Time reference in aphasia

Koukoulioti, Vasiliki; Bastiaanse, Roelien

Published in:
Journal of Neurolinguistics

DOI:
10.1016/j.jneuroling.2019.100872

Journal of Neurolinguistics 53 (2020) 100872

Contents lists available at ScienceDirect

Journal of Neurolinguistics

journal homepage: www.elsevier.com/locate/jneuroling

Time reference in aphasia: Evidence from Greek

Vasiliki Koukoulioti[a,1,*], Roelien Bastiaanse[b,c]

[a] Department of Linguistics, School of Philology, Aristotle University of Thessaloniki, University Campus, 54124, Thessaloniki, Greece
[b] Center for Language and Cognition Groningen (CLCG), University of Groningen, 9700, AB, Groningen, the Netherlands
[c] Center for Language and Brain, National Research University Higher School of Economics, 21/4 Staraya Basmannaya str., Moscow, Russian Federation

ARTICLE INFO

Keywords:
Aphasia
Time reference
Modern Greek
Tense
Aspect

ABSTRACT

Several studies have shown selective deficits in the production and comprehension of verb forms referring to the past. On the basis of this evidence the Past Discourse Linking Hypothesis (Bastiaanse et al., 2011) suggests that individuals with aphasia have difficulties with verb forms referring to the past, in comparison to non-past forms such as the present and the future. However, many studies provide counterevidence. This study presents a review of the literature and addresses the question of dissociation between the past and the non-past in aphasia in Greek, a language which distinguishes among three past forms. A mixed group of eight individuals with aphasia and a group of 10 non-brain-damaged speakers performed the two tasks of the Greek version of the Test for Assessing Reference of Time (Bastiaanse, Jonkers, & Thompson, 2008): a sentence completion task (primed by pictures) and a sentence-picture matching task. The sentence completion task tested the present, future and three past tenses: past perfective, past imperfective and present perfect. The sentence-picture matching task tested past perfective, present and future. The production data provide evidence for a deficit in the reference to the past but they also suggest difficulties with the future. Interestingly, a dissociation among the three past tenses tested was found. Above chance performance was found in comprehension across tenses. We consider possible accounts of the data and we discuss the implications of these findings for the Past Discourse Linking Hypothesis.

1. Introduction

The literature on aphasic language suggests that many speakers with aphasia after stroke suffer from morphosyntactic deficits, manifesting as substitution of bound grammatical morphemes and omission of free grammatical morphemes and verbs. These deficits are more pronounced in the so-called non-fluent/agrammatic aphasia, they also occur, however, in other types of aphasia. In the aphasiological research, several hypotheses have been formulated in order to account for these deficits, ranging from problems in phonological processing (Kean, 1977) to problems in information integration at the interface of syntax and semantics (e.g. Varlokosta et al., 2006). A recent account of morphosyntactic deficits with verbs in agrammatic aphasia suggests that agrammatic speakers fail to produce verb forms which refer to the past (Bastiaanse, 2013; Bastiaanse et al., 2011). Data from several languages, elicited by a test developed with this aim, the Test for Assessing Reference of Time (henceforth TART, Bastiaanse, Jonkers, & Thompson, 2008), support this hypothesis. In the present study we present the data collected with the Greek version of this test (Koukoulioti &

* Corresponding author. Department of Linguistics, Goethe University, Norbert-Wollheim-Platz 1, D-60629, Frankfurt am Main, Germany.
E-mail address: vasiliki.koukoulioti@gmail.com (V. Koukoulioti).
[1] Present address: Department of Linguistics, Goethe University, Norbert-Wollheim-Platz 1, D-60629 Frankfurt am Main, Germany.

https://doi.org/10.1016/j.jneuroling.2019.100872
Received 24 March 2019; Received in revised form 6 September 2019; Accepted 10 September 2019
Available online 27 September 2019
0911-6044/

Bastiaanse, 2008). Greek is an interesting language concerning this question because tense interacts with aspect and reference to the past can be tested with (at least) three tenses: past perfective, past imperfective and present perfect. The present study has two primary purposes: 1) to investigate production and comprehension of time reference by Greek-speaking individuals with aphasia and 2) to present data not only from individuals with agrammatic aphasia but also from individuals with anomic and Wernicke's aphasia, who have not received that much attention in the literature. Additionally, the present study aims to contribute to the research on inflection and time reference in aphasia by providing a review of the existing literature.

2. Aphasiological background - production and processing of past tense in aphasia

Broca's aphasia, is characterized by non-fluent speech, omissions of verbs and omissions or substitutions of grammatical morphemes, simplified syntax (lack of embedded clauses, avoidance of verbs with complex argument structure). Concerning inflection, it has been found that the deficit is more selective than a general failure of grammar: tense and aspect are more impaired than agreement. The most prominent hypotheses on the morphological deficit attribute the problems either to the impaired syntactic representations (e.g. Friedmann & Grodzinsky, 1997) or to the complexity of syntactic operations (Bastiaanse & van Zonneveld, 1998). According to the Tree Pruning Hypothesis (Friedmann & Grodzinsky, 1997) the syntactic tree is pruned and higher nodes are unavailable in contrast to lower ones. Bastiaanse and van Zonneveld (1998, 2005) claim that structures with derived word order are impaired in agrammatism—in Dutch, finite verbs in the matrix clause are in derived position and are vulnerable in Dutch agrammatic speech. Other researchers account for the selective deficit with tense (and aspect) in terms of the distinction between interpretable and uninterpretable features in the framework of the Minimalist Program (e.g. Fyndanis, Varlokosta, & Tsapkini, 2012; Nanousi, Masterson, Druks, & Atkinson, 2006; Varlokosta et al., 2006; Wenzlaff & Clahsen, 2004). These hypotheses assume that interpretable features (like tense) are underspecified which leads to tense and aspect errors.

More recently the inflection problem in aphasia has been found to be even more selective. In particular, Bastiaanse et al. (2011) found in a cross-linguistic study that reference to the past is impaired independent of the grammatical means in which it is expressed (e.g. simple inflected forms, periphrastic forms, or temporal adverbials). The deficit in the reference to the past is supposed to be due to its contextual salience: events in the past have to be linked to the discourse, as the event time is not included in the speech time. Difficulties with discourse-linked elements in Broca's aphasia go back to Avrutin (2006), who suggested that the language system is distinguished into two different domains: the narrow and the discourse syntax. Whereas narrow syntax deals with dependencies within sentence, discourse syntax concerns information structure. In terms of computational resources narrow syntax is less costly and discourse syntax computationally more expensive, i.e. error prone in case of language disorders. When referring to the present, speech time and event time overlap so there is no need for discourse linking. When referring to the past, the event time is outside the speech time and is related to the discourse which is already built through the dialogue (cf. the difference between personal and reflexive pronouns). Data supporting this hypothesis come from languages with different typological properties, such as Chinese, English, Turkish (Bastiaanse et al., 2011) Indonesian (Anjarningsih, 2012), Dutch (Bos & Bastiaanse, 2014), and Swahili (Abuom & Bastiaanse, 2013), (see Bastiaanse, 2013 for a review and below for more studies and details).

Avrutin (2006) formulated his hypothesis on the impairment of discourse-linked elements in order to interpret comprehension data, therefore, it should be assumed that processing reference to the past is also impaired. Bastiaanse et al. (2011) report lower performance in the comprehension of reference to the past compared to reference to the present, but the future is shown to be impaired as well, contrary to the assumptions of PADILIH.

Problems with verb inflection have also been found in fluent aphasia. Fluent aphasia is characterized by normal (or excessive) speech rate, phrase length and intonation. The term's use is not consistent across the literature and its usefulness also contested. This is due to the fact that the term, “fluent aphasia” characterizes aphasia on the basis of speech features, which are independent from linguistic symptoms or performance in comprehension[2] (Edwards, 2005; Huber, Poeck, & Weniger, 2000). Fluent aphasia has been used as an umbrella term for Wernicke's, anomic, transcortical sensory and conduction aphasia (Huber et al., 2000). Speech rate in Wernicke's aphasia is normal (or even excessive) and intonation is also normal. Concerning language symptoms, individuals with Wernicke's aphasia produce many phonological and semantic paraphasias (in severe cases jargon) and have problems producing grammatically well-formed sentences (paragrammatism). Moreover, they face severe problems in comprehension. Wernicke's aphasia has been contrasted with Broca's aphasia in terms of lesion site, fluency and deficits in production and comprehension. However, there is still a need for a satisfying definition of Wernicke's aphasia and distinction between Broca's and Wernicke's aphasia (De Bleser, 1987 for a historical review of the notions of agrammatism and paragrammatism; Edwards, 2005). Anomic aphasia, the other fluent aphasia type relevant for the present study, is characterized by intact sentence production and comprehension with the basic symptom being difficulties in word finding, phonemic and semantic paraphasias. Often the word-finding difficulties affect speech rate.

