyed by the temporal adverb. Such repair leads only to the omission of the aspectual adverb without the need to reanalyze the sentence and set up a new or altered time frame. Therefore, we believe that this repair and reanalysis mechanism is not especially complex or computationally demanding. According to previous studies, such as the monitoring account (Kolk & Chwilla, 2007; Van de Meerendonk et al., 2010), and studies on repair complexity in disagreement (Popov & Bastiaanse, 2018; Popov et al., 2020), the complexity of repair and reanalysis is reflected in the presence / absence or size of the P600. That is, according to the monitoring account, violations that do not require a complex repair and reanalysis mechanism elicit an N400. The P600 is elicited only if the processing demand (i.e., repair and reanalysis) is high enough, which we argue is not the case in this condition.

Interestingly, the situation was different in the condition in which an aspectual adverb was followed by an anomalous temporal adverb (AspFirst condition). In this condition, the time frame was set up by an aspectual adverb, which was violated by a temporal adverb at a later point. Since temporal adverbs are semantically more informative than aspectual adverbs, it is highly likely that the repair process targeted the aspectual adverb. In this case, once the violation was perceived, the parser had to reanalyze the time frame set up by the aspectual adverb and adjust it to the time frame indicated by the temporal adverb. Such a reanalysis process is more complex than that in the first condition, as the parser has to reanalyze the already established time frame of the whole utterance. We suggest that it is due to the complexity of this operation, that the P600 was elicited in addition to the N400, which is in line with the monitoring account (Kolk & Chwilla, 2007; Van de Meerendonk et al., 2010).

The presence of the P600 is in line with previous literature both on time reference processing and accounts of the P600. However, the P600 elicited in this study had a predominantly frontal distribution, which differs from previously reported posterior P600s. This difference in the distribution could indicate a difference in the underlying processes eliciting the P600. According to Kaan and Swaab (2003), the P600 in sentences containing a clear morphosyntactic violation leads to a more posterior P600. If there is no overt morphosyntactic violation, but there is still a need for reanalysis, the P600 tends to be more frontal. Such a revision process leads to an increase in discourse level complexity, meaning that a frontal P600 can signify discourse integration complexity (Kaan & Swaab, 2003).

The idea of the frontal P600 being related to discourse level integration is in line with our results. To reiterate, we suggest that the presence of the P600 in the AspFirst condition was due to the complexity of the (repair and) reanalysis process. In Indo-European languages, the reported P600 reflects a typical structural repair, in which a morphosyntactic violation is repaired by simply repairing the offending morphosyntactic means (i.e., inflectional morphology) for expressing time reference (e.g., **plays > played*). In the case of the AspFirst condition, the reanalysis is at the level of the whole sentence / utterance, that is, the whole available discourse. Once the violation is perceived at the temporal adverb, the parser returns to the aspectual adverb and tries to repair it, as noted above, most probably by deleting the offending aspectual adverb. At this level, the repair and reanalysis mechanism is identical for both TempFirst and AspFirst conditions. In TempFirst condition this process is not complex and does not elicit the P600. The next stage, which only takes place in the AspFirst condition, is to reanalyze the time frame. This reanalysis takes place at the discourse level, which is why the resulting P600 has a more frontal distribution.

There is still one potential issue that needs to be addressed. The study on Mandarin Chinese by Qiu and Zhou (2012) tested temporal violations on aspectual adverbs in sentences introduced by mismatching temporal adverbs, one of the conditions also tested here. They reported both an N400 and a (posterior) P600 effect. The N400 results were suggested to mark a temporal mismatch as in our study. The difference in the P600 effect is more difficult to explain. It is possible that the Mandarin Chinese aspectual adverbs used by Qiu and Zhou are more grammaticalized than those of Thai. In support of this explanation is the more posterior P600 in Mandarin Chinese which possibly indicates a more structural repair and reanalysis, unlike the discourse level time reference reanalysis reported in our study.

