

Verbal inflection in Greek aphasia*

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Abstract. The present study investigates verbal inflection in Greek aphasia. We present results from a sentence completion and a grammaticality judgment task with 7 Greek-speaking aphasics and 7 control participants matched for age and education. These results indicate that inflectional morphemes are not all impaired to the same degree in aphasia: agreement inflection is relatively intact, while tense and aspect are more severely impaired. These findings are discussed in light of previous studies on inflectional errors in Greek aphasia and are considered in the context of theoretical approaches to inflectional errors in aphasia.

1. Introduction

A number of studies in the past three decades have shown that inflectional errors are among the most prominent characteristics of aphasic non-fluent speech (Berndt & Caramazza 1980; Caplan 1985; Goodglass 1976; Grodzinsky 1984, among others). More recent studies, however, provide evidence that such impairment is selective and that not all inflectional morphemes are equally disturbed. In particular, with respect to verbal inflection, several studies present evidence that subject-verb agreement is relatively intact (De Bleser & Luzzatti 1994; Friedmann & Grodzinsky 1997; Höhle 1995, Wenzlaff & Clahsen 2004) while tense is severely impaired (Friedmann & Grodzinsky 1997; Höhle 1995; Wenzlaff & Clahsen 2004). Nonetheless, clear patterns of impaired and spared aspects of verb morphology production are not always observed. For example, Burchert, Swoboda-Moll & De Bleser (in press) found no overall tense-agreement differences in their agrammatic subjects and no consistently better tense or agreement performance in the two subjects who showed

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significant dissociations between the two functional categories using a sentence completion task.

Two types of accounts have been proposed to explain selective deficits in verbal inflection. Some researchers view the deficit that non-fluent individuals exhibit as a deficit in the performance of syntactic computations and thus attribute verbal inflectional errors to a breakdown of functional categories and their projections (Friedmann & Grodzinsky 1997; Grodzinsky 2000; Hagiwara 1995). Specifically, Friedmann & Grodzinsky (1997) have argued that impairment in agrammatic production can be characterised in terms of a deficit in the syntactic tree. Based on a dissociation between agreement and tense inflection in the production of a Hebrew-speaking agrammatic and assuming a bottom-up derivation along the lines of (1), they propose that the syntactic trees of agrammatic individuals are intact up to the T(ense) node but ‘pruned’ from that node up.

- (1) CP > TP > NegP > AgrP > VP

Friedmann & Grodzinsky’s (1997) tree-pruning hypothesis (TPH) does not entail an impairment necessarily in the T(ense) node; any node in the derivation can be impaired. However, a clear prediction follows from such an account: if structure building is impaired at a given level of projection no higher-level projections can be constructed but lower-level projections will be intact. Variability in aphasic performance as a function of degree of severity of aphasia thus should follow predictable patterns of impairment. Different groups of aphasics encounter difficulties at particular projections. For example, in some individuals both the Tense Phrase (TP) and the Complementizer Phrase (CP) nodes may be impaired, while in others only the CP node may be affected. What distinguishes one group from another is “the level in the syntactic tree at which the deficit (pruning) occurs” (Friedmann & Grodzinsky 1997:420). Mild impairment will affect only high nodes (i.e. CP), a more severe one will implicate TP, while a very severe one will affect lower nodes as well higher ones. The lower the defective node the greater the number of impaired functional categories and, hence, the more severe the impairment. Importantly, according to Grodzinsky (2000:16), dissociations between particular projections, such as between Tense and Agreement are production-specific and are not necessarily found in grammaticality judgment.

Another syntactic account (Wenzlaff & Clahsen 2004) explains the patterns of impairment in verbal inflection in terms of Chomsky’s (2000) Minimalist Program. This account, which does not assume a hierarchical

order between separate tense and agreement projections, also predicts preserved agreement and impaired tense because the functional category Tense is underspecified in agrammatism. However, in contrast to Grodzinsky's (2000) assertion that the dissociation between tense and agreement is specific to production, Wenzlaff & Clahsen found the dissociation between tense and agreement to be manifested in both production and grammaticality judgment, suggesting a central representational deficit.

Other researchers have suggested that difficulties in the production of particular inflectional morphemes are due to processing limitations (Crain, Ni & Shankweiler 2001; Hofstede & Kolk 1994; Kolk & Hartsuiker 2000). Within such accounts, grammatical representations are intact but access to them is impaired. The asymmetry in the performance of aphasic individuals on production vs. grammaticality judgment tasks has been taken as evidence for processing approaches (Linebarger, Schwartz & Saffran 1983). The attested variability in the performance of aphasic individuals across different tasks has also been interpreted in favor of reduced processing capabilities and spared linguistic knowledge. For example, Hofstede & Kolk (1994) found reduced omission rates but increased substitution rates of inflectional morphemes in picture description tasks as compared to free conversation. Furthermore, severity variation across individuals may manifest in similar profiles but in different absolute levels of performance. Although Friedman & Grodzinsky (1997) do acknowledge the existence of severity variation, for them a node or functional category is impaired when all or most exemplars within that node show impairment. However, varying levels of impairment in a functional category are commonly observed in the studies. Selectively excluding patients on the basis of production patterns which are associated with Broca's aphasia does not address the issue of level of severity and may bias the analysis of the observed deficits (see Berndt & Caramazza 1999). Last, the similar pattern of performance of different populations with respect to some linguistic phenomena that demand extra processing load has been viewed as strong indication of a processing rather than a structural account of such linguistic difficulties.

A related question is whether impairment in a functional category is associated with a particular aphasic diagnostic category, type of patient, or lesion site. The observation that impairment in the comprehension of syntactic structures is not limited to agrammatic aphasics or even to Broca's aphasics (Dick, Bates, Wulfeck & Dronkers 1998; see Dick et al. 2001) is compatible with processing accounts. Furthermore, damage to Broca's area does not necessarily cause Broca's aphasia (Mohr et al. 1978)

and, conversely, Broca's aphasia is not necessarily caused by damage to Broca's area (Dronkers et al. 1992). Therefore, the case for a priori selection of patients is very weak, whether selection is made on the basis of diagnostic subtypes or on the basis of lesion location. Any type-related conclusions should be reached only on the basis of empirical dissociations observed on groups of unselected individuals with aphasia.

