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Verb inflections in agrammatic aphasia: Encoding of tense features ☆

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Abstract

Across most languages, verbs produced by agrammatic aphasic individuals are frequently marked by syntactically and semantically inappropriate inflectional affixes, such as *Last night*, *I walking home*. As per language production models, verb inflection errors in English agrammatism could arise from three potential sources: encoding the verbs' morphology based on temporal information at the conceptual level, accessing syntactic well-formedness constraints of verbal morphology, and encoding morphophonological form. We investigate these aspects of encoding verb inflections in agrammatic aphasia. Using three sentence completion experiments, it was demonstrated that production of verb inflections was impaired whenever temporal reference was involved; while morphological complexity and syntactic constraints were less likely to be the source of verb inflection errors in agrammatism. These findings are discussed in relation to current language production models.

Keywords: Morphology; Broca's aphasia; Language; Verb; Inflection; Models of sentence production

Aphasia is an impairment in producing and/or comprehending language resulting from acute brain injury such as a cerebrovascular accident. Agrammatic speech is commonly associated with the clinical syndrome of Broca's aphasia, and is frequently characterized by ill-formed sentences, reduced syntactic complexity, a paucity of verbs, and grammatical morpheme errors. Production of both free grammatical morphemes and inflectional morphemes can be impaired in agrammatic aphasia. Across most languages that have been studied, verbs produced by agrammatic aphasic individuals are frequently marked by syntactically and semantically inappropriate inflectional affixes in a variety of tasks including spontaneous speech, picture description, naming, reading, and writing (Bates, Friederici, & Wulfeck, 1987; Faroqi-Shah & Thompson, 2003a; Jarema & Kehayia, 1992; Menn & Obler, 1990; Miceli, Silveri, Romani, & Caramazza,

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1989; Miceli, Capasso, & Caramazza, 2002). The rate of verb inflection errors in agrammatism has been reported to be 50–70% (Faroqi-Shah & Thompson, 2004; Rochon, Saffran, Berndt, & Schwartz, 2000; Saffran, Berndt, & Schwartz, 1989).

What makes the verb inflection deficit in agrammatism interesting is that not all verb inflections are equally impaired. In contrast to inflectional morphemes that mark number agreement, mood, or case, tense morphology is known to be especially vulnerable to disruption in agrammatic aphasia in several languages (in English: Arabatzi & Edwards, 2000; and Nadeau & Rothi, 1992; in Spanish: Benedet, Christiansen, & Goodglass, 1998; in Hebrew: Friedmann & Grodzinsky, 1997; in Dutch: Kolk, 2000; in German: Wenzlaff & Clahsen, 2004; in Italian: De Blesser, Bayer, & Luzzatti, 1996; in Greek: Stavrakaki & Kouvava, 2003; but see Burchert, Swoboda-Moll, & De Bleser, 2005, for contrary data). The typical cross-linguistic pattern is substitution of verb forms, such as, **The dentist fix my teeth* (target: *fixed* or *will fix*), and **The maid washing the window* (target: *washed* or *is/was washing*). Substitution errors could result from a variety of deficits: a conceptual-semantic deficit in encoding contextually appropriate tense, a deficit in retrieving verb forms corresponding to the encoded tense, a syntactic deficit in determining the legality of the encoded utterance, or a morphophonological impairment undermining affixation and the production of the final consonant cluster in *washed*.