4.5 CONCLUSIONS

In sum, the current study demonstrates that processing of temporal information in Thai is more dependent on lexical semantics, rather than purely morphosyntactic processes as reported in Indo-European languages. This is reflected by the negative clusters from the increased amplitude of the N400 in both sentence types. The frontal P600 observed in sentences with violations at the temporal adverbs might be caused by temporal reanalysis at the discourse level. The differential electrophysiological responses (as illustrated when the time markers switched position) indicate that the human brain does not necessarily process time markers, even within the same language, in a similar way.

5

General Conclusions & Discussion

5.1 OVERVIEW

The focus of the current dissertation was on the neurolinguistic aspects of time reference in relation to Thai, a language with different linguistic characteristics in terms of temporal expression when compared to Indo-European languages. More specifically, to express temporal information, Thai uses aspectual adverbs rather than inflectional morphology on the verb. This interesting feature of Thai motivated the investigation of time reference in the experimental chapters of this dissertation. In brief, Chapter 2 identified the characteristics of Thai agrammatic speech; Chapter 3 examined the production and comprehension of time reference in Thai agrammatism which is germane to the widely-studied cross-linguistic theory the PAsT DIscourse LInking Hypothesis (PADILIH); and Chapter 4 described an electrophysiological study of the processing of time reference in Thai. The entire project, overall, explored how grammatical problems with time reference can be detected in Thai. Several offline behavioral paradigms (a spontaneous speech elicitation, a sentence production, and an auditory sentence-to-picture matching comprehension tasks) and an online physiological paradigm (a violation paradigm with ERPs) were conducted with Thai agrammatic and non-brain-damaged (NBD) speakers to answer the research questions posed in the introductory chapter (Chapter 1).

To recap, the main research questions of this dissertation were as follows:

1. How can we characterize agrammatic speech in a language that has no grammatical morphology, like Thai? (Chapter 2)
2. Are specific features of Thai (serial verb constructions and politeness particles) impaired in Thai agrammatic speech? (Chapter 2)
3. What are the patterns of production and comprehension of time reference in agrammatic speakers of Thai, a language that does not use verb inflection but instead uses aspectual markers to refer to time? (Chapter 3)
4. How is temporal information processed by non-brain-damaged speakers in a tenseless language, Thai, when there is a mismatch between the time reference of two temporal markers, namely, aspectual adverbs and temporal lexical adverbs? (Chapter 4)

The aims of this final chapter are (i) to draw together important outcomes and discuss the implications of the results of the three experimental chapters, and (ii) to discuss limitations of this research and directions for further studies.

5.2 MAJOR FINDINGS AND IMPLICATIONS

In this section, first, the characteristics of Thai agrammatic speech are discussed. Then, I show how the production and comprehension of temporal information is implicated in Thai with respect to a linguistic theory that addresses agrammatism and time reference in aphasia (the PADILIH). Last, I explain how ERPs help improve understanding of the processing of temporal information, especially in a tenseless language, and compare this to other languages previously studied. The discussion of the major findings of the results of each study is laid out in relation to the research questions.

5.2.1 Agrammatism in Thai

Chapter 2 addressed the first research question regarding the characterization of Thai agrammatic speech. Specifically, I conducted interviews to obtain narrative speech samples from Thai speakers with non-fluent aphasia and compared it to that of NBD speakers. Both general characteristics of agrammatism that have been found cross-linguistically (e.g., mean length of utterances, speech rate, etc.) and features specific to Thai (e.g., serial verbs, aspectual adverbs for time reference, and politeness particles) were analyzed.

Overall, like the agrammatic speakers of other languages, the Thai agrammatic speakers produced slow speech, and used short utterances that were often ungrammatical. Their sentence length was roughly half that of the NBD speakers. This nonfluent speech output has been reported across various languages (e.g., Saffran et al., 1989 and Thompson et al., 2010 for English; Bastiaanse & Jonkers, 1998 for Dutch; Arslan et al., 2016 for Turkish; Anjarningsih et al., 2012 for Standard Indonesian; Abuom & Bastiaanse, 2012 for Swahili-English).