Inflectional errors have been reported in studies of Greek non-fluent aphasia (Plakouda 2001; Stavrakaki & Kouvava 2003; Tsapkini, Jarema & Kehaya 2001; 2002). The issue of the alleged breakdown of functional categories related to verbal inflection is discussed in Plakouda (2001) on the basis of an experiment with a Greek-speaking non-fluent aphasic speaker with agrammatic speech output. The results of a sentence completion task designed to assess three functional categories, namely subject-verb agreement, tense and aspect, indicated that the most problematic category was that of aspect, with only 60% correct responses. Tense and agreement were relatively intact, with 95% and 87% correct responses, respectively. These findings were taken as evidence against the TPH or any type of account that explains verbal inflectional errors in non-fluent aphasia as a deficit in the syntactic tree.

Stavrakaki & Kouvava (2003) presented an investigation of two Greek-speaking non-fluent aphasics with characteristics of agrammatic speech. The results of a range of tasks (spontaneous speech, picture description, grammaticality judgment, and preference test) showed a clear task effect on the patients' performance. The results of the spontaneous speech data indicated that both patients encountered some difficulties in the production of past tense forms (64% and 82.5% correct responses) and that most of the errors were found in contexts of high syntactic complexity (e.g. contexts where the subject had to use a C(omplementizer)). Aspect errors were found exclusively in contexts of perfective aspect (52% and 78% correct responses), whereas agreement reached high percentages of correct use, with only a few problems for one patient. Crucially, the results of a grammaticality judgment task indicated high level of performance by both patients on past tense marking as well as on subject-verb agreement (rate of correct responses over 80%). Similarly, high level of performance with respect to these categories was also found in the preference test. These findings were interpreted by Stavrakaki & Kouvava as evidence against structural accounts and in favor of processing ones.

Tsapkini, Jarema & Kehayia (2001) investigated verbal morphology (specifically tense) in a Greek patient with non-fluent aphasia through a series of different tasks (spontaneous speech, sentence-picture matching, repetition, reading, and elicitation tasks). They observed problems

particularly in production, with more errors in the computation of rule-based forms than forms with stem-allomorphy. More importantly, they found that difficulties arise not just when the subject has to compute one operation, specifically the rule-based perfective suffix, but when more complex computations are needed, as in the case where the subject has to compute the perfective suffix and access at the same time an allomorphic form of the verb. To account for their observations regarding inflectional impairments in the Greek verb, Tsapkini et al. proposed a computational load deficit in processing the perfective rule together with the allomorphic stem.

The purpose of the present study is to investigate (a) the relative sensitivity of functional categories related to verbal morphology in Greek aphasia and the systematicity thereof; and (b) the relation between patterns of impairment in production and grammaticality judgments. As discussed in the next section, both agreement and tense are considered to be higher in the clause structure of Greek than aspect, which is the category located closest to the verb root. Given such a hierarchy, TPH would predict that aspect should be the least impaired category in Greek aphasia, showing impairment only in the most severely affected patients, who would also show impairment in tense and agreement. Furthermore, since TPH is a production theory, dissociations between particular projections are not necessarily expected in grammaticality judgments. Wenzlaff & Clahsen's (2004) tense underspecification theory, on the other hand, would predict preserved agreement relative to tense. Processing accounts would predict variation in the production of different functional categories as a function of differences in the processing capacity of the patients and differences in task demands (e.g., Hofstede & Kolk 1994).

2. Background on Greek

(Modern) Greek is a highly inflected, null-subject language with relatively free word order (Holton, Mackridge & Philippaki-Warburton 1997). Each verb in Greek is formed by a combination of a stem and an inflectional ending that expresses a complex system of grammatical categories, such as agreement (first, second and third person, singular and plural number), tense (past, non-past), aspect (perfective, imperfective), voice (active, passive) and mood (imperative, non-imperative) (Holton et al. 1997). The

agreement paradigm distinguishes six inflections, as illustrated in Table 1 for the Present Tense of the Active Voice¹.

Table 1 The Greek agreement paradigm for the Present Tense in the Active Voice

Person	Singular	Plural
1 st	-o	-omε/umε
2 nd	-is	-ετε
3 rd	-i	-un(ε)

Greek makes an aspectual distinction between Perfective and Imperfective Aspect (Holton et al. 1997; Moser 1994). The aspectual distinction shows up in the Past Tense, in the Future Tense², and in the *na*-construction³. In the Present Tense there is no aspectual distinction, that is, the Present Tense always uses the Imperfective stem. Table 2 illustrates the interaction of Aspect and Tense in Greek.

Table 2 The interaction of Aspect and Tense in Greek (for the verb 'play' with the Imperfective stem *pez-* and the Perfective stem *peks-*)

	Imperfective	Perfective
Present	pez-o 'I play'	n.a.
Past	ε-pez-a 'I was playing'	ε-peks-a 'I played'
Future	θα pez-o 'I will be playing'	θα peks-o 'I will play'
<i>na</i> -construction	na pez-o 'to be playing'	na peks-o 'to play'

Greek presents three different types of active past-tense formations (Ralli, 1988) challenging thereby the established dichotomy between rule-based vs. stored allomorph mechanisms: (a) a rule-based paradigm, which includes verbs with a phonological change, e.g. *graf-o* ('I write'), *e-γrap-s-a* ('I wrote') or *lin-o* ('I untie'), *e-li-s-a* ('I untied'). In the presence of the aspectual marker *-s-*, there is a phonological alternation in the former case and a stem-final consonant deletion in the latter one; (b) a stored allomorph paradigm, which includes verbs with a stem-internal change, e.g. *plen-o* ('I

¹ Greek does not have infinitives and the only non-finite forms are the gerund and the non-finite form that is used to compose the perfect tenses.

² The Future Tense in Greek is expressed by the particle *θα* combined with a non-past form (Perfective or Imperfective) (see Table 2). When the particle *θα* combines with a past form, it expresses a number of modalities (e.g. *θα epeza* 'I would play') (Holton et al. 1997).