The grammatical deficit and the inflection problems in fluent aphasia have received much less attention than in non-fluent aphasia. The problems have been attributed to a general cognitive deficit (Butterworth & Howard, 1987) or to a deficit to integrate syntactic and lexical computations (e.g. Bastiaanse & Edwards, 2004). Bastiaanse and Edwards (2004) suggest that morphosyntactic problems in Wernicke's aphasia are due to difficulties to integrate word retrieval and grammatical operations. With respect to time reference, Jonkers and de Bruin (2009) compared production and comprehension of present and past and found that individuals with

[2] Following this view, in the present study we used the linguistic symptoms as criterion in order to allocate the patients into different aphasia types (for details see section 4.2.1.) rather than fluency. We use the term *fluent aphasia* when reviewing previous studies, following the authors' terminologies.

both Broca's and Wernicke's aphasia had more problems with reference to the past than reference to the present; with the difference being significant only in comprehension. Bos and Bastiaanse (2014), who reported similar results, compared production of past and present with the Dutch version of the TART. They found that subjects with both agrammatic non-fluent and fluent aphasia were more impaired in the past than in the present condition, but the groups produced different error types. Individuals with Broca's aphasia substituted past forms (simple past) with other forms that refer to the past more infrequently in comparison to individuals with fluent aphasia. The researchers suggest that the different error types point to different underlying deficits: speakers with agrammatic aphasia avoid reference to the past and speakers with fluent aphasia, being challenged by the discourse-linking required in producing past forms, face retrieval problems. Kljajevic and Bastiaanse (2011) tested Serbian individuals with fluent aphasia and confirmed difficulties in the production of past tense. Additionally, they report that errors for non-past targets consisted mainly of substitutions with non-past forms, whereas errors for past targets were substitutions with non-past forms. Concerning comprehension, Kljajevic and Bastiaanse (2011) report selective impairment with comprehension of the future tense.

Dragoy and Bastiaanse (2013) also report problems with reference to the past in Russian, but they found an interaction of reference to the past with aspect, which seems to relativize the reference to the past deficit. They tested perfective and imperfective verb forms (which have different entries in the dictionary in Russian) in past and non-past. There was a general deficit with reference to the past for both fluent and non-fluent subgroups. Nevertheless, reference to the past was less impaired than reference to the non-past for perfective verbs, and the opposite held for imperfect verbs.

Whereas data acquired with the TART are relatively consistent with respect to reference to the past, this is not the case with reference to the future. According to Zagona (2003, 2013) the future refers to events that have not happened yet and might never happen. In this respect the future cannot be discourse-linked and according to the PADILIH, it should be preserved in (agrammatic) aphasia. Bastiaanse et al. (2011) report good performance in the production of the future for English, Turkish and Chinese. Yarbay Duman and Bastiaanse (2009) also found better performance in the future than in the past for agrammatic speakers of Turkish. The findings of Martínez-Ferreiro and Bastiaanse (2013) are more contradictory, as they found that the future was the best preserved tense for the Catalan-speaking individuals with non-fluent aphasia of their study, but they also found low performance in the future for their Spanish-speaking individuals with non-fluent aphasia. Rofes, Bastiaanse, and Martínez-Ferreiro (2014) examined the use of the future and the two conditional forms in Catalan, one (the simple) referring to the future and one (the periphrastic) referring to the past, by testing a group of individuals with non-fluent aphasia (Broca's, transcortical motor and global). All forms were relatively impaired, but in irrealis reference to the past is more impaired, i.e. the periphrastic form was more difficult than the future and the simple conditional. Note that irrealis conditional clauses "fall under the scope of non-fact modality […] they, thus have no truth value." (Givón, 2001, p. 331). However, the performance in the future was impaired as well (mean performance 53.5%).

Several other studies report no dissociation among time frames. Wenzlaff and Clahsen (2004) failed to find dissociation between the past and non-past in a forced-choice completion task for a group of seven agrammatic individuals. Similar results are reported by Clahsen and Ali (2009) for a group of English-speaking agrammatic patients. Wenzlaff and Clahsen (2004) as well as Clahsen and Ali (2009) failed to find a dissociation between past and present in grammaticality judgment tasks as well, which tap into tense processing rather than production. Importantly, Faroqi-Shah and Friedman (2015) performed a meta-analysis and provided evidence that the past/non-past dissociation is a task-specific effect, due to the higher computational load of a picture description task. Moreover, they conducted a version of sentence production with a picture description task and they did not find any dissociation between different time frames.

Concerning Greek-speaking individuals with agrammatic aphasia, Stavrakaki and Kouvava (2003) report selective difficulties with the past perfective in comparison to the present but also the past imperfective in the spontaneous speech of two agrammatic speakers and the preserved use of the future. Despite the impairment in production the agrammatic speakers of Stavrakaki and Kouvava (2003) manifested very high sensitivity to the grammaticality of past tense marking. Nanousi et al. (2006), however, reported selective difficulties with the past perfective as well as the future in comparison to the past imperfective and the present in a sentence transformation task. Fyndanis et al. (2012), on the other hand, found that the present was especially impaired (presumably due to inappropriate cueing adverbials) and found no dissociation between the past and the future for two agrammatic patients. In a very recent study, Fyndanis, Arcara, Christidou, and Caplan (2018) did not find a past/non-past dissociation in a group of eight patients with agrammatic aphasia. Similarly, Fyndanis, Varlokosta, and Tsapkini (2013) report no dissociation among the past, present and future in a sentence-picture matching and a grammaticality judgment task for three agrammatic individuals.

With respect to non-agrammatic aphasia in Greek, Varlokosta et al. (2006) report problems with future and equal difficulties in perfective and imperfective aspect for a mixed group of individuals with aphasia (one individual with anomia, four individuals with non-fluent aphasia, one individual with fluent aphasia, with grammatical deficits and one individual with Wernicke's aphasia) in a sentence completion task. Koukoulioti (2013) applied a similar task and provided evidence for an interrelation between time reference, grammatical and lexical aspect in a sentence completion task. Finally, Koukoulioti and Stavrakaki (2014) report that while the production of the past tense did not affect verb retrieval in a mixed group of individuals with aphasia, it did have a detrimental effect for one agrammatic patient, who made both inflection and lexical errors, in a sentence production with a video description task. Table 1 summarizes the findings of the studies which address the difference between time frames concerning the modality tested, the type of aphasia, the language and the method used.

3. Theoretical background – verb inflection in Modern Greek

As mentioned above, the verb in Greek is inflected for tense and aspect. With respect to tense, "the verb forms differentiate only between past and non-past." (Holton, Mackridge, & Philippaki-Warburton, 2004, p. 118). Three aspects are distinguished in Greek: 1) the imperfective (the event is described as in progress or taking place repeatedly) 2) the perfective (the event is described as completed) and

Table 1
Summary of the results of studies which address the production of verbs in different time frames.