This study investigates the psycholinguistic underpinnings of aphasic verb inflection deficits using the framework of language production models (Bock & Levelt, 1994; Eberhard, Cutting, & Bock, 2005; Janssen, Roelofs & Levelt, 2002; Levelt, 1989, 1999; Levelt, Roelofs, & Meyer, 1999; Roelofs, 2000). We focus on tense marking because tense substitutions are among the most frequent morphological errors in aphasia. Although no single language production model gives a complete account of the processes involved in tense marking, the following picture emerges from combining various psycholinguistic proposals: speakers formulate a message that includes encoding of temporal reference and specification of *diacritic parameters*. In this context, diacritics refer to aspects of a speaker's message that are typically represented by inflectional affixes, such as tense, number, mood, and aspect. Thus, the diacritic feature of tense involves conceptualization of temporal reference, such as +PAST or +PRESENT. It is noteworthy that tense diacritic parameters are essentially identical for morphologically regular and irregular verbs. Other diacritic parameters, such as verb number for subject–verb agreement, are operational only during syntactic encoding and need not be specified during message formulation (Bock, 2004; Eberhard et al., 2005). Production of finite verbs is assumed to proceed by retrieving inflectional affixes or verb forms[1] that correspond to the selected diacritic features from the mental lexicon (for example, +PAST → Verb + D). Thus, the production of the correct verb form crucially depends on whether the correct diacritical features are selected and whether these features successfully connect to the correct verb form. For the purposes of this study, these early conceptual-lexical-semantic processes are collectively referred to as *diacritic encoding and retrieval* (henceforth DER). Two sources of evidence suggesting DER operations are stranding errors seen in normal slips of the tongue, such as *They ordered up ending some fish dish* (...ended up ordering...) (Butterworth, 1982), and reading errors in aphasic individuals, such as *buy* for *bought* (Badeckar, 1997). The example of stranding can be explained as a derailment of DER that results in the diacritical features +PAST and +PROGRESSIVE incorrectly being linked with *order* and *end* respectively. The example of reading error is most easily explained if one assumes a DER deficit in encoding *bought* as *buy* + PAST (see Stockall, 2004, for evidence of morphological decomposition of irregular verbs). Verb inflection errors in aphasia could potentially arise from a tense related DER deficit, that is, a failure to encode diacritical features appropriate to the temporal context or to utilize tense diacritics to retrieve inflectional affixes/verb forms from the mental lexicon. In this case, aphasic individuals would be expected to demonstrate deficits not only in narrative speech, but also in tasks that elicit a finite verb in a specific temporal context, such as *Yesterday my mother* _____ *a cake* (options provided: bakes, baked). In this example, a response such as *My mother bakes a cake* is rendered incorrect due to a mismatch between the temporal context (*Yesterday*) and verb tense (+PRESENT). Importantly, a DER deficit would result in a comparable impairment in the production of both regular and irregular finite verbs. To our knowledge, a DER deficit has not been previously implicated as a source of verb inflection errors in agrammatic aphasia.

Although the exact nature of morphological representations is a contentious issue (McClelland & Patterson, 2002; Pinker & Ullman, 2002), the majority view is that regular and irregular verbs have different morphological frames and that the production of regularly inflected verbs and semantically transparent derivational affixes involves affixation operations by means of a slot-

[1] We use the term *verb form* to refer to whole word inflected representations of verbs, such as that assumed by single route and connectionistic models of lexical representation (Butterworth, 1983; Seidenberg & McClelland, 1989). Since the nature of mental representations of morphologically complex words (decompositional versus whole word) is highly debated, we acknowledge both possibilities.

and-filler mechanism (Clahsen, 1999; Janssen, Roelofs, & Levelt, 2002; Janssen, Roelofs, & Levelt, 2004; Pinker & Ullman, 2002; Prasada & Pinker, 1993; Roelofs & Meyer, 1998). One account of agrammatic aphasic individuals' difficulties in producing inflectional morphology derives from dual-mechanism theories of morphology that propose rule-based affixation operations for regular inflections and whole word access for irregular inflections (Ullman et al., 1997, 2005). It is proposed that individuals with agrammatic aphasia are unable to perform affixation operations necessary for the production of regular verbs (Ullman et al., 1997). This account makes two predictions: a dissociation between regular and irregular inflections with worse performance on regular inflections, and a predominant error pattern of affix omissions, resulting in verb stems. Previous investigations of regularity in agrammatic aphasia have yielded mixed results: worse performance on irregulars (Balaguer, Costa, Sebastian-Galles, Juncadella, & Caramazza, 2004; Penke, Janssen, & Krause, 1999), worse performance on regulars (Ullman et al., 1997), as well as no differences between regulars and irregulars (Bird, Lambon Ralph, Seidenberg, McClelland, & Patterson, 2003). Although some of these differences have been attributed to differences in stimuli and languages studied, the role of morphological complexity in the production of finite verbs in agrammatism needs further investigation.