³ In modal and other embedded contexts where languages like English use an infinitive, Greek makes use of a verb form introduced by the particle *na* and inflected for subject-verb Agreement and Aspect. This construction, referred to here as the *na*-construction, expresses formally the subjunctive in Greek (Philippaki-Warburton & Veloudis 1984, among others).

wash'), *e-plin-a* ('I washed'); (c) a mixed paradigm, which includes verbs with both an allomorph and the addition of the aspectual marker *-s-*, e.g. *mil-o* ('I speak'), *mili-s-a* ('I spoke').

Given the richness of the Greek inflectional paradigm, several functional categories are instantiated in the extended projection of the Greek verb. The order of some of the categories remains controversial because Greek is a language in which most inflectional forms are fused. Nonetheless, a number of proposals have been put forward regarding the organization of clause structure in Greek on the basis of the most transparent verb forms (Philippaki-Warburton, 1973; 1990; 1998; Tsimpli, 1990, among others). According to Philippaki-Warburton (1990; 1998), the likely clause structure for Greek with respect to agreement, tense and aspect is (2):

- (2) CP > MoodP > NegP > **FutP** > **AgrP** > **TP** > VoiceP > **AspectP** > **VP**

Aspect is placed nearest to the verb root because it affects the verb morphology as it very often causes internal stem modification (e.g. imperfective *per-n-o* 'I am taking', perfective *tha par-o* 'I will take' and *pir-a* 'I took'). This placement of Aspect is uncontroversial.

With respect to agreement and tense, which appear fused in many verb forms (e.g. *graf-o* 'I am writing', *eyraf-a* 'I was writing' where the final *-o* and *-a* signify both agreement and tense), it is argued by Philippaki-Warburton (1998:161) that Agr is syntactically a more peripheral category than T because in a number of verb forms the exponents of T clearly precede those of Agr. For example, in *graf-i-s* 'you are writing', *eyraf-e-s* 'you were writing', *tha graf-ti-s* 'you will be written/registered', *graf-tic-e-s* 'you were written/registered' the final *-s* marks 2nd person, while *-i* vs. *-e* and *-ti* vs. *-tic-e-* mark the difference between present and past, respectively. Finally, based on a number of similarities between indicative forms and forms with the future particle *tha*, Philippaki-Warburton (1998:166-170) argues that *tha* (unlike the subjunctive particle *na*) is not a mood marker situated in the Mood Phrase (Rivero & Terzi 1995) but a particle within the indicative that marks future and hosts its own projection, namely FutP.

Tsimpli (1990), on the other hand, proposes that TP is higher than AgrP in the clause structure of Greek. According to Tsimpli (pp. 231-232), the hierarchical relation between the two projections cannot be determined on the basis of their order because the verb complex in Greek has the form [T +V + Agr], that is, T and Agr appear on opposite sites of the verb root.

Tsimpli reaches this conclusion as she takes the augment *e-* to be the only exponent of the past tense in Greek (e.g. *γρᾱf-o* ‘I am writing’, *e-γρᾱf-a* ‘I was writing’). Tsimpli proposes that the hierarchical relation between the two categories can be determined through the distribution of object clitics in future tense clauses. More specifically, the fact that object clitics intervene between the future tense particle *θα* and the verb, as shown in (2), is taken as an indication that the verb and Agr form a complex that excludes T. That, in turn, implies that T is structurally higher than Agr.

3. Method

3.1 Participants

Seven individuals (all male) clinically diagnosed with aphasia (“patients”) participated in the study, their ages ranging between 42 and 81 years. All patients had suffered a single cerebrovascular accident at least 3 months prior to testing (except for P5 who had also suffered another CVA 5 years ago) and were judged by a speech pathologist to be free of dementia. All aphasic patients who were located by the investigators and who agreed to participate were included in the study. No patient was excluded because of diagnostic category or severity of aphasia. An eighth patient was excluded from the study because of inability to participate in the production tasks due to the aphasia. Because there are no standardized language tests or common materials in Greek, a control group of seven male individuals without aphasia (“controls”) was employed in order to obtain a reference measure of unimpaired performance for the specific tasks we used. Each individual was matched to one participant with aphasia, to the extent possible, on age and (years of) education. The controls had no reported history of neurological or psychiatric disorder nor any memory difficulties. They had no significant anxiety or depression, were not taking any psychoactive medication and were not under any treatment interfering with cognitive function. All participants in the study were right-handed. All participants were non-paid volunteers living independently at home. Table 3 lists the participants’ individual information.

Table 3 Participant information

N	Initials	Age	Sex	Education (years)	Type of stroke	Clinical diagnosis of aphasia	Time post- onset
P1	BM	54	M	16	ischaemic	Wernicke	4yr
P2	PI	81	M	12	ischaemic	nonfluent	2.5 yr
P3	TK	62	M	6	ischaemic	nonfluent	10 mo
P4	CA	64	M	6	ischaemic	nonfluent	4 mo
P5	AN	55	M	16	unknown	anomic	2.5 yr
P6	AK	42	M	16	haemorrhagic	nonfluent	5 mo
P7	NN	57	M	16	haemorrhagic; secondary to left temporal lobe meningioma removal	Broca's aphasic initially; fluent with grammatical deficits	12 mo
C1	TD	52	M	16	–	–	–
C2	AA	79	M	13	–	–	–
C3	RA	57	M	6	–	–	–
C4	FI	62	M	3	–	–	–
C5	GA	52	M	18	–	–	–
C6	FD	43	M	14	–	–	–
C7	EI	56	M	16	–	–	–

3.2 Material

Testing included an interview, a picture description task, a grammaticality judgment task, and a sentence completion task.

The interview, intended to elicit spontaneous speech from the patient, included questions about the patient's identity, stroke, rehabilitation (e.g., speech therapy), prior occupation, and hobbies. The picture description task consisted of the description of two pictures, *Cookie Theft* from the Boston Diagnostic Aphasia Examination (BDAE; Goodglass & Kaplan 1983) and *Scene 2 (Department Store)* from the Wechsler Memory Scale-III (WMS-III; Wechsler 1997). Results from the spontaneous speech measures are not reported here.