Study	Type of aphasia	Method	Language(s)	Modality	
				Production	Comprehension
Abuom and Bastiaanse (2013)	Agrammatic	TART test	Kenyan-English Swahili	Kenyan-English: Past < Present and Future Swahili: Past < Present and Future	Kenyan-English: Past < Present and Future Swahili: Past < Present and Future
Anjarningsih (2012)	Agrammatic	TART test	Indonesian	Past = Present = Future (all time frames require discourse-linking)	Past = Present = Future (all time frames require discourse-linking)
Bastiaanse et al. (2011)	Agrammatic	TART test	Chinese English Turkish	Chinese: Past = Present = Future English: Past < Present and Future Turkish: Past < Present and Future	Chinese: Past < Future < Present English: Past < Future < Present Turkish: Past and Future < Present
Bos and Bastiaanse (2014)	Non-fluent agrammatic Fluent (anomic and Wernicke)	TART test	Dutch	Past < Present Different error types	–
Clahsen and Ali (2009)	Agrammatic	Forced choice completion Grammaticality judgement	English	Past = Non-past	Past = Present
Dragoy and Bastiaanse (2013)	Non-fluent Fluent	TART test	Russian	Past < Non-past (Present and Future) Interaction of time reference and lexical aspect	–
Faroqi-Shah and Friedman (2015)	Broca's, Mixed	Meta-analysis Sentence production with picture description	English	No dissociation between time frames	–
Fyndanis, Arcara, Christidou, and Caplan (2018)	Agrammatic	Sentence completion task	Greek	Past = Non-past (Future)	–
Fyndanis, Varlokosta and Tsapkini (2012)	Agrammatic	Sentence completion task	Greek	Present < Past and Future	–
Fyndanis, Varlokosta, and Tsapkini (2013)	Agrammatic	Sentence-picture matching	Greek		Past = Present = Future
Jonkers and de Bruin (2009)	Broca's Wernicke's	Sentence completion Sentence-to-picture matching	Dutch	Past = Present	Past < Present
Kljajevic and Bastiaanse (2011)	Fluent	TART test	Serbian	Past < Future < Present	Future < Past and Present
Koukoulioti (2013)	Mixed group (Agrammatic, Anomic, Wernicke)	Sentence completion task	Greek	No specific deficit with past, interaction between time reference, grammatical and lexical aspect	–
Koukoulioti and Stavrakaki (2014)	Mixed group (Agrammatic, Anomic, Wernicke)	Sentence production with video description	Greek	Verbs inflected for past tense were more difficult to produce for one agrammatic patient but no effect for other participants	–
Martinez-Ferreiro and Bastiaanse (2013)	Non-fluent (Broca's, mixed transcortical and global)	TART test	Spanish Catalan	Spanish: Past and Future < Present Catalan: Past < Present < Future Two languages together: Past < Present and Future	Two languages together: Past < Future < Present
Nanousi et al. (2006)	Agrammatic	Sentence transformation task	Greek	Past perfective and Future < Past imperfective and present	
Rofes, Bastiaanse and Martínez-Ferreiro (2014)	Non-fluent	TART test	Catalan	Irrealis reference to the past < Future Low performance in Future	–
Stavrakaki and Kouvava (2003)	Agrammatic	Spontaneous speech Grammaticality judgement	Greek	Past perfective < Past imperfective, Present and Future	Good performance across tenses
Varlokosta et al. (2006)	Mixed group (Anomic, Non-fluent, fluent and Wernicke)	Sentence completion task	Greek	Problems with future, no specific reference to past	–
Wenzlaff and Clahsen (2004)	Agrammatic	Forced choice completion Grammaticality judgement	German	Past = Non-past	Past = Present
Yarbay Duman & Bastiaanse (2009)	Agrammatic	Sentence completion task	Turkish	Future > Past	

3) perfect (the event is described as completed in the past but with relevance for some other subsequent point of time).

The present tense is always imperfective[3] and refers to the present, to an eventuality that is in progress and happens at the time of utterance, or in a time span, in which the time of utterance is included (e.g. this month, this year, etc) or is iterated up to a time span in which the time of utterance is included (e.g. *Every summer I travel to Athens*). The past perfective and past imperfective refer to the past and describe an event as bounded and unbounded, respectively. Unbounded are eventualities which are "ongoing at an interval", whereas bounded are eventualities which are "contained in an interval and as such they have reached an endpoint or they are terminated" (Iatridou, Anagnostopoulou, & Izvorski, 2003, p. 155). In terms of morphology, the present and past imperfective share the same imperfective stem (e.g. *δen*-of verb *δeno* 'tie'), whereas the past perfective is formed by the perfective stem (e.g. *δes*-of verb *δeno*) (see Table 2).

In the current study, we tested two periphrastic verb forms, the future and the present perfect. The future is formed by the particle[4] *θa* 'will/shall', the future reading of which is one of its various (modal) readings (Roussou & Tsangalidis, 2010; Tsangalidis, 1999) as the interpretation of *θa* depends on the temporal and aspectual features of the verb form with which it is combined. *θa* combined with the dependent form expresses exclusively futurity (*θa δes-o* 'I will/shall tie'), whereas combined with –past/-perfective forms it can convey either futurity or an epistemic statement about the present (probability). The particle *θa* can also be combined with [+past] form referring to past events (such as epistemic assertions about the past). Tsangalidis (1999) argues that the dependent form has a non-specific, non-past time reference and, combined with *θa,* it can only convey futurity. Consequently, whether a periphrasis with *θa* receives a temporal location or not depends on the processing of the inflected verb.

The second periphrastic tense tested is the present perfect. Present perfect is formed by the present tense of *exo* 'have' and the non-finite form which consists of the perfective stem and the suffix *–i*, e.g. *exo δesi* 'I have tied'. The perfect is a special form as it is not clear whether it is a tense or an aspect. One of the two uses of present perfect in Greek, the experiential perfect denotes that a person has a certain experience, e.g. *Exo oδijisei antika δio fores* 'I have driven an old-timer twice'. The other use, the perfect of result can be combined only with telic events and denotes that an eventuality took place, e.g. *Exo xasi ta jialia mu* 'I have lost my glasses' (the example from Iatridou et al., 2003). Moser (2003) claims that the present perfect in Modern Greek is idiosyncratic in the sense that "its relationship with the present is rather tenuous" (p. 236) and that actually the past perfective and the present perfect are in most cases interchangeable in Modern Greek. The difference between the two forms is in the remoteness. Specifically, Moser suggests that the present perfect denotes anteriority and she proposes a continuum in the forms referring to the past. In her view, "the perfect describes an event more remote than the aorist,[5] and the past perfect an event more remote than the perfect" (Moser, 2003, p. 244).

Veloudis (1990, 2003) rejects a temporal meaning of the present perfect and suggests that the present perfect makes an anaphoric reference, in the sense that it extracts a piece of shared knowledge (e.g. a situation, an event) between the speaker and the hearer. In particular, the present perfect appeals to a situation and does not describe it, which is what the simple past does. Veloudis (1990) explicates this claim by suggesting that the present perfect is the grammatical means of conveying a conventional implicature. Conventional implicatures are non-truth-conditional (Levinson, 1983). Thus, the truth value of a proposition which describes an event in the present perfect cannot be judged as true/false, rather it is inferred by a proposition which describes the same event in past tense (e.g. *John has run* vs *John ran*). In sum, present perfect is more complex than the other tenses tested in this study, as it is morphologically a non-past form (see Table 2), which makes assertions about the present time on the basis of past events.

4. The present study

4.1. Aims and predictions

The aim of the present study is to investigate production and comprehension of time reference in individuals with aphasia. Although the hypothesis was originally formulated in order to account for agrammatic language, previous research has shown that individuals with fluent aphasia are also affected, although they make other kinds of errors (Bos & Bastiaanse, 2014). The PADILIH predicts that reference to the past should be selectively impaired, independent of form. The future should be relatively preserved as a non-past form. Note, however, that in previous studies on Greek dissociations between past verb forms have been found (Nanousi et al., 2006; Stavrakaki & Kouvava, 2003), as well as problems with the future tense too (Fyndanis et al., 2012; Nanousi et al., 2006; Varlokosta et al., 2006). Therefore, such dissociations are probable on the basis of previous data.

4.2. Methods

4.2.1. Participants

Eight individuals with aphasia (hereafter IwA) were included in the study (one female, mean age = 58, standard deviation = 7.3, mean years of education = 14, standard deviation = 1.7), the demographics and illness data are presented in Table 3. All IwA except for An4, who was in the subacute period, were in the chronic phase. The diagnosis was made on the basis of the Boston Diagnostic Aphasia Examination (adapted for Greek by Tsapkini, Vlahou, & Potagas, 2009/2010) and the spontaneous speech. The individual scores in the tasks of the BDAE are presented in Appendix A. The performance of each patient was compared to that of their age and educational group and, if found more than 2 standard deviations below the mean, it was judged as impaired (cf. Borod, Goodglass, & Kaplan, 1980). Concerning spontaneous

[3] We will discuss the dependent non-past perfective form when we refer to the future.

[4] See Roussou and Tsangalidis (2010) for a different view on the status of *θa*.

[5] By aorist Moser means the past perfective and by past perfect she means the pluperfect.

speech, all individuals with anomic aphasia faced word-finding difficulties, An2 and An4 had fluent speech, whereas the speech of An1, An3 and An5 included pauses due to word-retrieval difficulties. All participants with anomic aphasia produced grammatical sentences, of normal length and often embedded clauses. Moreover, all except for An1 presented mild comprehension difficulties as shown by their score in BDAE. With respect to the participants with agrammatic aphasia, Ag1 is a case of mild agrammatism, as she produced short, simple sentences, occasionally omitting verbs and prepositions, whereas verb morphology was relatively spared. Ag2 produced short utterances and incomplete sentences; his language was characterized by frequent verb omissions and impaired verb morphology. According to the BDAE he also had mild comprehension deficits. Finally, the speech of the individual with Wernicke's aphasia was fluent with phonological paraphasias. At times the individual produced empty speech. Ten non-brain-damaged speakers (NBDs) have been also tested (seven female, age: mean = 59, standard deviation = 9.2, years of education: mean = 13, standard deviation = 3.3). All participants participated on a voluntary basis and gave their written consent before being tested.