If morphological complexity undermines the production of verb inflections in agrammatic aphasia, then we might expect decreased performance on other morphologically complex words, particularly derivations such as *speaker* (speak + er).[2] In fact, lexical–phonological variables such as stem frequency, syllable number, and the presence of consonant clusters, have been found to similarly affect repetition and reading of both inflections and derivations in agrammatism (Mathews & Obler, 1997; Mathews, Obler, Harris, & Bradley, 2001; Meth, Obler, Harris, & Schwartz, 1995). However, some authors have shown better performance with derivational morphology compared to inflectional morphology in agrammatic aphasic patients (Miceli & Caramazza, 1988). English offers a good test of DER versus morphological complexity in agrammatism because past tense regular and irregular verbs are finite and undergo the same DER operations, but irregular past tense verbs are considered morphologically simple because they typically do not have a delineable affix (but see Halle & Marantz, 1993 for a different view). In contrast, regular verbs and derivations are morphologically complex, but derivations do not undergo the same DER operations as inflected verbs. Thus for English agrammatic speakers, a DER deficit would impair the production of both regular and irregular inflections, while a post-lexical morphological affixation deficit would impair regular inflections and derivations, but not irregular inflections.

As per language production models, a third potential locus of verb inflection errors in aphasia is syntactic encoding. In recent versions of linguistic theory such as the minimalist program, syntax refers to constraints on the combination of lexical items and movement operations (Chomsky, 1992). Crucially, syntactic constraints refer to combinatorial rules that are relatively independent of the message content, and are standard for all sentences of that language. According to Bock and Levelt (1994), syntactic mechanisms ensure that speech conforms to language specific well-formedness constraints, including decisions about whether grammatical morphemes such as auxiliaries need to be produced with particular verbal inflections. Thus, *He walked* and *He is walking* are syntactically well-formed but not **He walking* and **He is walk*.

Given that agrammatic aphasic individuals often produce syntactically ill-formed speech, it has been proposed that verb inflection errors in agrammatism occur because syntactic well-formedness constraints are rendered inaccessible (Arabatzi & Edwards, 2002; Tree-Pruning Hypothesis (TPH): Friedmann & Grodzinsky, 1997). Previous syntactic accounts are based on the observation that agreement morphology seems to be better preserved than tense morphology in agrammatic aphasia, and have suggested that tense nodes are inaccessible to the checking mechanism, while agreement nodes are accessible (Friedmann & Grodzinsky, 1997), or that tense is underspecified (Tense Underspecification Hypothesis (TUH): Wenzlaff & Clahsen, 2004). However, these accounts do not differentiate between DER and syntactic mechanisms, perhaps because psycholinguistic models rarely make this distinction. For example, a popular method of eliciting verb inflections in studies of agrammatic aphasia is asking patients to produce verb morphology in response to a temporal adverb (e.g., *Everyday I rob a bank. Just like everyday, yesterday I _____: robbed a bank*) (Ullman et al., 1997). This task confounds DER and syntactic mechanisms since errors such as *Yesterday I robbing a bank* could potentially arise from a deficit in extracting and implementing diacritical information from the sentence initial adverb (Yesterday → + PAST → rob + D), or impaired access to local syntactic constraints. In order to tease apart DER and syntactic mechanisms, a comparison should be made between sentences that specify a temporal context for DER (such as, *Yesterday the thief _____ a bank*) and sentences in which choice of verb form is constrained by the immediately preceding con-

[2] Although inflection and derivation are considered distinct lexical processes by most authors, both groups of words are morphologically complex and there is evidence for decomposition of both (Pillion, 1998; Stockall, 2005). Therefore, a general deficit in post-lexical affixation operations is likely to impair production of both inflection and derivation.

Table 1
Description of the experiments

	Sentence types	Example	# stimuli	Tense marking	Overt affix	Local morphosyntax
Experiment 1	Verb	The mailman *drops* the mail in the mailbox	15	Y	Variable	Y
	Non-verb	There are *drops* of water on the floor	15	N	Variable	Y
Experiment 2	Regular past	Last year, he *lived* in New York	15	Y	Y	
	Irregular past	Yesterday, she *spent* a hundred dollars	15	Y	N	
	3rd singular	Everyday, the hotel *provides* breakfast	15	Y	Y	
	Derivation	Yesterday I paid the *builder*	15	N	Y	
	Non-finite	Last year, I wanted to *build* a house	15	N	N	
Experiment 3	1st present	Everyday I *return* home at 5o'clock	15	Y	N	
	Future	Tomorrow I *will send* the package	15	Y	N	
	Past prog.	Last year I *was writing* a book	15	Y	Y	

text, such as the presence or absence of a preceding auxiliary (for example, *The thief will _____ a bank*). For an individual with intact access to syntactic mechanisms, the latter sentence would not pose a problem because local syntactic well-formedness constraints are sufficient to guide verb selection.[3] Thus, syntactic accounts of verb inflection deficits will need re-thinking if aphasic individuals make significantly more verb form selection errors on sentences with temporal reference than on sentences that rely on local syntactic constraints.