For the grammatical tasks, sentences were constructed using 8 transitive, two-syllable verbs, stressed on the penultimate syllable in their base form. Half of the verbs formed a regular perfective aspectual theme (with prefix *e-* and infix *-s-*) and the other half were irregular (including at least a root vowel change). Regularity was crossed with familiarity, resulting in half of the verbs in each condition being of high familiarity and the other half of low familiarity. Only written word frequency is available for Greek, based on text corpora containing a large proportion of

news, literary and legal texts (Hatzigeorgiu et al. 2000). Written word frequency counts may offer poor estimates of spoken usage for certain common everyday words: in the low-frequency range, two words of similar printed frequency can differ greatly in familiarity (Gernsbacher 1984). Therefore, in order to assess familiarity, 15 elderly adults (not the control participants) with no known neurological condition rated the familiarity of the pre-selected verbs on a scale of 1 (low: used “rarely, if ever”) to 5 (high: used “every day”). Table 4 lists the chosen verbs and their main characteristics. Each familiarity-regularity pair includes one verb with a consonant cluster and one with no clusters.

Table 4 Properties of the 8 verbs used to construct the test sentences

No	Present (perfective)	Past (imperfective)	Regularity	Mean subjective familiarity ^a	Estimated frequency ^b	Consonant cluster in stem
1	γραφο 'I write'	εγρapsa 'I wrote'	regular	4.1	frequent	Yes
2	xano 'I lose'	εxasa 'I lost'	regular	3.4	frequent	No
3	πλέκο 'I weave'	επλέksa 'I wove'	regular	1.8	infrequent	Yes
4	δέno 'I tie'	εδέsa 'I tied'	regular	2.6	infrequent	No
5	βλέπο 'I see'	ίδa 'I saw'	irregular	4.7	frequent	Yes
6	δίno 'I give'	εδόsa 'I gave'	irregular	4.5	frequent	No
7	δέrno 'I beat'	εδίra 'I beat'	irregular	2.5	infrequent	Yes
8	κέo 'I burn'	εkapsa 'I burned'	irregular	2.1	infrequent	No

^a Determined experimentally in a pre-test (see text).

^b Categorization on the basis of the familiarity estimate, using a cutoff of 3.

Using these eight verbs, sentences were constructed to test for agreement, tense and aspect. The sentences were as simple as possible while allowing constraint of the desired verb type (e.g., including a temporal term for tense). Every sentence was affirmative and included only one verb, in the active voice. All verbs were used in the construction of sentences for all grammatical category conditions. For all conditions, target (base) sentences were constructed first, and were then complemented with a corresponding cue sentence (for the sentence completion task) and with an incorrect sentence (for the grammaticality judgment task). The cue and incorrect sentence were matched for

contrastive type. For example, to test number agreement in the plural, compared against the singular, the following base sentence was constructed: “emis vlepume ti vroxi” (“We watch_(1st.pl) the rain”). From this, the cue sentence was “eyo vlepo ti vroxi” (“I watch_(1st.sg) the rain”) and the incorrect sentence was “emis vlepo ti vroxi” (“We watch_(1st.sg) the rain”). The rationale for this set derived from the intended tasks: in the sentence completion task, the cue sentence was to be given to the participant in order to elicit the target (base) sentence; in the grammaticality judgment task, both the incorrect and target sentences were to be (separately) offered for judgment.

For the agreement condition, 32 base sentences were constructed, half for number and half for person (number and person were tested in separate sentences). Base types were in the present tense, always in the plural for number, and in the first or second person for person. Number was tested in the first and third persons. Contrastive types for person were always first person for the second-person base, and third person for the first-person base. For example, one test item for the agreement condition was “o manos yrafi ena yrama || emis _____” (“Manos writes a letter. We _____”). It was not feasible to test every possible contrast between persons, because the duration of the test would exceed the tolerance of the patients, but in this way there is a fairly wide range of types and contrasts within agreement.

For the tense condition, 16 base sentences were constructed, using the imperfective aspect, half in the past and half in the future. All contrastive types for tense were in the present, which is considered to be the unmarked case, and were matched for aspect, person, and number. For instance, the following test item was given in the tense elicitation task: “i popi vlepi tileorasi || xthes i popi _____” (“Popi watches TV. Yesterday Popi _____”).

For the aspect condition, 32 base sentences were constructed, half in the perfective and half in the imperfective aspect. Of each group, half were in the past and half were in the future. Contrastive types were in the opposite aspect, matched in person, number, and tense. An example of the imperfective aspect production task is the following test item: “xthes i yramateas olo to proi eyrafe tin epistoli || xthes i yramateas se eksi lepta _____ tin epistoli” (“Yesterday all morning the secretary was writing the letter. Yesterday the secretary in 6 minutes _____ the letter”).

The sentence completion task was constructed by pairing each complete cue sentence with the corresponding base sentence up to the word preceding the verb. Thus, for the above example, the test item would

be “*eyo vlepō ti vroxi. emis _____*” (“I watch the rain. We _____”). The total number of items in the sentence completion task was 80. For the aspect condition only, because of the greater sentence length needed to constrain the intended form, only the critical verb was missing from the written cue and not the remainder of the sentence.

The grammaticality judgment task was made up of the list of base sentences and the list of corresponding incorrect sentences. Thus, for the aforementioned example “*emis vlepume ti vroxi*” (base, correct) the incorrect item would be “*emis vlepō ti vroxi*”. An equal number of correct and incorrect items, totaling 160, were used in the grammaticality judgment task.

3.3 Procedure

Each person was tested individually at home or at the speech therapy clinic. For most of the patients, presence of a family member and/or a speech therapist was necessary to provide emotional support during the interaction. This person was instructed to refrain from interfering with the test administration and to remain silent while the patient was formulating the responses.

Testing took place in one (4 patients) or more 30 to 55 minute long sessions; when more than one session was necessary the sessions were spaced one or more days apart. The participant was first administered the interview and production tests, followed by the picture description and grammaticality judgment test, in a fixed order. Testing was interrupted when fatigue or emotional reactions were obvious; thus for 2 patients 3 sessions were required to complete testing. For controls, testing was completed in a single session, with a short break in the middle. All testing was tape recorded, and all scoring was later verified from the recordings.