4.2.2. Design, materials, procedure and scoring

The Greek version of the TART's production part examined five tenses: present, future and three past tenses: past perfective, past imperfective and present perfect. The material consisted of 9[6] pairs of verbs, which could take the same complement, for example one pair was *to sweep* and *to mop*. For each verb three pictures were constructed, one presenting the action in progress, one completed and one about to be initiated. The participants were presented with 2 pictures at a time in the same time frame. Above each picture the target verb was written in the 1st person singular present (the default form, as Modern Greek lacks infinitives). The experimenter described the first picture in a specific tense and began the description of the second picture with an adjunct phrase which required the same verb form. The pictures depicting actions in progress were used for present and past imperfective target sentences. The pictures with the action completed were used for eliciting the past perfective and the present perfect. Finally, the pictures with the action as about to begin were used for the future. There were 6 practice items. See (1) for an example of an experimental item.

(1) Right now the woman is sweeping the floor and right now the woman …. (Target: is mopping the floor).

We applied a correct/incorrect scoring—correct being the answers in which the verb was produced in the target form. Agreement errors were not taken into account. However, it was decided post-hoc that the production of the 1st person singular present was to be taken as an error even in present-tense targets, as it was used as the default form and at least one agrammatic speaker overused it, which suggests no productive use thereof.

In the comprehension test three tenses were tested (present, past, future) with 10 picture pairs each. The same pictures were used. The participants had to perform a sentence-to-picture matching task, with two pictures in each item. Both pictures depicted the actions of the target verb and for the present and future targets the distractor picture depicted the event as completed and for past targets the distractor was a picture with the action in progress.

5. Results

5.1. Production

The data was analysed in R (R Core Team, 2019)[7] by means of generalized linear mixed-effects models of the R package *lme4* (Bates, Mächler, Bolker, & Walker, 2015). We used generalized linear mixed-effects models because: 1) they take into account both the variance between subjects and between items (random intercepts) and the variance between subjects and between items for all factors (random slopes) (Bates, Kliegl, Vasisth & Baayen, 2018 among others) and 2) they can handle binary responses (Agresti, 2019). Moreover, we used the package *emmeans* (Lenth, 2018) for the post-hoc analyses, when necessary. Table 4 presents the percentages of correct responses in the production part.

As the table shows, the NBDs performed at ceiling. Concerning the IwA, we will first examine the production performance in the whole group, although the group is mixed in terms of aphasia type (hereafter mixed group). Several models were computed and the model with the best fit which converged was the one with the tense as fixed effect (with 5 levels[8]), one random intercept for item and participant. See Table 5 for the estimates, standard errors, Z-values and *p*-values of the model (rows for *Model for mixed group*). As shown in the table, the performance in the present tense was significantly better than in all past tenses, as predicted by the PADILIH, but was also significantly better than the performance in the future tense. In order to obtain *p*-values for the pairwise comparisons between the other tenses, we performed post-hoc tests (Tukey method), the *p*-values of which are presented in Table 6 (column for *Mixed group*). The estimates, standard errors, degrees of freedom and z-ratios are presented in Table 1 of Appendix B.

As the *p*-values in Table 6 show, the present perfect was significantly worse than all other tenses, whereas the past imperfective, the past perfective and the future did not differ from each other. Concerning the comparison between the present and the past imperfective, the post-hoc comparison deviates from the results of the model, in that it does not indicate significant difference between the two tenses. This divergence is due to the fact that the post-hoc comparisons are more conservative, but also suggests that the past imperfective, which has the same stem as the present, is slightly different from the other past tenses. We will discuss this finding in the discussion section.

[6] 20 verbs were planned to be used for each tense, but due to a randomizing error only 18 were included in the analysis.
[7] We used several versions during the process of data analysis, the most recent is the 2019. The results do not deviate.
[8] Treatment contrasts were used with present being the baseline.

Table 2
Overview of the morphological properties of the forms tested in the present study (based on Holton et al., 2004, p. 120).

	Aspect		
	Imperfective	Perfective	Perfect
Tense			
Non-Past	*δen-o*	*δes-o*	*exo δes-i*
	'I tie'	'to tie'	'I have tied'
	'I am tying'		
	Present	Dependent	Perfect
Past	*e-δen-a*	*e-δes-a*	*ixa δes-i*
	'I was tying'	'I tied'	'I had tied'
	'I used to tie'		
	Imperfective	Simple Past	Pluperfect

The next planned group analysis pertained to the group of the individuals with anomic aphasia, the only homogeneous group in terms of aphasia type. The percentage correct performance of this group is also presented in Table 4. We conducted a similar statistical analysis for the mixed group. Table 5 (rows for *Model for anomic aphasia*) shows the estimates, standard errors, Z-values and *p*-values of the model fitted for the anomic participants. The pattern of the anomic aphasia group is similar to the pattern of the mixed group. Again, performance in the present is better than performance in the present perfect, the past perfective and the future. Nevertheless, the difference between the present and past imperfective is not significant (similar to the post-hoc analysis of the model fitted for the mixed group). The column *Anomic aphasia* of Table 6 presents the p-values of the post-hoc comparisons for the anomic aphasia group (Table 2 of Appendix B presents the estimates, standard errors, degrees of freedom and z-ratios for these post-hoc comparisons). As in the analysis of the whole group, the post-hoc comparisons showed that performance in the present perfect is significantly worse than in all other tenses and that there is no significant difference in performance among the past imperfective, the past perfective and the future. Therefore, the pattern of performance in the group of the individuals with anomic aphasia is similar to the pattern of the mixed group and it is safe to claim that aphasia type does not play a role concerning the production of time reference (at least for the individuals with aphasia in the present study).

Next, we considered the individual results. Table 7 presents the percentages of correct responses for each tense. Ag1, An1 and An4 had ceiling performance. All other IwA had ceiling performance in the present and remarkable difficulties with the present perfect. Performance in the other three tenses was comparable with no specific pattern.

In view of the fact that three out of eight patients had ceiling performance, we conducted a third group analysis, which concerned the group of IwA who showed impaired performance (i.e. participants Ag2, An2, An3, An5 and We hereafter *impaired IwA*). The last row of Table 4 shows the percentage correct performance of the impaired IwA and Table 5 (rows *Model for impaired IwA*) presents the estimates, standard errors, z-values and *p*-values of the model fitted for this group. The analysis results indicate that performance in the present was better than in all other tenses, including the past imperfective. The post-hoc comparisons, presented in column *Impaired IwA* of Table 6 (the estimates, standard errors, degrees of freedom and z-ratios for these post-hoc comparisons are presented in Table 3 of Appendix B), showed the same pattern as in the other two analyses: the present perfect is more impaired than all other tenses and the past imperfective, past perfective and future do not differ from each other. As in the analysis of the whole group, the difference between the past imperfective and the present failed to reach significance in the post-hoc comparisons.

Summarizing the group analyses, the results indicate that in all three analyses, i.e. for the mixed group, for the individuals with anomic aphasia and for the impaired IwA: 1) the present perfect is more impaired than all other tenses 2) the present was better than the past perfective and the future 3) the past imperfective, the past perfective and the future did not differ from each other. The difference between the present and the past imperfective is not very clear. When we consider the mixed group and the impaired IwA the difference is significant, but it is not significant for the analysis of the data from the participants with anomic aphasia and it fails to reach significance in the post-hoc comparisons in all three analyses.

We further performed error analysis for each IwA separately. Recall that Bos and Bastiaanse (2014) found that individuals with agrammatic aphasia substituted past forms (simple past) mainly with forms referring to other time frames, whereas individuals with fluent aphasia replaced it with another past verb form. We consider now the type of errors produced by individuals with aphasia with non-ceiling performance for present perfect and past perfective targets, the two most impaired past forms. Ag2 produced mainly the default form (1st singular present) across tenses, which suggests a general tense production failure. An2 produced mainly present (39%) instead of the present perfect, and past imperfective (17%) and present (11%) instead of the past perfective. An3 produced present (50%), the basic form (28%) and past perfective (22%) instead of the present perfect and his performance on the past perfective was relatively good, but when he made errors he produced the basic form (11%) or present (5.6%). An4 had problems only in the past perfective, which he substituted with present perfect. An5 produced present instead of the present perfect (39%) and his performance in the past perfective was good, but the few errors he made were the production of past imperfective. The fact that many individuals with anomic aphasia (An2, An3, An5) used the present instead of the present perfect is not especially surprising given that the present perfect makes assertions about the present on the basis of events in the past (see below for discussion). With respect to the past perfective, the participants with anomic aphasia who had poor performance in this condition (An2, An4 and An5) produced preponderantly past time frame forms. Finally, the individual with Wernicke's aphasia substituted present and the basic form for both the present perfect and the past perfective.