5.2.2 The Verb is Vulnerable; The Particles are Spared

The second research question in the first study (Chapter 2) concerned the characteristics of specific features of Thai—serial verbs and polite particles—in Thai individuals with agrammatic aphasia. The data showed that the number of verbs the agrammatic speakers produced was lower than that of the NBD speakers. Since the 1990s, verbs have been reported to be impaired in agrammatic speech in languages with morphological inflections (Bastiaanse & Jonkers, 1998; Saffran et al., 1989; Thompson et al., 1995). It has been argued that agrammatic speakers have problems retrieving verbs and inflecting them for tense and agreement (Bastiaanse & Jonkers, 1998; Rossi & Bastiaanse, 2008). In Standard Indonesian, another language that uses aspectual adverbs rather than inflectional morphology for time

reference, a trade-off between verb retrieval and the use of aspectual adverbs was observed (Anjarningsih & Bastiaanse, 2011), showing that the deficit was more general: a problem with retrieving the name of the event and indicating when this event happened, happens or will happen. The Thai findings confirm the results of previous studies that verb production is an affected element in agrammatism, but, unlike in Standard Indonesian, no trade-off between verb retrieval and aspectual adverb use was found.

When serial verbs were examined, the verb problem also was also present: the Thai agrammatic speakers produced fewer serial verbs than the NBD speakers. Overall, our analysis showed that the production of verbs was low, not because the agrammatic speakers produced utterances without a verb, but because of the complexity of serial verbs. Recall that Thai verbs are complex: more than one verb can be connected in a single clause. When a series of verbs is used in a sentence, that sentence becomes grammatically complicated. To exemplify, the sentence, *Suchart norn arn nungsue*: lit. ‘Suchart lie (down) read book’ describes a simultaneous event of two actions. It shows that Suchart is not just lying down, or just reading a book, but is reading a book while lying down. Importantly, the two verbs have to be in this exact order to correctly express which verb modifies the other. The finding that Thai agrammatic speakers have difficulty producing serial verbs is novel and important. It is novel because never before have serial verbs in agrammatic speech been investigated. It is important because the results add to the body of literature on verbs: agrammatic speakers’ use of verbs is simplified, both in languages that use verb inflections, which are bound morphemes, and in languages with serial verbs, which are free morphemes.

In terms of particles, surprisingly, the number of polite particles produced by the agrammatic speakers was different from that of the NBDs, but in the opposite direction to that which would be expected. On the basis of the results from Standard Indonesian agrammatic speakers (Anjarningsih et al., 2012), we expected the production of particles to be impaired. However, the Thai agrammatic speakers produced more particles than the NBD speakers. We note that, unlike particles in Standard Indonesian which are grammatical words (Anjarningsih et al., 2012), particles in Thai are lexical words. Based on Boye and Harder’s (2012) theory (the usage-based theory of grammatical status and grammaticalization), this dichotomy between particle use in the two languages is not surprising. According to this theory, the same word class can have different functions across and within languages. The fact that Thai particles are lexical explains why they are produced frequently by Thai agrammatic speakers.

It is also worth noting that the overuse of particles by the Thai agrammatic speakers may have been caused by the experimental setting. Social hierarchy in Thai is important. The

young and those who are lower in social hierarchy are more likely to use polite particles than the old and those who are in socially higher positions. By adding polite particles at the end of a sentence, Thai speakers show politeness and respect to the people they address. The use of polite particles also demonstrates that the speakers converse appropriately to their status (Bhamoraput, 1972). It is likely that the agrammatic speakers perceived their social status to be lower than that of the interviewers. In a hospital setting, they were patients and the interviewer was to be associated with the hospital authorities. Our results suggest that Thai agrammatic speakers rely on pragmatics to a large degree. They obey the politeness rules, and include polite particles despite the fact that polite particles are non-essential elements that can be left out of a sentence (Prasithrathsint, 2001). In contrast, the NBD speakers were interviewed by telephone and were not in a patient-hospital setting, which may explain their low use of politeness particles.