For the sentence completion test, the experimenter first explained the task and provided two or more examples, until it was clear that the participant was responding appropriately. Cue sentences were presented orally and, for the patients only, also in print at the same time. The participant always responded orally. Explanations were sometimes necessary to avoid semantic responses (such as responding to “I write a book. You _____” with “you read it”). No additional explanation or help was given during administration of the test items unless it was clear from the participants’ responses and comments that an inappropriate strategy was used. The three conditions (agreement, tense, and aspect; always in this order) were blocked whereas the order of items within each condition was randomized (once and held the same for all participants). During task

procedure self-corrections were allowed and the final answer was the one that was analyzed. If requested, the examiner repeated the cueing sentence once.

For the grammaticality judgment test, the experimenter again explained the task and provided two or more examples until it was understood. Sentences to be judged were presented orally and, for the patients, also in print. The participant always responded orally. Explanations were often necessary to avoid responses based on content rather than on form. No additional explanation or help was given during administration of the test items unless it was clear from the participants' responses and comments that an inappropriate strategy was used. As with the production task, conditions were blocked and presented in the same fixed order; item order within each condition was randomized.

4. Results

4.1 Sentence completion

Each patient, with the exception of P5 who made no errors, naturally, made many more errors than the corresponding matched control participant ($\chi^2 > 12$, $p < 0.001$, or better). Table 5 summarizes the performance of the participants in the sentence completion task.

Table 5 Proportion of errors (per cent, relative to the total number of test items in each category) made by each participant in each condition (Agr: agreement; T: tense; Asp: aspect) of the sentence completion task. Lexical errors include only errors in verb root; form errors include only errors in grammatical form. The two add up to more than the total because it is possible to make both types of errors in a single response

Participant	Total errors			Lexical errors			Form errors		
	Agr	T	Asp	Agr	T	Asp	Agr	T	Asp
Patients									
P1	15.6	12.5	43.8	0.0	0.0	0.0	15.6	12.5	43.8
P2	37.5	93.8	81.3	12.5	12.5	25.0	25.0	87.5	68.8
P3	28.1	81.3	56.3	18.8	18.8	31.3	12.5	81.3	37.5
P4	56.3	68.8	68.8	12.5	6.3	50.0	53.1	68.8	46.9
P5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
P6	9.4	0.0	12.5	0.0	0.0	0.0	9.4	0.0	12.5
P7	15.6	12.5	37.5	0.0	0.0	3.1	15.6	12.5	34.4
Controls									
C1	0.0	0.0	3.1	0.0	0.0	3.1	0.0	0.0	0.0
C2	9.4	0.0	12.5	0.0	0.0	3.1	9.4	0.0	9.4
C3	18.8	0.0	9.4	6.3	0.0	6.3	12.5	0.0	6.3

C4	9.4	0.0	0.0	0.0	0.0	0.0	9.4	0.0	0.0
C5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C6	0.0	0.0	3.1	0.0	0.0	0.0	0.0	0.0	3.1
C7	0.0	0.0	3.1	0.0	0.0	3.1	0.0	0.0	0.0

Concentrating on the critical verb of the response only, we considered as error any production deviating from the correct verb lemma in its expected grammatical form for the relevant category;⁴ these are counted under “total errors.” A great variability is observed among participants in overall performance. However, the pattern of performance was quite systematic in that low or high error proportions in all three functional category conditions simultaneously are observed for each person. As a group, patients made more errors in aspect than in agreement ($z=-2.37$ by Wilcoxon signed ranks test, exact $p=0.016$, two-tailed). The group differences between tense and the other two conditions did not reach statistical significant ($p>0.4$).

We conducted a series of chi-square tests comparing individual aphasic performance in the three functional categories. After adjusting per-participant α to 0.017 (for the 3 comparisons: tense-aspect, tense-agreement, aspect-agreement), we found that that the performance of P2 was better for agreement than for both tense or aspect, the performance of P3 was better for agreement than for tense and marginally so than for aspect, and the performance of P1 was better for agreement than for aspect (see Table 6). Therefore, when statistically significant differences are observed among the three functional categories, it is agreement that is less impaired than either tense or aspect. The pattern of errors among tasks and the fact that participants did not make random errors across the board suggests that the specific task requirements (computation of the particular grammatical form) constitute a major contributing factor to the observed performance failures. Thus, the tasks apparently do index the degree of difficulty of producing the particular grammatical forms for each participant.

⁴ Therefore, in the agreement and aspect tasks any tense would be acceptable, in the tense and agreement tasks any aspect would be acceptable and so on.

Table 6 Comparison of individual aphasic sentence completion and grammaticality judgment in the three functional category conditions (Agr: agreement; T: tense; Asp: aspect). Patients are ordered by overall number of errors (least to most) in the sentence completion task. Blank χ^2 statistic indicates no errors

	Sentence completion			Grammaticality judgment		
	Agr-T	Agr-Asp	T-Asp	Agr-T	Agr-Asp	T-Asp
Patients	χ^2	χ^2	χ^2	χ^2	χ^2	χ^2
P5				2.02	1.01	0.26
P6	1.60	0.16	2.18	1.02	2.99	3.78
P7	0.08	3.93*	3.23	19.86***	25.12***	0.22
P1	0.08	6.06**	4.69*	1.02	6.94**	6.21**
P3	12.13***	5.19*	2.92	15.44***	12.95***	0.75
P4	0.70	1.07	0.00	34.35***	37.50***	0.02
P2	12.39***	11.09***	1.34	3.00	0.00	3.00

* $p < .05$, ** $p < .017$, *** $p < .001$

Errors, however, are not of a single type. According to standard models of inflectional morphology (Ralli 1988; 2004) lemma retrieval is dissociable from morphological suffixation (or other modification). Production of the intended verb in an incorrect grammatical form (a “morphological error”) is clear indication of a morphological difficulty whereas production of an incorrect verb (a “lexical error”) may indicate different, or more general, difficulties in language use. Table 5 also shows, separately, the proportion of lexical and morphological errors for each participant. Here, any verb produced in the intended grammatical category is considered as having the correct form and, conversely, the intended verb in any form (valid or not) other than the intended one is considered as lexically correct⁵.