Table 3
Demographic data of the aphasic individuals. Ag: agrammatic, An: anomic, We: Wernicke.

Participant	Aphasia	Lesion site	Cause	Months post onset	Age	Profession	Hemiplegia (yes/no)	Sex
Ag1	Expressive aphasia with agrammatic pattern (not always)	Distribution of middle cerebral artery	CVA (ischaemic)	180	55	Worker	Yes right	Female
Ag2	Mixed aphasia with agrammatic production	Left temporal parietal region (left middle cerebral artery)	CVA (ischaemic)	10	61	Telecommunication technician	Yes right	Male
An1	Anomic	Left hemisphere	CVA (haemorragic)	104	59	Engineer	Yes right	Male
An2	Anomic with minor comprehension deficits	Distribution of middle cerebral artery	CVA (ischaemic)	6	62	Lumper	Yes right	Male
An3	Anomic with minor comprehension deficits and mild dysarthria	Left parietal lobe	CVA (ischaemic)	6	73	Army officer (pensioner)	No	Male
An4	Anomic aphasia	Distribution of middle cerebral artery, temporal lobe	CVA	2	53	Captain	No	Male
An5	Anomic aphasia with minor comprehension deficits	Left temporal, frontal and parietal	CVA	26	49	Elevator technician	Yes right	Male
We	Receptive aphasia with naming deficits and mild dysarthria	Left parietal-occipital region	CVA (haematoma)	4	55	Clerk	Yes right	Male

Table 4
Percentages of correct responses in the production task. NBDs: non-brain-damaged participants, Mixed IwA: all individuals with aphasia, Individuals with anomic aphasia: only participants An1, An2, An3, An4, An5, Impaired IwA: Individuals who did not have ceiling performance.

	Time reference				
	Present	Past			Future
	Tense				
Group	Present	Present Perfect	Past imperfective	Past perfective	Future
NBDs	99	91	100	97.2	99
Mixed IwA	85	50	76	67	70
Individuals with anomic aphasia	94	62	87	81	80
Impaired IwA	78	23	61	54	52

5.2. Comprehension

Table 8 shows the group results for the IwA and NBDs and the individual results of the IwA for the comprehension test. The NBDs had ceiling performance, across time frames. Concerning the IwA, the group performance was above chance across tenses ($p = 0$). The comparison to chance performance was done by means of the binomial test, a procedure for comparing the observed frequencies of a dichotomous variable to the frequencies that are expected under a probability parameter. On an individual level, all IwA had above chance performance except for the participant with Wernicke's aphasia, who had chance performance across the board and An2 who had a selective deficit with future.

6. Discussion

All in all, we found worse performance in tenses that denote events in the past than in the present in the production test, which is in accordance with the predictions of PADILIH. Interestingly, this pattern was consistent in all group analyses: in the mixed group, in the subgroup of individuals with anomic aphasia, and in the subgroup of IwA who manifested deficits in inflection. Additionally, for each IwA at least one tense referring to the past was worse than the present. However, we also found that production of the future was impaired. Another interesting finding, which cannot be accounted for by PADILIH in its present form, was the dissociation among the three tenses referring to the past: 1) the present perfect was more impaired than all other tenses and 2) the difference between the past imperfective and the present failed to reach significance for the anomic aphasia group and in any of the post-hoc analyses. Concerning comprehension, there was not any dissociation among the past, the present and the future at the group level and for each IwA individually, except for An2.

First, we will consider the dissociation among the three tenses referring to the past. With respect to the past imperfective, it seems to have an intermediate status between the present and the past perfective. In this sense, the results of the mixed group and from the impaired IwA do not straightforwardly replicate any of the previous studies which addressed the difference between the past perfective and the past imperfective in Greek aphasia. Nevertheless, the results of the individuals with anomic aphasia are in accordance with those of Nanousi et al. (2006) and Stavrakaki and Kouvava (2003), who found a difference between the past perfective and the past imperfective. This is a striking similarity, as the participants of these two studies suffered from agrammatic aphasia. The performance of the individuals with agrammatic aphasia in the present study is not especially informative, as one of them had ceiling performance and the other one was severely impaired across the board.

Looking at the data beyond aphasia types, the results confirm the intermediate status of past imperfective in aphasic language in Greek: on the one hand, it refers to events in the past and on the other hand, it shares the same (imperfective) stem with the present tense (see Table 2). Stavrakaki and Kouvava (2003) suggest that the past imperfective is more preserved in agrammatic aphasia because the formation of the past imperfective from the present (from imperfective to imperfective) is computationally less demanding than the formation of the past perfective from the present (perfective from imperfective). Consequently, the role of morphophonological processes cannot be excluded in the production of the past perfective. Rather, reference to the past and morphophonological computations seem to have an additive effect both in agrammatic and in anomic aphasia in Greek.

Turning to the present perfect, this tense is more complex in many aspects, hence it is not especially surprising that it is more impaired than the other past tenses. From a morphological point of view, it is periphrastic and the auxiliary is in present tense, although the form is related to past events. As Kljajevic and Bastiaanse (2011) suggested, IwA might have problems integrating the meaning of an auxiliary in the present tense. From a semantic/pragmatic point of view it is more remote than the past perfective (Moser, 2003), or it has the status of conventional implicature (Veloudis, 1990). This last property is particularly relevant: whereas all other past tenses describe events in the past, the present perfect makes assertions about the present on the basis of these events and its truth value must be inferred from other propositions. If this assumption is correct, then the worse performance in the present perfect is in accordance with the PADILIH: the present perfect is more difficult because it depends heavier on prior knowledge and it requires processing of this information in order to draw conclusions relevant to the present-reference time. The error analysis confirms this assumption, as the present perfect was mainly substituted by present tense, whereas past perfective was substituted by other forms referring to the past, as in Dutch (Bos & Bastiaanse, 2014) and Serbian (Kljajevic & Bastiaanse, 2011).

Table 5
Estimates, standard errors, Z-values and *p*-values of the models fitted for the analysis of the production data. Model for mixed group: all IwA, Model for anomic aphasia: only the anomic patients, Model for impaired IwA: only patients with non-ceiling performance. In bold the p-values which denote a significant difference.

	Fixed Effects	Estimate	Standard Error	Z-value	p-value
Model for mixed group	(Intercept)	2.88	0.76	3.77	< **0.001**
	TargetTense2 (Present vs. Present Perfect)	−2.89	0.40	−7.17	< **0.001**
	TargetTense3 (Present vs. Past imperfective)	−0.93	0.38	−2.43	**0.015**
	TargetTense4 (Present vs. Past perfective)	−1.61	0.38	−4.20	< **0.001**
	TargetTense5 (Present vs. Future)	−1.39	0.38	−3.64	< **0.001**
Model for anomic aphasia	(Intercept)	3.47	0.78	4.46	< **0.001**
	TargetTense2 (Present vs. Present Perfect)	−2.72	0.54	−5.04	< **0.001**
	TargetTense3 (Present vs. Past imperfective)	−1.04	0.57	−1.82	0.068
	TargetTense4 (Present vs. Past perfective)	−1.52	0.55	−2.75	**0.006**
	TargetTense5 (Present vs. Future)	−1.61	0.55	−2.91	**0.004**
Model for impaired IwA	(Intercept)	1.62	0.61	2.68	**0.007**
	TargetTense2 (Present vs. Present Perfect)	−3.17	0.45	−7.10	< **0.001**
	TargetTense3 (Present vs. Past imperfective)	−1.04	0.39	−2.64	**0.008**
	TargetTense4 (Present vs. Past perfective)	−1.41	0.40	−3.56	< **0.001**
	TargetTense5 (Present vs. Future)	−1.53	0.40	−3.85	< **0.001**

Table 6
P-values of the post-hoc comparisons in the production task of all three group analyses: Mixed group of IwA: all Iwa, Anomic aphasia: only the anomic patients, Impaired IwA: only patients with non-ceiling performance.