The preservation of grammatical elements that are used to express politeness has been observed earlier. In Standard Indonesian, the passive is used to express politeness. This notoriously difficult construction is not affected in Standard Indonesian agrammatic aphasia as would be expected (Anjarningsih et al., 2012; Jap et al., 2016). Coupled with the findings in Standard Indonesian, the Thai data enhance our understanding of the interplay between pragmatics and syntax such that, in agrammatism, pragmatic constraints may interact with effects of grammatical complexity. These results may serve as a basis for future studies on the interaction between pragmatics and syntax.

5.2.3 Impairments of Time Reference Differ Depending on Language Structure

For the third research question regarding the pattern of impairment of time reference in Thai, the agrammatic and NBD participants were invited to take part in a sentence production and an auditory sentence-to-picture matching comprehension task (Chapter 3). The findings were not completely predicted by the PADILIH. For production, the PADILIH correctly predicted the results, but only when the production of *yangmai*, ‘not yet’, in place of the target word *jaa*, ‘will’, was counted as correct. Without this adjustment to coding, future time reference appeared to be particularly affected. For comprehension, reference to the future was also more vulnerable than reference to the past and the present. This is an interesting finding because if discourse linking is problematic in agrammatism, as predicted by the PADILIH, reference to all time frames should be equally impaired in languages that use aspectual markers to refer to time (as aspectual markers require discourse linking), regardless of modalities.

For the production study, the use of the negative, *yangmai*, in place of the future aspectual marker, *jaa*, is complicated for two reasons. First, *yangmai* is an acceptable alternative way for referring to the future in Thai. Second, *jaa* is the only marker that can be linguistically categorized as a modal, while the other time reference markers tested (*koei* for past; and *kamlang* for present) are aspectual adverbs. Taking these two considerations into account, there is a possibility that the Thai agrammatic speakers encounter processing difficulties because the word *jaa* is a grammatical word. According to Boye and Bastiaanse (2018), individuals with agrammatic aphasia have more problems producing words classified as grammatical than those classified as lexical. This leads to the further exploration of the grammatical-lexical distinction of Thai aspectual adverbs in Chapter 4 using ERPs. I come back to this in the next section.

In regards to the processing of time reference, it can be postulated that if the Thai agrammatic speakers had trouble with reference to the future, they should not have used another word which also expresses the future time frame (i.e., the negative phrase) as a replacement. Therefore, reference to the future may not be the cause of their problem, but rather the target word *jaa* may be too complex for these agrammatic speakers to compute. Despite this observation, it is true that, at an individual level, only two participants, SP and SM, showed an impairment to the future. For the comprehension study, however, there was no significant difference between conditions for any individual, but this is most likely due to the lack of power given that participants performed relatively well on the task. Replication with greater power is needed to be confident of the robustness of the results across individuals.

The analysis also showed that the internal structure of a phrase can differ in difficulty depending on whether that phrase is a specifier or a head in a syntactic tree. According to Rispens et al. (2001), it was more challenging for agrammatic speakers to construct negative sentences when the negation word was a functional head than when it was a specifier. Our results support Rispens et al.'s (2001) claim: the Thai negation *yangmai*, which is a specifier (Visonyangoon, 2000) was relatively spared in Thai agrammatic speakers.

All in all, the Thai results are inconclusive with respect to the PADILIH. The PADILIH has been tested extensively cross-linguistically, and past time reference which is discoursed-linked has been shown to be specifically affected. Similarly, in Chinese and Standard Indonesian, languages that use aspectual markers to express different time frames, equal impairment has been found across different event times. The reason that the future reference was poorly produced in Thai may have been affected by the grammatical status

of the target word, as earlier noted. The results encouraged us to look further at the lexical-grammatical function of aspectual markers, which was the focus of the research reported in Chapter 4.