Again, a systematic error pattern emerges: Form errors are more numerous than lexical errors for the patients ($z=2.20$ by Wilcoxon signed ranks test, exact $p=0.03$, two-tailed), and lexical errors are made only by the more severely affected patients, in proportion to the total number of errors made by each patient. For P4, most lexical errors are seen in the aspect task than in the agreement ($\chi^2 = 10.47$) and the tense task ($\chi^2 = 8.93$; $p = 0.003$ for both comparisons). As for form errors, it is still the case that P2 ($\chi^2 = 16.78$) and P3 ($\chi^2 = 22.04$) show less impaired agreement than tense (both $p < 0.0005$), and that P2 also ($\chi^2 = 12.30$, $p < 0.001$) shows less impaired agreement than aspect (P1 and P3 did not quite reach significance

⁵ Partial or incorrect computation of the intended grammatical form *as required for the specific verb* is also counted as a grammatical error. See discussion on irregular inflectional classes.

in this comparison: $\chi^2 = 6.06$, $p < 0.027$; and $\chi^2 = 5.33$, $p < 0.041$, respectively). Thus, it appears that lexical errors are not only *not* dissociated from form errors (since they follow the same pattern) but likely reflect a heightened difficulty in language production, their presence alone indexing the degree of severity. This observation is in line with the hypothesis that morphological computation is more difficult than lemma retrieval, and with the relative vulnerability of grammatical morphology, relative to lexical skills, in conditions of linguistic impairment, developmental (Leonard 1998) or acquired (Bates, Wulfeck & MacWhinney 1991).

An alternative interpretation is simply that the cue sentence primes the correct lemma in the incorrect (for the response) grammatical form. If this were the explanation for the preponderance of grammatical over lexical errors then we should observe a much higher proportion of grammatical errors made in the cue form than in any other form. Moreover, this pattern should not depend greatly on whether a marked or unmarked form is offered in the cue sentence. Table 7 shows the breakdown of agreement and tense form errors into repetition and non-repetition type. Because there are only two possible aspects, all aspect errors are necessarily of the repetition type, and therefore, for aspect, the table partitions errors into perfective and imperfective form responses. Tense shows a greater overall number of repetition errors than non-repetition errors and aspect shows a greater overall number of imperfective error responses than perfective error responses; however, none of these differences are statistically significant for the patient group (by Wilcoxon signed ranks test, $p > 0.3$ for the repetition-nonrepetition comparisons, $p = 0.094$ for perfective vs. imperfective)

Table 7 For the agreement and tense conditions of the sentence completion task, number of grammatical errors made in each task broken down into repetition ("Rep") and non-repetition ("NonRep") response types with respect to the cue sentence (a repetition error is one that reproduces the cue form; any other response is a non-repetition error). For the aspect task, number of grammatical errors broken down into perfective ("Perf") and imperfective ("Imperf") errors

Participant	Agreement		Tense		Aspect	
	NonRep	Rep	NonRep	Rep	Imperf	Perf
Patients						
P1	3	0	1	0	11	2
P2	2	6	1	13	9	11
P3	2	2	0	10	9	2
P4	4	10	2	8	8	4
P5	0	0	0	0	0	0
P6	3	0	0	0	2	2

P7	2	0	2	0	11	0
<hr/>						
Controls						
C1	0	0	0	0	0	0
C2	3	0	0	0	3	0
C3	4	2	0	0	1	1
C4	0	3	0	0	0	0
C5	0	0	0	0	0	0
C6	0	0	0	0	1	0
C7	0	0	0	0	0	0

Control participants made no errors of any sort in the tense condition, but P2 and P3 made a similar number of non-repetition errors with their controls (C2 & C3), indicating perhaps that overall the elicitation forms were sufficiently clear, not prone to alternative communicative interpretations (compared with the agreement condition), and that the sentences were sufficiently brief and easy, not likely to be forgotten (compared with the aspect condition). In this light it seems important that several participants with aphasia made a large proportion of errors in the tense condition.

4.2 Grammaticality judgment

Performance for the patient group on the grammaticality judgment was higher for the agreement condition than for aspect ($z=-2.20$ by Wilcoxon signed ranks test, exact $p=0.031$, two-tailed). As for the sentence completion task, the group differences between tense and the other two conditions did not reach statistical significance ($p>0.1$).

We also conducted a series of chi-square tests comparing individual aphasic grammaticality judgment in the three functional categories. After adjusting per-participant α to 0.017 (for the 3 comparisons: tense-aspect, tense-agreement, aspect-agreement), we found that the performance of P3, P4, and P7 was better for agreement than for either tense or aspect, and that the performance of P1 was poorer for aspect than for either agreement or tense (see Table 6). Thus, similar to the sentence completion tasks, when differences are observed among the three functional categories, it is agreement that is less impaired than either tense or aspect. Table 8 summarizes the performance of the participants in the grammaticality judgment task (chance performance is 50% correct).

Table 8 Proportion of errors (per cent, relative to the total number of test items in each category) made by each participant in each condition (Agr: agreement; Ten: tense; Asp: aspect) of the grammaticality judgment task. Patients and matched control participants appear on the same row

Patient/ Control	Agr	Ten	Asp	Agr	Ten	Asp
1	3.1	0.0	17.2	0.0	3.1	6.3
2	43.8	62.5	43.8	1.6	0.0	6.3
3	17.2	56.3	46.9	7.8	21.9	10.9
4	1.6	50.0	48.4	0.0	12.5	1.6
5	0.0	3.1	1.6	0.0	0.0	6.3
6	3.1	0.0	10.9	0.0	0.0	0.0
7	0.0	28.1	32.8	1.6	0.0	0.0

The performance of control participants in grammaticality judgment is notably less than perfect, especially for C3. Most tense errors (10 out of 12) for participant C3 are due to the possibility in Greek (as in other languages) to express a future event using the present tense without marking it with the future particle. Similarly, for aspect both forms can be acceptable in certain cases and this cannot be avoided (e.g., by different phrasing). Table 9 shows the number of errors made by each person in each task, separately for accepted erroneous sentences (Acc) and rejected correct sentences (Rej). It can be seen that for the controls the great majority of errors are of the acceptance type ($z = -2.21$ by Wilcoxon signed ranks test, exact $p=0.031$, two-tailed), mainly in the tense and aspect conditions, where certain “erroneous” sentences can in fact be considered acceptable. For the patients a similar separation of error types is evident but the difference is not so large (a 2:1 ratio as compared with 9:1 for the controls) and it did not reach statistical significance in the group comparison ($z = -1.99$, $p=0.063$; although it was individually significant by χ^2 for patients P3, P4, and P7). The difference in the proportion of “accept” vs. “reject” errors between the two groups is significant ($\chi^2 = 11.40$, exact $p=0.001$, two-sided). It appears, then, that the patients’ performance is comparatively more uniformly affected, especially for those least impaired in terms of overall number of errors in grammaticality judgment (P1, P5, and P6), and that it differs fundamentally from the performance of the control participants in being genuinely impaired rather than indicative of alternative form acceptance.