Contrast	Mixed group	Anomic aphasia	Impaired IwA
Present – Present Perfect	0.000	0.000	0.000
Present – Past Imperfective	0.107	0.360	0.064
Present – Past Perfective	0.000	0.047	0.003
Present - Future	0.003	0.029	0.001
Present Perfect – Past Imperfective	0.000	0.001	0.000
Present Perfect – Past Perfective	0.002	0.016	0.000
Present Perfect - Future	0.000	0.029	0.000
Past Imperfective – Past Perfective	0.300	0.812	0.849
Past Imperfective - Future	0.687	0.696	0.663
Past Perfective - Future	0.969	1.000	0.997

Table 7
Percentages of correct responses for each individual with aphasia in each tense in the production task. Ag: agrammatic, An: anomic, We: Wernicke.

Participant	Present	Present Perfect	Past Imperfective	Past Perfective	Future
Ag1	94	89	100	94	100
Ag2	30	0	20	20	40
An1	100	94	100	94	100
An2	94	61	100	67	67
An3	80	0	60	80	60
An4	100	100	100	80	100
An5	94	56	72	83	72
We	80	0	60	20	20

The future tense was also impaired in the current study and equally impaired as the past perfective, as has been found in other studies in Greek (Fyndanis et al., 2012; Nanousi et al., 2006; Varlokosta et al., 2006). With respect to other languages, relatively good performance in the future has been reported for English, Dutch, Turkish and Swahili (Bastiaanse, 2013 and references therein). On the other hand, Martínez-Ferreiro and Bastiaanse (2013) report impairment in producing the future tense in Spanish but not in Catalan, whereas Rofes et al. (2014) report impaired performance in the future in Catalan. Similar to the present perfect, the future tense in Greek is periphrastic. Moreover, futurity is only one of the particle *θα*'s meanings, which can be combined with past forms too. The meaning of futurity results from a combination of the particle and the temporal and aspectual features of the inflected verb. As suggested above for the present perfect and following Kljajevic and Bastiaanse (2011), one possibility is that IwA face difficulties producing the future tense because they have to integrate the meaning of *θα* and the dependent form. This assumption suggests that the problems with the future in Greek aphasia may not have to do with time reference per se, but rather with the morphological idiosyncrasy of this tense and in particular with the status of the particle *θα*.

However, there is an alternative possibility. Martínez-Ferreiro and Bastiaanse (2013) propose that difficulties with future are related to the fact that speech time and event time are not simultaneous. Building on this proposal, we suggest that problems with the future are

Table 8
Individual and group results for the IwA and group results for the NBDs in the comprehension test. NBD: Non-brain-damaged. Ag: agrammatic, An: anomic, We: Wernicke.

Patient	Present	Past	Future
Ag1	100	80	100
Ag2	95	95	95
An1	100	100	100
An2	85	80	45 (Chance)
An3	95	80	85
An4	100	90	80
An5	95	80	90
We	55 (Chance)	35 (Chance)	55 (Chance)
IwA total	90	80	81
NBDs	98	96	96

related to the fact that it lacks a truth-value at the time of utterance. In particular, as Zagona (2013) claims, future events are "not definite or immutable, and as such, they cannot be part of the knowledge base of the speaker; consequently their truth or existence cannot be asserted. Such events are inherently irrealis" (p. 764). Taken together with the data from irrealis conditional clauses of Rofes et al. (2014), one can suggest that the lack of truth-value at the time of utterance is a factor affecting the production of specific verb forms. This assumption can also embed the performance in the present perfect, as its truth-value cannot be based on the state of the world at the time of utterance, but it has to be inferred. Thus, we suggest that reference to the past is not the only semantic/pragmatic factor which affects production of tense in aphasia. The assignment of truth-value at the time of utterance is an additional factor. Table 9 summarizes the features which are relevant for predicting performance in tense production on the basis of the present data.

From a methodological point of view, this is exactly what Faroqi-Shah and Friedman (2015) point out in their criticism of the elicitation paradigm which is used in the present study. They claim, in particular, that low performance in past tenses and future are due to the fact that the action is not depicted in the picture which is supposed to prime the sentence. In our opinion, different methods of inflection elicitation bring out different aspects of the inflection deficit in aphasia. In this sense, the present findings are not task-specific, rather they highlight the semantic/pragmatic aspects of the inflection deficit in aphasia. Of course, future research has to address what other linguistic (e.g. +/− periphrastic) or cognitive factors contribute to each task.

Finally, before attributing the performance of the IwA to the semantic/pragmatic or morphophonological properties of each tense we should exclude frequency effects. Bastiaanse (2011) reports that inflected verbs in the spontaneous speech of individuals with fluent aphasia are verbs of higher frequency and this indicates a retrieval deficit at the level of phonological forms. Therefore, one possibility is that the difference among the three past tenses is an artefact of differences in type frequency. Table 10 shows the mean percentages and mean log of the occurrence frequency percentages of the forms used in each tense.[9] For each tense we show the mean frequency in the 3rd person singular which was also the target. The frequencies for the present perfect and the future are the same because the forms searched are homophones. In particular, we searched for the non-finite form (e.g. *δesi* of the verb *δeno* 'tie') and the present dependent form, which is inflected for person but the 3rd person singular is identical to the non-finite form (*θa δesi* 'he/she will tie'). We also give the mean percentage frequency of the 1st person singular present, as it was the default form and a frequent error, especially of Ag2. As the table shows, the 3rd person singular of the past imperfective was the least frequent form in 3rd singular person with all other forms having similar occurrence frequencies. Remarkably, the frequency of the 1st person singular present is the most infrequent form. We compared the frequencies (in the logarithmic scale) with pairwise t-tests with Bonferroni corrections. The results showed that past imperfective is significantly less frequent than the past perfective and present (both $p < 0$) and it differs marginally from the future ($p = 0.06$). The past perfective and the present do not differ from each other. Consequently, the pattern found cannot be attributed to the form frequencies (cf. Martínez-Ferreiro & Bastiaanse, 2013).

Concerning comprehension, the IwA of the current study showed above chance (and in certain cases, ceiling) performance across tenses, in accordance with previous studies both in Greek and other languages. This finding implies a selective deficit in production, which is not in accordance with the PADILIH, as this hypothesis would predict deficits both in production and comprehension, at least in agrammatic aphasia.

An essential question is what this data implies about the relation between brain damage and linguistic representations. If our account of the data is correct, it suggests that multiple linguistic levels can be affected in aphasia, independent of aphasia type. Specifically, as shown in Table 9 we postulate the interplay of two kinds of factors in the performance: semantic/pragmatic factors, such as time reference and truth-value at the time of utterance, but also morphophonological factors such as relation of a target form to the default form, or whether a form is periphrastic and requires the integration of two components or not. Whether all these factors interact within each IwA and to what extent cannot be concluded from this data. Given the individual variability it seems that for each IwA these factors have a slightly different effect. In addition, one has to take into account the cognitive profile of IwA and how it affects the performance in each task. Cognitive profile has been, to a large extent, ignored in the aphasiological literature (although it gains more and more attention lately). In any case and looking beyond aphasia types and individual variability the present study indicates that at least semantic/pragmatic and morphological processing are vulnerable in aphasia and it has shown which are the relevant parameters at each level: time reference, truth value and morphophonological complexity.

[9] The frequencies were retrieved from the Hellenic National Corpus (http://hnc.ilsp.gr) on the 24th April 2018.

Table 9
Summary of the features of the tenses tested, which are relevant for predicting performance in production.

Time reference	Present	Past imperfective	Past perfective	Future	Present Perfect
	Non-past	Past	Past	Non-past	Past
Truth-value at the time of utterance	+	+	+	–	–
Morphologically complex	–	–	+	+	+
Integration of a particle/auxiliary	–	–	–	+	+

Table 10
Mean percentages and mean log of the percentages of the occurrence frequency of each form.

Form	Frequency	
	Percentage	Log Percentage
Present (3rd singular)	0.0072	−2.6
Present (1st singular)	0.0015	−3.4
Present Perfect	0.0060	−2.7
Past imperfective	0.0026	−3.1
Past perfective	0.0062	−2.6
Future	0.0060	−2.7

7. Conclusions

Summing up, the performance of the IwA in the current study suggests impairments with reference to the past and the Greek data can inform but also enrich the PADILIH. In particular, the advantage of past imperfective in comparison to past perfective suggests that morphophonological processes have an additive effect to difficulties with reference to the past. The performance in the present perfect and the future tenses implies that the absence of a clause's truth value at the time of the utterance is an additional burden for IwA. Concerning the future and the present perfect, one cannot exclude the role of the periphrastic status or the impairment in integrating the particle/auxiliary, but we cannot disentangle the two on the basis of these data. The comprehension of time reference for theses IwA was largely intact.