5.2.4 Brain Responses to Time Reference Violation in Thai

The final research question of this dissertation was whether there are differences in brain responses to the processing of temporal information violations in the tenseless language Thai. Different ERP results to those typically found in Indo-European languages were observed. In previous studies on temporal violation in Indo-European languages, a P600, sometimes preceded by a left anterior negativity, LAN, was elicited (Baggio, 2008; Bos et al., 2013; Dragoy et al., 2012; Steinhauer & Ullman, 2002). For the study in Chapter 4, however, in the condition where an introductory temporal adverb was violated by a later aspectual adverb, an N400 was found. In the condition where an introductory aspectual adverb was violated by a later temporal adverb, a similar N400 was detected, but in this case, it was followed by a P600. This suggests that, to a large degree, the processing of the free-standing morphemes, Thai temporal markers, relies on semantic information irrespective of how the violation occurs (i.e., at an aspectual adverb, or at a temporal adverb).

In Chapter 4, it was noted that in languages that inflect verbs for time reference, the observed P600 was argued to reflect the grammatical properties of the morphological affixation on the verb stems (the morphological perspective; Baggio, 2008). Unlike Indo-European languages, Thai does not depend on morphosyntax to express time, but uses free-standing words. The N400 obtained in both conditions indicates that time reference in Thai has a stronger semantic component than is the case in Indo-European languages.

It was proposed that the P600, that was solely observed in the condition where the time frame was set by the aspectual adverb and was violated by a lexical adverb, was caused by a ‘repair and reanalysis’ mechanism. This is due to the fact that temporal adverbs carry more semantic information than aspectual adverbs. For instance, as noted in our analysis (Chapter 4), the temporal adverb *meuxwan*: ‘yesterday’ indicates that an event occurs within the time frame of a 24 hour period in the past. The aspectual adverbs, *jaa* and *koei*, however, are not as semantically enriched (like temporal adverbs) for they do not denote a specific time period: *jaa* for anytime in the future, and *koei* for sometime in the remote past. Thus, I argued, because temporal adverbs have richer temporal semantic characteristics, once participants encountered the temporal adverb, they considered it to indicate the correct time frame, and simply ignored the later, mismatching aspectual

adverb (i.e., ignored a repair scenario of omission / deletion). According to the monitoring account, this computation is not sufficiently complex and demanding to elicit the P600 (Kolk & Chwilla, 2007; Van de Meerendonk et al., 2010).

Critically, when the time frame set by an aspectual adverb was violated by a lexical adverb, reanalysis targeted the aspectual adverb, because aspectual adverbs are not as semantically informative as temporal adverbs. More specifically, the participants reanalyzed the time frame set up by the aspectual adverb and adjusted it to the time frame indicated by the temporal adverb. This operation is more complex and more demanding than the other condition discussed above (temporal followed by aspectual mismatch), and, thus, resulted in a frontal P600 (Kolk & Chwilla, 2007; Popov & Bastiaanse, 2018; Popov et al., 2020; Van de Meerendonk et al., 2010). According to Kaan and Swaab (2003), a frontal P600 reflects the need for sentence reanalysis when there is no overt morphosyntactic violation. The reanalysis in this case appears to take place at the discourse level.

5.3 SUMMARY

Both agrammatic behaviour and ERP studies inform us about how language is represented in the human brain. In Chapter 2, I show that the basic characteristics of Thai agrammatic speech do indeed resemble the general features of agrammatic profiles in other languages. Verbs are reported to be a vulnerable element in agrammatism, regardless of how they are used (i.e., affixation or free morphemes). Polite particles were shown to be relatively spared in Thai agrammatic speech. In Chapter 3, in both production and comprehension, my sample of Thai agrammatic speakers was more affected in reference to the future than to the past and the present. However, for production, the grammatical status of the future marker as a modal may be the cause of the impairment of reference to the future. Finally, in Chapter 4, I demonstrated that temporal information in Thai is more semantically processed than in Indo-European languages.

5.4 OVERALL CONCLUSIONS

It is clear that aspectual adverbs, which are typical linguistic features used to express time reference in Thai, are a grammatical class that has not received much attention in neurolinguistics in the past. The overall findings of the current project help us to understand the nature of language impairments in a broader and deeper perspective. It is broader in a sense that aside from the neurolinguistic knowledge gained from widely-

studied Indo-European languages, we now learn something more about an understudied language in the aphasia literature, Thai. It is deeper in a sense that the concept of time reference in Thai was intensively examined, providing further evidence on time reference and agrammatism. I, therefore, hope that the current findings will lead to a development of better diagnostic assessment and clearer directions for aphasia treatment, and thereby help maximize the recovery of aphasia, especially through the use of linguistically-based therapies.