To summarize, our objective is to investigate if the psycholinguistic processes involved in encoding verb inflections can be delineated in agrammatic aphasic speakers if we use carefully designed stimuli, and if so, which of the following three processes are impaired: (1) syntactic well-formedness constraints for tense marking, (2) encoding of morphologically complex (affixed) words, or (3) DER operations associated with tense marking. The syntactic constraints were examined in Experiment 1. In Experiment 2, we examined the effect of morphological complexity and tense-DER. In Experiment 3, we confirmed the findings of Experiment 2 by using a different set of comparisons. These comparisons are listed in Table 1. The same aphasic individuals participated in all three experiments with a 2–3 week interval between experiments for each participant. In this study, we did not examine phonological aspects of verb inflection encoding. Phonological encoding is addressed in a different paper (Faroqi-Shah and Thompson, in preparation).

Most studies of production of verb inflections in aphasia have used a sentence completion task that involves a transformation. For example, the verb stem is provided in a preceding sentence such as *Everyday I rob a bank. Just like everyday, yesterday I _____* (sentence from Ullman et al., 1997). In fact, performance of agrammatic aphasic patients on the same transformation task has been used to support diverse accounts of agrammatic production (compare: Bird et al., 2003; Friedmann & Grodzinsky, 1997; Wenzlaff & Clahsen, 2004; Ullman et al., 1997, 2005). In addition to the difficulty in distinguishing between DER, syntactic checking and morphophonological operations, this task has other inherent drawbacks. First, it yields disproportionately more stem substitutions than other tasks such as reading or repetition, probably because presentation of the verb stem in the preceding sentence increases (or primes) the likelihood of the verb stem being repeated (Bird et al., 2003). Inflected verbs can be similarly repeated from the preceding sentence. For example, Arabatzi and Edwards (2002) found that Broca's aphasic patients produced responses such as *He not shaves* following probe sentences such as *He shaves*. Second, since this task involves a transformation of verb forms, production of regular and irregular inflections may involve different processes: the former require affixation of the default *ed* or *ing* affix, whereas in the case of irregular inflections, idiosyncratic transformations such as vowel and/or consonant changes or retrieval of a different stem allomorph are involved. In studies with normal individuals, differences between regular and irregular verbs were observed only when transformation was involved (Okrent, 2004). Third, non-finite verbs and derivations are not very easily elicited using this sentence completion paradigm.

For the above reasons, we used a variation of the sentence completion paradigm utilizing a multiple choice format. A multiple choice task minimizes the tendency to repeat the verb stem and matches the processing demands for regular and irregular verb trials. Another advantage is that accuracy is less likely to be confounded by auxiliary and verb retrieval deficits when compared to sentence completion that necessitates free recall. For instance, Arabatzi and Edwards (2002) found a large number of auxiliary omission errors, such as *Tomorrow*

[3] We use the term *selection* rather than *production* because the demands of a sentence completion task are best described as such. We thank Robert Hartsuiker for pointing this out.

she cook a cake for *Tomorrow she will bake a cake* and omissions of the progressive *be*. Arabatzi and Edwards categorized these as tense omission errors although auxiliary omission could result from a function word retrieval deficit that is unrelated to encoding of tense (Bird, Franklin, & Howard, 2002; Harris, Stanford, & Campbell, 1989; Yaffee, 1990). An unavoidable drawback of the multiple choice sentence completion task is its unnaturalness when compared to narrative speech. However, this manipulation is necessary to empirically tease apart the confounding effects of DER, morphological and syntactic processes. Also, this task has fewer computational demands when compared to narrative speech and hence the accuracy scores obtained may be relatively higher than in narrative speech.

Experiment 1: Syntactic constraints

As mentioned earlier, tense information in English sentences is conveyed by different auxiliary-verb inflection permutations which need to follow certain local syntactic well-formedness constraints. Inability to access or comply with these syntactic well-formedness principles could potentially result in the sort of verb errors that render sentences ungrammatical in agrammatic speech. In order to demonstrate that verb inflection errors in agrammatic aphasia arise from a deficit in local syntactic constraints that is only specific to verbal morphology, we also need control stimuli that elicit non-verbs. Words that are homophonous with inflected verbs but function as nouns or adjectives provide such as controlled comparison. For example, *The injured soldier went home* vs. *Tom injured his finger*. In the first sentence, *injured* is an adjective, while in the latter sentence *injured* functions as a verb. This experiment was designed to address two questions: whether agrammatic aphasic individuals who produce verb inflection errors are sensitive to syntactic well-formedness constraints that govern the occurrence free and bound verbal morphology, and whether the ability to select syntactically appropriate verb forms when given a sentence context differs from the ability to select homophonous and frequency-matched non-verbs when given a syntactic context.