Funding

This work was partly supported by an ERASMUS exchange scholarship to the first author for visiting the University of Groningen. The author Roelien Bastiaanse is partially supported by the Center for Language and Brain NRU Higher School of Economics, RF Government grant, ag. № 14.641.31.0004.

Acknowledgments

We would like to thank the participants with aphasia, their families and the non-brain- damaged participants for participating in the study. Parts of this work have been presented in Science of Aphasia 2010, Annual Meeting of the Department of Linguistics 2018, Language Disorders in Greek 2018 and at the Lab Meeting of the Research Unit Experimental Syntax and Heritage Languages of the Department of English and American Studies, Humboldt Universität zu Berlin. We are grateful to the audiences for their fruitful comments.

Appendix A. Scores of the aphasic participants in the short version of the BDAE. * = significantly worse than the age subgroup

Participant	Auditory Comprehension			Total (max = 32)	Production						Total (max = 48)
	Words (max = 16)	Orders (max = 10)	Complex material (max = 6)		Automatised Sequences (max = 4)	Word repetition (max = 5)	Sentence repetition (max = 2)	Naming (answers) (max = 10)	Naming BNT (max = 15)	Naming (special categories) (max = 12)	
Ag1	15.5	10	4.5	30	4	4	2	7*	12*	12	41*
Ag2	12*	8*	6	26*	4	4*	1*	5*	9*	10*	33*
An1	15.5	10	5.5	31	4	4	2	10	10*	12	43
An2	14*	10	5.5	29.5	4	5	2	8*	7*	12	38*
An3	16	9*	5*	30*	4	3*	0*	10	9*	12	38*
An4	16	7*	6	29*	4	5	2	9	8*	12	40*
An5	15*	8*	6	29*	4	5	2	10	11*	11	43*
We	13*	9*	2.5*	24.5*	4	5	2	10	11*	11*	43

Appendix B

Table 1
Estimates, standard error, degrees of freedom, z-ratio and p-values of the post-hoc comparisons in the production task of the mixed group of IwA. SE: standard error, df: degrees of freedom.

Contrast	Estimate	SE	df	z-ratio	p-value
Present - PresPerf	2.89	0.40	Inf	7.17	0.000
Present - PastImperf	0.93	0.38	Inf	2.43	0.107
Present - PastPerf	1.61	0.38	Inf	4.20	0.000
Present - Future	1.39	0.38	Inf	3.64	0.003
PresPerf - PastImperf	−1.96	0.36	Inf	−5.40	0.000
PresPerf - PastPerf	−1.28	0.34	Inf	−3.74	0.002
PresPerf - Future	−1.50	0.35	Inf	−4.30	0.000
PastImperf - PastPerf	0.68	0.35	Inf	1.93	0.300
PastImperf - Future	0.46	0.35	Inf	1.31	0.687
PastPerf - Future	−0.22	0.34	Inf	−0.64	0.969

Table 2
Estimates, standard error, degrees of freedom, z-ratio and p-values of the post-hoc comparisons in the production task for the individuals with anomic aphasia. SE: standard error, df: degrees of freedom.

Contrast	Estimate	SE	df	z-ratio	p-value
Present - PresPerf	2.722	0.54	Inf	5.04	0.000
Present - PastImperf	1.045	0.57	Inf	1.82	0.360
Present - PastPerf	1.522	0.55	Inf	2.75	0.047
Present - Future	1.606	0.55	Inf	2.91	0.029
PresPerf - PastImperf	−1.678	0.42	Inf	−4.02	0.001
PresPerf - PastPerf	−1.201	0.39	Inf	−3.10	0.016
PresPerf - Future	−1.117	0.38	Inf	−2.92	0.029
PastImperf - PastPerf	0.477	0.44	Inf	1.09	0.812
PastImperf - Future	0.561	0.43	Inf	1.29	0.696
PastPerf - Future	0.084	0.41	Inf	0.21	1.000

Table 3
Estimates, standard error, degrees of freedom, z-ratio and p-values of the post-hoc comparisons in the production task for the impaired IwA. SE: standard error, df: degrees of freedom.

Contrast	Estimate	SE	df	z-ratio	p-value
Present - PresPerf	3.17	0.45	Inf	7.10	0.000
Present - PastImperf	1.04	0.39	Inf	2.64	0.064
Present - PastPerf	1.41	0.40	Inf	3.56	0.003
Present - Future	1.53	0.40	Inf	3.85	0.001
PresPerf - PastImperf	−2.13	0.40	Inf	−5.29	0.000
PresPerf - PastPerf	−1.77	0.39	Inf	−4.48	0.000
PresPerf - Future	−1.65	0.39	Inf	−4.20	0.000
PastImperf - PastPerf	0.37	0.36	Inf	1.01	0.849
PastImperf - Future	0.49	0.36	Inf	1.34	0.663
PastPerf - Future	0.12	0.36	Inf	0.34	0.997

References

Abuom, T. O., & Bastiaanse, R. (2013). Production and comprehension of reference of time in Swahili–English bilingual agrammatic speakers. *Aphasiology, 27*(2), 157–177. https://doi.org/10.1080/02687038.2012.699632.

Agresti, A. (2019). *An introduction to categorical data analysis* (3rd ed.). Hoboken, NJ: John Wiley & Sons.

Anjarningsih, H. Y. (2012). *Time reference in standard Indonesian agrammatic aphasia.* Groningen: University of Groningen.

Avrutin, S. (2006). Weak syntax. In Y. Grodzinsky, & K. Amunts (Eds.). *Broca's region* (pp. 49–62). Oxford ; New York: Oxford University Press.

Bastiaanse, R. (2011). The retrieval and inflection of verbs in the spontaneous speech of fluent aphasic speakers. *Journal of Neurolinguistics, 24*(2), 163–172. https://doi.org/10.1016/j.jneuroling.2010.02.006.

Bastiaanse, R. (2013). Why reference to the past is difficult for agrammatic speakers. *Clinical Linguistics and Phonetics, 27*(4), 244–263. https://doi.org/10.3109/02699206.2012.751626.

Bastiaanse, R., Bamyaci, E., Hsu, C.-J., Lee, J., Duman, T. Y., & Thompson, C. K. (2011). Time reference in agrammatic aphasia: A cross-linguistic study. *Journal of Neurolinguistics, 24*(6), 652–673. https://doi.org/10.1016/j.jneuroling.2011.07.001.

Bastiaanse, R., & Edwards, S. (2004). Word order and finiteness in Dutch and English Broca's and Wernicke's aphasia. *Brain and Language, 89*(1), 91–107. https://doi.org/10.1016/S0093-934X(03)00306-7.

Bastiaanse, R., Jonkers, R., & Thompson, C. K. (2008). *Test for assessing reference of time.* University of Groningen.

Bastiaanse, R., & van Zonneveld, R. (1998). On the relation between verb inflection and verb position in Dutch agrammatic aphasics. *Brain and Language, 64*(2), 165–181. https://doi.org/10.1006/brln.1998.1972.

Bastiaanse, R., & van Zonneveld, R. (2005). Sentence production with verbs of alternating transitivity in agrammatic Broca's aphasia. *Journal of Neurolinguistics, 18*(1), 57–66. https://doi.org/10.1016/j.jneuroling.2004.11.006.

Bates, D., Kliegl, R., Vasishth, S., & Baayen, H. (2018). Parsimonious mixed models. *ArXiv:1506.04967v2 [Stat]*. Retrieved from http://arxiv.org/abs/1506.04967v2.

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software, 67*(1)https://doi.org/10.18637/jss.v067.i01.

Borod, J. C., Goodglass, H., & Kaplan, E. (1980). Normative data on the boston diagnostic aphasia examination, parietal lobe battery, and the boston naming Test. *Journal of Clinical Neuropsychology, 2*(3), 209–215. https://doi.org/10.1080/01688638008403793.

Bos, L. S., & Bastiaanse, R. (2014). Time reference decoupled from tense in agrammatic and fluent aphasia. *Aphasiology, 28*(5), 533–553. https://doi.org/10.1080/02687038.2014.886322.

Butterworth, B., & Howard, D. (1987). Paragrammatisms. *Cognition, 26*(1), 1–37. https://doi.org/10.1016/0010-0277(87)90012-6.

Clahsen, H., & Ali, M. (2009). Formal features in aphasia: Tense, agreement, and mood in English agrammatism. *Journal of Neurolinguistics, 22*(5), 436–450. https://doi.org/10.1016/j.jneuroling.2009.02.003.