5.5 LIMITATIONS AND FURTHER STUDIES

The current project offers some insights into the characteristics of Thai agrammatism, and sheds some light into the electrophysiological correlates of temporal agreement in Thai in a neurolinguistic context. Whilst the results of the time reference study in Thai did not fully confirm the PADILIH prediction that all time frames are equally impaired in languages with aspectual markers, it did substantiate that time reference is indeed a problematic element in agrammatic aphasia. More research in Thai and in other languages with aspectual markers is, therefore, needed to understand the underlying deficit of temporal expressions in agrammatism. Further, it would be interesting to examine serial verb construction in more detail, to see if all types of verb series are affected, or if there is a specific kind of verb series that is particularly vulnerable in agrammatic aphasia. In addition, as only polite particles were examined in the current project, the findings may not be transferable to other types of particles. Thus, follow-up studies should come up with a more fine-grain method that allows a better production of other types of particles. For the ERP study, as some aspectual markers in Thai are more grammatical while others are more lexical (Muansuwan, 2002), it might be interesting to try to operationalize that scalar distinction and conduct a follow up study where a cline of grammatical and lexical status is a factor for language processing.

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Appendices

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)	4F's, 5M'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	Handedness	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)	5F's, 4M'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	krappao	pack	suitcase
waad	loop	draw	picture
took	kai	crack	egg
perd	jodmai	open	letter
prang	fun	brush	teeth

S

Summary

This dissertation focuses on the linguistic expression of time reference in people with language impairment (agrammatic aphasia) and non-brain damaged (NBD) speakers, using online and offline methodologies. The language in focus is Thai, a Southeast Asia language that is structurally and morphologically different from Indo-European languages. The study contributes to increasing the representation of Asian languages in the aphasiology and neurolinguistic literature, and to a deeper understanding of temporal processing.

Chapter 1 gives an outline of the thesis. It starts by introducing the concepts of agrammatic speech and temporal expression. An overview of the relevant characteristics of the Thai language is then given to familiarize readers with the basic structures of Thai, followed by an outline of relevant theoretical frameworks and methodologies. Finally, research questions are posed.

Chapter 2 characterizes the spontaneous speech of Thai speakers with agrammatic aphasia. The grammatical abilities of nine agrammatic speakers are analyzed and compared to that of nine NBD speakers. The study both investigates typical features of agrammatic speech and examines specific features of Thai—serial verbs, aspectual adverbs, and polite particles. The findings are in line with key agrammatic characteristics observed in other previously reported languages, such as a slower speech rate and short and often ungrammatical utterances. The individuals with agrammatic aphasia also showed differences in features specific to Thai: they produced fewer serial verbs, but more polite particles than the NBD speakers.

Chapter 3 evaluates patterns of production and comprehension of time reference in Thai agrammatic speakers. Importantly, unlike Indo-European languages, Thai lacks verb inflection and conveys time reference by means of aspectual markers. In both production and comprehension, a sample of nine Thai agrammatic speakers were more impaired in reference to the future than the past and the present. However, for production, error analysis showed substitution and omission errors for reference to the past and the present but also the use of negation for the future. It is argued that negation is an alternative way to refer to the future in Thai. Taking this into account, no difference was found in accuracy of the three time frames. This pattern is discussed with reference to the PADILIH.

Chapter 4 explores how temporal violations are processed in Thai. An ERP-paradigm was used to examine temporal violations processing and repair when the violations are caused by two different kinds of adverbs—lexical and aspectual. The results showed an N400 effect for temporal disagreement, with a P600 only in the condition where the violation occurs

when a temporal adverb follows an aspectual adverb (and not in the reverse condition). It is proposed that temporal (lexical elements) and aspectual adverbs (grammaticalized elements) trigger different kinds of sentence repair and reanalysis (as reflected by the P600). When compared to Indo-European languages, where time reference violation by verb inflection results in a (LAN+) P600, in Thai, temporal and aspectual adverbs are semantic in nature and elicit N400. However, since temporal adverbs are more temporally specific than aspectual adverbs, violation of temporal adverbs also elicits P600.