Methods

Participants

Ten aphasic participants were recruited from the subject pool of Northwestern University's Aphasia and Neurolinguistics Research Laboratory (age range: 55–68 years). Demographic and neurological details of the aphasic participants are given in Table 2. All aphasic participants had a single left hemisphere lesion resulting from a cerebrovascular accident (CVA). Eight out of 10 patients had a lesion in the region of the left middle cerebral artery. Information about lesion location for patient B8 was not available. Patients B1 through B9 had an ischemic episode. B10 suffered a haemorrhagic event primarily in the basal ganglia that extended to the temporal and parietal lobes. They were all at least one year post-onset. With the exception of two participants, all were right-handed before the CVA. None of the aphasic participants had complicating medical or neurological conditions such as alcohol/drug abuse, dementia, or psychiatric disturbances. All participants were native speakers of standard American English. They all had at least a high school education. All participants passed a puretone audiometric screening at 500, 1000 and 2000 Hz at 40dBHL ANSI:1969 in at least one ear. One participant's (B9) hearing was not tested because he used a hearing aid to correct his hearing to normal, as per his audiological report. The corrected

Table 2
Demographic details of the aphasic participants

Participant	Age (years)	Gender	Handedness	Education (years)	Years post onset	Lesion
B1	55	M	L	20	13	[a]LCVA
B2	58	M	R	18	4	LCVA
B3	59	M	R	16	14	LCVA
B4	64	M	R	16	5	LCVA
B5	55	F	R	14	9	LCVA
B6	68	M	R	16	10	LCVA
B7	59	F	R	15	8	LCVA
B8	63	M	R	18	9	LCVA
B9	66	M	L	20	5	[b]LCVA
B10	55	F	R	12	6	[c]LCVA
Mean (SD)	60.2 (4.7)			16.5 (2.5)	8.3 (3.4)	

[a] LCVA—left hemisphere cerebrovascular accident.
[b] B9 had two seizures in the years following his initial stroke.
[c] As mentioned in the text, B10 had a haemorrhagic stroke of the basal ganglia.

visual acuity of all participants measured at least 20/40 on the Snellen's chart.

Language testing

All aphasic participants completed a set of pre-tests that were intended to establish their diagnosis of Broca's aphasia with agrammatic speech, characterized by errors in the production of inflectional morphology. The tests and their findings are described below and summarized in Table 3. Inclusionary criteria were: a profile of Broca's aphasia, absence of significant apraxia or dysarthria, functional reading abilities, and difficulty with verbal morphology as determined from narrative speech and a verb inflection pretest. The diagnosis of Broca's aphasia was made by a Speech-Language pathologist using a standardized aphasia test, the Western Aphasia Battery (WAB) (Kertesz, 1982). As per the WAB, all participants had impaired sentence structure and fluency (a fluency score of 5 or lower on the WAB), with relatively spared auditory comprehension (score of 6.9 or higher on the comprehension subtests), and oral repetition (score of 3 or higher on the WAB). Three single word reading subtests of the WAB, subtests C (written word stimulus-object choice matching), D (written word stimulus-picture matching), and E (picture stimulus-written word choice matching) were also administered to test overall single word reading capability. Aphasic individuals were screened for motor speech disorders such as dysarthria and apraxia using the *oral expression* subtest of the Boston Diagnostic Aphasia Examination (BDAE) (Goodglass, Kaplan, & Barresi, 2001). This subtest includes measures of verbal and non-verbal agility. The maximum score for the verbal and non-verbal agility subtests are 14 and 8, respectively. All participants scored 8 points or above on each of these subtests.