De Bleser, R. (1987). From agrammatism to paragrammatism: German aphasiological traditions and grammatical disturbances. *Cognitive Neuropsychology, 4*(2), 187–256. https://doi.org/10.1080/02643298708252039.

Dragoy, O., & Bastiaanse, R. (2013). Aspects of time: Time reference and aspect production in Russian aphasic speakers. *Journal of Neurolinguistics, 26*(1), 113–128. https://doi.org/10.1016/j.jneuroling.2012.05.003.

Edwards, S. (2005). *Fluent aphasia.* Cambridge, UK ; New York: Cambridge University Press.

Faroqi-Shah, Y., & Friedman, L. (2015). Production of verb tense in agrammatic aphasia: A meta-analysis and further data. *Behavioural Neurology, 2015*, 1–15. https://doi.org/10.1155/2015/983870.

Friedmann, N., & Grodzinsky, Y. (1997). Tense and agreement in agrammatic production: Pruning the syntactic tree. *Brain and Language, 56*, 397–425.

Fyndanis, V., Arcara, G., Christidou, P., & Caplan, D. (2018). Morphosyntactic production and verbal working memory: Evidence from Greek aphasia and healthy aging. *Journal of Speech Language Hearing Research, 61*(5), 1171. https://doi.org/10.1044/2018_JSLHR-L-17-0103.

Fyndanis, V., Varlokosta, S., & Tsapkini, K. (2012). Agrammatic production: Interpretable features and selective impairment in verb inflection. *Lingua, 122*(10), 1134–1147. https://doi.org/10.1016/j.lingua.2012.05.004.

Fyndanis, V., Varlokosta, S., & Tsapkini, K. (2013). Morpho)syntactic comprehension in agrammatic aphasia: Evidence from Greek. *Aphasiology, 27*(4), 398–419. https://doi.org/10.1080/02687038.2013.770817.

Givón, T. (2001). In Rev (Vol. Ed.), *Syntax: An introduction: Vol. 2.* Amsterdam: Benjamins.

Holton, D., Mackridge, P. A., & Philippaki-Warburton, I. (2004). *Greek: An essential grammar of the modern language.* London: Routledge.

Huber, W., Poeck, K., & Weniger, D. (2000). Aphasie. In W. Hartje, & K. Poeck (Eds.). *Klinische neuropsychologie (4.* (pp. 80–143). Stuttgart, New York: Thieme.

Iatridou, S., Anagnostopoulou, E., & Izvorski, R. (2003). Observations about the form and meaning of the Perfect. In A. Alexiadou, M. Rathert, & A. von Stechow (Eds.). *Perfect explorations* (pp. 153–204). Berlin, New York: Mouton de Gruyter.

Jonkers, R., & de Bruin, A. (2009). Tense processing in Broca's and Wernicke's aphasia. *Aphasiology, 23*(10), 1252–1265. https://doi.org/10.1080/02687030802289192.

Kean, M.-L. (1977). The linguistic interpretation of aphasic syndromes: Agrammatism in Broca's aphasia, an example. *Cognition, 5*(1), 9–46. https://doi.org/10.1016/0010-0277(77)90015-4.

Kljajevic, V., & Bastiaanse, R. (2011). Time reference in fluent aphasia: Evidence from Serbian. In A. Vatakis (Ed.). *Multidisciplinary aspects of time and time perception: COST TD0904 international workshop, athens, Greece, october 7-8, 2010: Revised selected papers* (pp. 258–274). Heidelberg ; New York: Springer.

Koukoulioti, V. (2013). *Ορισματική δομή και κλιτική μορφολογία: Μία συγκριτική μελέτη ανάμεσα σε ελληνόγλωσσους ομιλητές με αφασία και σημασιολογική άνοια [argument structure and verb inflection: A comparison between Greek-speaking patients with aphasia and semantic dementia]*. Thessaloniki: Aristotle University of Thessaloniki. Retrieved from http://hdl.handle.net/10442/hedi/37283.

Koukoulioti, V., & Bastiaanse, R. (2008). *Test for assessing reference of time (Greek version).* Groningen: University of Groningen.

Koukoulioti, V., & Stavrakaki, S. (2014). Producing and inflecting verbs with different argument structure: Evidence from Greek aphasic speakers. *Aphasiology, 28*(11), 1320–1349. https://doi.org/10.1080/02687038.2014.919561.

Lenth, R. (2018). emmeans: Estimated marginal means, aka least-squares means. Retrieved from https://CRAN.R-project.org/package=emmeans.

Levinson, S. C. (1983). *Pragmatics.* Cambridge, New York: Cambridge University Press.

Martínez-Ferreiro, S., & Bastiaanse, R. (2013). Time reference in Spanish and Catalan non-fluent aphasia. *Lingua, 137*, 88–105. https://doi.org/10.1016/j.lingua.2013.09.003.

Moser, A. (2003). Tense, aspect, and the Greek perfect. In A. Alexiadou, M. Rathert, & A. von Stechow (Eds.). *Perfect explorations* (pp. 235–252). Berlin, New York: Walter de Gruyter.

Nanousi, V., Masterson, J., Druks, J., & Atkinson, M. (2006). Interpretable vs. uninterpretable features: Evidence from six Greek-speaking agrammatic patients. *Journal of Neurolinguistics, 19*(3), 209–238. https://doi.org/10.1016/j.jneuroling.2005.11.003.

R Core Team. R: a language and environment for statistical computing. (2019). Retrieved from https://www.R-project.org/ Version 3.5.3.

Rofes, A., Bastiaanse, R., & Martínez-Ferreiro, S. (2014). Conditional and future tense impairment in non-fluent aphasia. *Aphasiology, 28*(1), 99–115. https://doi.org/10.1080/02687038.2013.850650.

Roussou, A., & Tsangalidis, A. (2010). Reconsidering the 'modal particles' in modern Greek. *Journal of Greek Linguistics, 10*(1), 45–73. https://doi.org/10.1163/156658410X495817.

Stavrakaki, S., & Kouvava, S. (2003). Functional categories in agrammatism: Evidence from Greek. *Brain and Language, 86*(1), 129–141. https://doi.org/10.1016/S0093-934X(02)00541-2.

Tsangalidis, A. (1999). *Will and tha: A comparative study of the category future.* Thessaloniki: Aristotle University of Thessaloniki.

Tsapkini, K., Vlahou, C. H., & Potagas, C. (2009/2010). Adaptation and validation of standardized aphasia tests in different languages: Lessons from the boston diagnostic aphasia examination - short form in Greek. *Behavioural Neurology, 3*(4), 111–119. https://doi.org/10.3233/ben-2009-0256.

Varlokosta, S., Valeonti, N., Kakavoulia, M., Lazaridou, M., Economou, A., & Protopapas, A. (2006). The breakdown of functional categories in Greek aphasia: Evidence from agreement, tense, and aspect. *Aphasiology, 20*(8), 723–743. https://doi.org/10.1080/02687030500513703.

Veloudis, I. (1990). Ο μεταγλωσσικός χαρακτήρας του παρακειμένου. Παρακείμενος α'[The metalinguistic character of present perfect. Present perfect a]. *Πρακτικά της 10ης ετήσιας συνάντησης του Τομέα Γλωσσολογίας της Φιλοσοφικής Σχολής του ΑΠΘ [Proceedings of the 10th Annual meeting of the department of linguistics* (pp. 359–378). Thessaloniki: Kyriakidis.

Veloudis, I. (2003). Possession and conversation: The case of the category perfect. In A. Alexiadou, M. Rathert, & A. von Stechow (Eds.). *Perfect explorations* (pp. 381–399). Berlin, New York: Walter de Gruyter.

Wenzlaff, M., & Clahsen, H. (2004). Tense and agreement in German agrammatism. *Brain and Language, 89*(1), 57–68. https://doi.org/10.1016/S0093-934X(03)00298-0.

Yarbay Duman, T., & Bastiaanse, R. (2009). Time reference through verb inflection in Turkish agrammatic aphasia. *Brain and Language, 108*(1), 30–39. https://doi.org/10.1016/j.bandl.2008.09.009.

Zagona, K. (2003). Tense and anaphora: Is there a tense-specific theory of coreference? In A. Barss (Ed.). *Anaphora: A reference guide* (pp. 140–171). Malden, MA: Blackwell Pub.

Zagona, K. (2013). Tense, aspect, and modality. In M. den Dikken (Ed.). *The cambridge handbook of generative syntax* (pp. 746–792). Cambridge: Cambridge University Press.