Table 9 Number of grammaticality judgment errors in each condition made by each participant, broken down into acceptance of incorrect sentences (Acc) and rejection of correct sentences (Rej)

Participant	Agreement		Tense		Aspect		Total	
	Acc	Rej	Acc	Rej	Acc	Rej	Acc	Rej
A. Patients								
P1	0	2	0	0	5	6	5	8
P2	19	9	8	12	14	14	41	35
P3	11	0	10	8	30	0	51	8
P4	1	0	13	3	22	9	36	12
P5	0	0	0	1	1	0	1	1
P6	2	0	0	0	6	1	8	1
P7	0	0	4	5	18	3	22	8
All	38	21	42	40	114	46	194	107
B. Controls								
C1	0	0	1	0	4	0	5	0
C2	0	1	0	0	3	1	3	2
C3	4	1	7	0	7	0	18	1
C4	0	0	4	0	1	0	5	0
C5	0	0	0	0	3	1	3	1
C6	0	0	0	0	0	0	0	0
C7	1	0	0	0	0	0	1	0
All	6	2	12	0	20	2	38	4

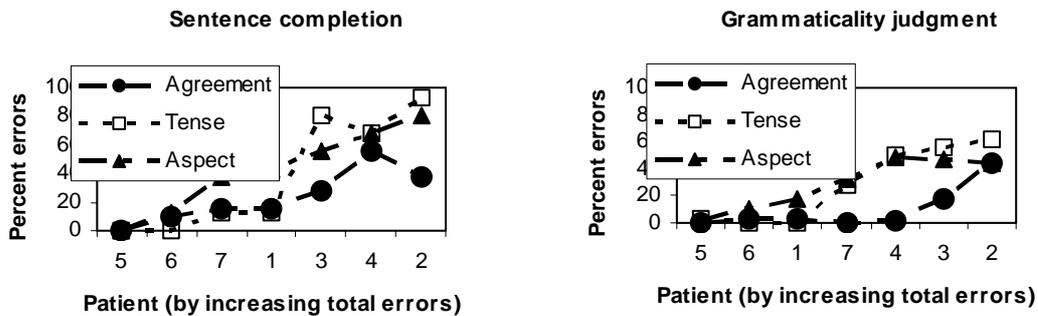


Fig. 1 Percent errors per functional category in each task for each patient. The patients are ordered by number of total errors in the corresponding task, from least (left) to most (right)

In Figure 1 we plot the number of errors in each category for the two tasks by patient, ordered by “severity,” as defined by the number of total errors made by each patient in the corresponding task. In addition to the similar patient orders for the two tasks, indicating comparable relative

deficits in sentence completion and grammaticality judgment, the same *pattern* of deficits is seen across tasks: All three functional categories suffer as overall number of errors increases, but agreement appears to be the most resistant category, and aspect least resistant, in the patients who showed dissociations in sentence completion or grammaticality judgment tasks. Testing whether individual patient performance is impaired by comparing the mean number of individual errors in each condition to 0 (via t-test at $\alpha=0.017$), we find that, for the sentence completion task, patients P2, P3, and P4 are impaired in agreement (P1 and P7 only marginally so, $p=0.023$) and in tense, whereas P1, P2, P3, P4 and P7 are all impaired in aspect (P6 missed significance, $p=0.044$). In the grammaticality judgment task, only patients P2 and P3 are impaired in agreement, patients P2, P3, P4, and P7 are impaired in tense, whereas all but P5 are impaired in aspect.

5. Discussion

Three patterns of production performance were observed in these patients, similar to Burchert et al. (in press). The two least impaired patients in terms of overall number of errors in production (P5, P6) showed no dissociation in performance patterns, with performance well above chance or perfect. One patient (P4) showed no dissociation in performance patterns, with performance around chance. Finally, three patients (P1, P2, P3) showed a dissociation in production, with better agreement than either tense or aspect. The same three patterns were observed in grammaticality judgment. The two least impaired patients in terms of overall number of errors in production (P5, P6) showed no dissociation in performance patterns, with performance well above chance. One patient (P2) showed overall impairment in all three categories, with no dissociation and performance around chance. Last, four patients (P1, P3, P4, P7) showed a dissociation in grammaticality judgment, with better agreement than tense or aspect. Note that patients 2, 3, 4, and 6, are diagnosed as nonfluent. The grammaticality judgment performance of the patients shows a much larger overall percentage of errors than the performance of the controls, as expected, indicating a genuine deficit in language, which nevertheless varies in degree among the patients.

Concerning the production performance, if participants were more likely to simply repeat the cue item in general, then they would be inclined to repeat the same verb in particular, thus making few if any lexical errors. In that case, the three patients who made many more repetition than non-repetition form errors (P2, P3, and P4), should also make a much smaller

proportion of lexical errors. In fact, the opposite pattern was observed: P2, P3 and P4 also made the highest number of lexical errors. Therefore, repetition cannot account for the discrepancy between lexical and form errors. It seems that there is a genuine computational difficulty contributing to the preponderance of form errors over lexical errors, while it remains the case that the two are far from dissociable. In other words, it seems that form errors and lexical errors, even though not coextensive, do co-occur in aphasia. This finding is in agreement with evidence for qualitative and quantitative links between lexical and grammatical deficits in aphasia and other forms of language impairments (Bates & Goodman 1997; Bates, Devescovi & Wulfeck 2001; Dick et al. 2001).