This dissertation ends with general conclusions and discussion in **Chapter 5**. Three major conclusions were drawn. First, key characteristics of agrammatic speech were found to be consistent across languages. However, investigation of Thai demonstrated that there are also language-specific features. Second, impairments of time reference differ from one language to another depending on the language structure. Last, the human brain responds differently to different kinds of time reference violation, and once again, investigations from Thai provide crucial insights for our understanding of how the brain processes time reference.

Overall, through investigations of an understudied language, Thai, which has distinct features from the majority of languages that have been investigated in the past, this dissertation has provided a broader and deeper understanding of language impairment and language processing. As a result, it has also provided potential directions for future research, both theoretical and clinical.

NS

Nederlandse Samenvatting

Dit proefschrift richt zich op de linguïstische aspecten van tijdsverwijzing bij mensen met een taalstoornis (agrammatische afasie) en sprekers zonder hersenletsel. Er is gebruik gemaakt van online en offline methodes. De taal waarop wordt gefocust is het Thai, een Zuidoost-Aziatische taal die qua structuur en morfologie verschilt van Indo-Europese talen. Dit onderzoek draagt bij aan het vergroten van de kennis over afasie in en neurolinguïstische verwerking van Aziatische talen en tevens tot een beter begrip van tijdsverwijzen met behulp van linguïstische middelen.

Hoofdstuk 1 geeft een overzicht van het proefschrift. Het introduceert de concepten van agrammatisch taalgebruik en tijdsverwijzing. Vervolgens wordt een overzicht gegeven van de relevante kenmerken van de Thaise taal om de lezers vertrouwd te maken met de basisstructuren van het Thai. Daarnaast wordt een samenvatting gegeven van relevante theoretische kaders en methodologieën. Tenslotte worden de onderzoeksvragen gepresenteerd.

Hoofdstuk 2 schetst een beeld van de spontane taal van Thaise agrammatische sprekers. De grammaticale en lexicale vaardigheden van negen agrammatische sprekers worden geanalyseerd en vergeleken met die van negen sprekers zonder hersenletsel. De studie onderzoekt zowel typische kenmerken van agrammatisch taalgebruik als ook specifieke kenmerken van de Thaise taal: seriële werkwoorden, aspectuele bijwoorden en beleefdheidspartikels. De bevindingen zijn in overeenstemming met de belangrijkste agrammatische kenmerken gerapporteerd voor andere talen, zoals een lagere spreek snelheid en korte en vaak ongrammaticale uitingen. De sprekers met agrammatische afasie vertoonden ook verschillen op de variabelen die specifiek zijn voor het Thai: ze produceerden minder seriële werkwoorden, maar meer beleefdheidspartikels dan de sprekers zonder hersenletsel.

Hoofdstuk 3 onderzoekt patronen van productie en begrip van tijdsverwijzing bij Thaise agrammatische sprekers. Het Thai, in tegenstelling tot Indo-Europese talen, gebruikt geen tijdsmarkering op het werkwoord om te verwijzen naar het tijdvak van de gebeurtenis. Het Thai gebruikt aspectuele markering voor tijdsverwijzing. Bij een steekproef van negen Thaise agrammatische sprekers was het verwijzen naar de toekomst meer aangetast dan verwijzen naar het heden, voor zowel productie als begrip; er was geen verschil tussen verwijzing naar het heden en het verleden. De foutenanalyse voor productie toonde het gebruik van negatie als verwijzing naar de toekomst. Er wordt beargumenteerd dat negatie een alternatieve manier is om in het Thai naar de toekomst te verwijzen. Wanneer hiermee rekening werd gehouden was er geen verschil in accuratesse tussen de drie tijds categorieën. Deze observaties worden besproken in het kader van de PADILIH.

Hoofdstuk 4 onderzoekt hoe schendingen van tijdsverwijzing in het Thai wordt verwerkt. Met behulp van een ERP-opzet werd de verwerking van foutieve tijdsverwijzing onderzocht. Hierbij werden de incorrecte tijdsverwijzingen verkregen door twee verschillende soorten bijwoorden: lexicaal en aspectueel. De resultaten toonden een N400-effect voor een mismatch in de tijdsaanduiding. Er werd ook een P600-effect gevonden, maar alleen in de conditie waarin de schending bestond uit een lexicaal bijwoord gevolgd door een aspectueel bijwoord (en niet in de omgekeerde conditie). Er wordt gesteld dat lexicale bijwoorden en aspectuele bijwoorden (die een grammaticale functie hebben) verschillende soorten heranalyse triggeren (zoals aangetoond door de P600). In vergelijking met Indo-Europese talen, waar foutieve tijdsverwijzing door vervoeging van een werkwoord resulteert in een (LAN +) P600, zijn in het Thai temporele en aspectuele bijwoorden lexicaal van aard en zij veroorzaken een N400. Aangezien temporele bijwoorden meer tijdspecifiek zijn dan aspectuele bijwoorden, veroorzaakt schending van temporele bijwoorden ook een P600.

Het proefschrift eindigt met algemene conclusies en discussie in **Hoofdstuk 5**. Er worden drie belangrijke conclusies getrokken. Ten eerste bleken de belangrijkste kenmerken van agrammatisch taalgebruik consistent te zijn in verschillende talen. Dit onderzoek naar de Thaise taal heeft aangetoond dat er daarnaast ook taalspecifieke kenmerken zijn, die ook gestorod zijn. Ten tweede verschillen de problemen met tijdsverwijzing van taal tot taal, afhankelijk van de taalstructuur. Ten slotte blijkt dat de menselijk hersenen anders reageren op verschillende typen schendingen van tijdsverwijzing. Daarmee biedt het onderzoeken van het Thai belangrijke inzichten voor ons begrip van hoe de hersenen tijdsverwijzing verwerken.

Het Thai is een weinig bestudeerde taal die in veel opzichten verschilt van de meeste talen die in het verleden zijn onderzocht. Door het Thai te onderzoeken heeft dit proefschrift een breder en dieper begrip opgeleverd van taalstoornissen en taalverwerking. Hierdoor levert dit proefschrift waardevolle theoretische en klinische suggesties voor toekomstig onderzoek.

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GRODIL

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P.O. Box 716
9700 AS Groningen
The Netherlands

PROPOSITIONS

1. In the spontaneous speech of agrammatic speakers, the production of verbs is affected, regardless of the form in which they appear in a language.
– *This dissertation (Chapter 2)*
2. Thai agrammatic speakers have restricted production of verbs, because these individuals find it difficult to express complex events using serial verb constructions.
– *This dissertation (Chapter 2)*
3. In languages that use non-obligatory aspectual adverbs, reference to all time frames (past, present, future) is discourse-linked, making time reference difficult for agrammatic individuals with discourse linking impairments.
– *This dissertation (Chapter 3)*
4. In Thai agrammatic speakers, reference to the future is affected because of its grammatical role as a modal.
– *This dissertation (Chapter 3)*
5. Non-brain damaged individuals show different brain responses to time reference violations, depending on the linguistic means used to express time reference, be it the use of affixation, temporal adverbs or aspectual adverbs.
– *This dissertation (Chapter 4)*
6. The violation of time reference realized through lexical means (i.e., lexical and aspectual adverbs) elicits an N400 effect, reflecting the semantic nature of the violation.
– *This dissertation (Chapter 4)*
7. The reanalysis of a sentential / discourse time frame elicits a frontal P600.
– *This dissertation (Chapter 4)*
8. We can know only that we know nothing. And that is the highest degree of human wisdom.
– *Leo Tolstoy, War and Peace*
9. The cure for boredom is curiosity.
– *Dorothy Parker*
10. Those who cannot dance, blame it on the flute and the drum.
– *Thai Proverb*