Comparing the performance of patients to that of control participants, we see that each patient, naturally, made many more errors than the corresponding matched control participant. The latter made a few lexical errors, typically using a phonetically similar verb from the set of verbs used in the study, as well as few form errors, many of which indicated an interlocutory mode of response as opposed to the intended continuation mode (example: “I see a butterfly. You ___”; “I see a butterfly”). There was no indication of repetition tendencies or of a preferred aspect in the responses of these participants (Table 6).

We will next discuss our findings in light of previous studies on inflectional errors in Greek aphasia as well as in light of theoretical approaches to inflectional errors in aphasia. Although our results are not directly comparable to results of previous studies on Greek aphasia, because of differences in the methodologies used, the following observations can be made. The findings of our sentence completion task are not entirely similar to the ones obtained by Plakouda (2001) who, using a similar methodology to ours, observed that performance on the aspect task was worse than on the other two tasks and thus argued for a dissociation between aspect and the other two categories. Even though we also found worst performance on the aspect task, we would not conclude from our data that agreement and tense can be grouped together in a comparison against aspect.

Some similarities as well as differences can be observed between our findings and the results Stavrakaki & Kouvava (2003) obtained through analysis of the spontaneous speech data of two non-fluent patients. Agreement in their study reached high percentages of correct use whereas some difficulties were encountered in the production of past tense forms and perfective aspect at least for one of their subjects. Stavrakaki & Kouvava found no errors in future forms, which contrasts with our findings. The proportion of errors in the future tense forms in our sentence

completion task is 42.8% (24 out of 56 incorrect responses in total). Moreover, unlike Stavrakaki & Kouvava, we observed errors not only in the perfective aspect but in the imperfective as well (cf. Table 7), in statistically indistinguishable proportions. Last, although we observed an overall lower proportion of errors in the grammaticality judgment task, some patients made quite a few errors in the tense and aspect conditions (see figure 1). In this respect, our results are different from those in Stavrakaki & Kouvava, who found a high level of performance by their subjects on past tense marking⁶.

Let us now consider the ramifications of our findings for the various analyses proposed to explain inflectional errors in aphasia. Our results indicate that inflectional morphemes are not all impaired to the same degree in aphasia. Agreement inflection is relatively intact, while tense and particularly aspect are more severely impaired. Thus, our findings do not support a global impairment of inflectional morphemes in aphasia (Berndt & Caramazza 1980; Caplan 1985; Goodglass 1976) but a selective one (De Blesser & Luzzatti 1994; Friedmann & Grodzinsky 1997), and, in particular, a dissociation between agreement and tense and/or aspect (Friedmann & Grodzinsky 1997; Höhle 1995; Wenzlaff & Clahsen 2004).

However, our findings do not support a hierarchical account along the lines of Friedmann & Grodzinsky (1997). Given the clause structure of Greek shown in (1), according to which AspP is placed nearest to the verb root while AgrP is structurally more peripheral than TP, the TPH predicts that aspect would be the least impaired category while subject-verb agreement would be at least as impaired as tense, assuming the syntactic tree is pruned at the T node. However, performance on aspect and/or tense was lower than performance on agreement. Even if one assumes Tsimpli's (1990) analysis of Greek clause structure, according to which TP is higher than AgrP, the TPH does not predict impairment of the AspP. On the assumption that the TP-layer is pruned (given the low performance of most patients on tense), no functional categories below it should be affected. In other words, not only AgrP but AspP should be intact, a prediction not confirmed by our data. Moreover, even if one assumes that the deficit affects not just the TP-layer but a lower-level projection, such as the AspP (an assumption allowed by the TPH), then the TPH predicts impairment of all functional categories above the pruned one (including the AgrP). This prediction, however, is not borne out by our data either. Last, our findings indicated dissociations between particular projections in grammaticality judgments as well, which are not necessarily expected within TPH. To sum

⁶ Stavrakaki & Kouvava (2003) did not test aspect in the grammaticality judgment task.

up, as far as the TPH is concerned, our findings are consistent with the conclusions of Plakouda (2001), as well as of Stavrakaki & Kouvava (2003), who argue that “high or low tree position in the sentence hierarchy was not the only determinant of the aphasic performance”.

Instead, when a dissociation is observed, it is between agreement, on the one hand, and aspect and/or tense, on the other hand. This is consistent with Wenzlaff & Clahsen’s (2004) tense underspecification theory which predicts preserved agreement relative to tense, although predictions about aspect are not made. Thus, the asymmetry that arises is between categories that establish a structural relation between elements in the clause (subject-verb agreement) and categories that do not establish such relations but contribute to the semantic interpretation of the sentence (tense and aspect). Traditionally, tense is a grammatical category that denotes the temporal location of an event, while aspect indicates the temporal structure of an event, that is, the way in which the event occurs in time. This distinction between the above grammatical categories is reflected in recent versions of syntactic theory. Within Chomsky’s (2000) Minimalist Program, categories such as agreement and tense are effectively different. Agreement is not a functional category (as in previous versions of the Principles and Parameters framework) but is considered an *operation* by which certain uninterpretable features of T are checked against certain interpretable features of the subject. Tense, on the other hand, is an interpretable feature of the *functional category* T. Something along these lines may hold for aspect as well, although not discussed in Chomsky (2000). Therefore, it appears that categories which carry interpretable features may cause more difficulties to non-fluent aphasics, perhaps because of the extra processing load they impose on the subjects.

In conclusion, our findings are compatible either with Chomsky’s (2000) Minimalist Program and with Wenzlaff & Clahsen’s (2004) tense underspecification theory but not with TPH, irrespective of variations in tree structure. Moreover, severity variation, as defined here in terms of total number or errors per individual, is compatible with processing accounts. The performance of the aphasics indicates that functional categories related to verbal inflection are impaired in a systematic pattern, suggesting the existence of underlying genuine linguistic impairments. Further research is needed to replicate of the pattern of impairment we have observed and to further explore the vulnerability of verb inflection in order to understand the specific linguistic deficits in Greek aphasia.

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