Samples of narrative speech were elicited by having participants describe the cookie theft picture which is a part of the Boston Diagnostic Aphasia Examination (BDAE) (Goodglass et al., 2001) and narrate the Cinderella fairy tale. Rate of speech was calculated as the number of words produced per minute (WPM) and this ranged from 26 to 95, showing a reduction from the normal range (107–232, Rochon et al., 2000). The narratives were coded for syntactic and lexical features according to the procedure of Thompson et al. (1995). The coded samples were used to compute the mean length of utterance (MLU), proportion of grammatical sentences, and open class: closed class ratio.[4] All Broca's aphasic participants showed evidence of agrammatic speech as revealed by a reduction in the above measures in comparison to the narratives of 10 age-matched normal individuals (Kim & Thompson, 2003) (see Table 3). All

[4] This is the ratio of the total number of open class words (nouns, verbs, etc.) to the total number of closed class words (determiners, auxiliaries, etc.) produced.

Table 3
Test scores of all participants

Participant	WAB				Narrative speech		Proportion verbs with correct morphology	Naming		Verb inflection pretest
	Aphasia quotient	Reading	WPM	MLU	Proportion grammatical sentences	Open:closed class ratio		Verbs ($N = 31$)	Nouns ($N = 63$)	
B1	82.3	18	89	7	0.5	2.9	0.8	28	52	0.3
B2	81.4	18	56	2.8	0.5	2.7	0.7	25	58	0.2
B3	70.8	8	49	4.1	0.45	1.5	0.3	22	27	0.55
B4	81.8	18	32	6	0.49	1.1	0.5	20	47	0.4
B5	58.1	6	43	3.5	0.1	3.3	0.2	19	20	0.2
B6	75.6	15	65	2.9	0.2	3.9	0.3	22	54	0.2
B7	66	10	95	5.1	0.4	2.5	0.4	14	22	0.2
B8	77.1	16	56	5.9	0.33	2.9	0.8	12	44	0.3
B9	68.2	18	26	2.8	0.18	1.8	0.6	15	42	0.25
B10	78.6	18	80	9	0.65	2.3	0.6	27	59	0.25
Aphasic mean (SD)	73.9 (8)	14.5 (4.7)	59 (23)	4.9 (2.1)	0.38 (0.2)	2.5 (0.8)	0.52 (0.2)	20.4 (5.5)	42.5 (14.6)	0.3 (0.2)
Normal mean (SD)			160.8 (37)	15.8 (3.7)	0.88 (0.1)	0.98 (0.1)	0.99 (0.01)			

aphasic participants were given the confrontation naming subtest of the Northwestern Naming Battery (Thompson and Weintraub, in preparation). This subtest measures the naming of 63 nouns, including body parts, tools, colors, and 31 verbs with a variety of argument structures using simple black and white line drawings. Six patients had worse naming scores for verbs compared to nouns, while the remaining four exhibited the reverse pattern (see Table 3).

Difficulties with production of verb inflections were pre-tested using a picture description task since narrative speech may elicit a different number and variety of verbs across participants, and may not reveal the true occurrence of verb inflection errors. The verb inflection pretest consisted of 20 picture stimuli. Five stimuli each were designed to elicit one of four verbal forms (*V*, *V+ing*, *V+ed*, and *V + s*) using word cues that were printed on the stimuli (*tomorrow, now, yesterday*, and *everyday*).[5] An example of an elicited sentence is *Yesterday the man kissed the woman*. Participants were instructed to describe the picture stimuli using the temporal word cue. Accuracy for the production of verb inflections was below 70% for all participants (see Table 3).

Materials

A total of 30 sentences were used. One half of the stimuli (15 sentences) consisted of sentences in which the accurate response was determined by the presence/absence and type of auxiliary. These were called *verb trials*. The sentences were constructed such that access to local syntactic well-formedness constraints of verb morphology was sufficient for successful performance. For example, in English the auxiliary *will* rarely precedes the *ed* form of a verb (as in **will called*). Thus, in principle, aphasic patients who can access criteria governing verbal morphology can successfully complete these sentences such as *The man will _____ the Canadian border* (response options: *cross*, *crosses*, *crossing*), even in the presence of deficits in DER. Eight trials had an auxiliary preceding the blank (e.g., *The man is crossing the Canadian border*) and 7 trials did not contain auxiliaries (e.g., *I locked the door; She calls her mother*).

Verb trials were compared with sentences that could be completed using frequency-matched nouns (12 trials) and adjectives (3 trials) (*non-verb trials*). All non-verb stimuli were homophones of the verbs used in the verb trials (e.g., *cross* as in *The man wore a cross around his neck*; and *injured* as in *The injured soldier went home*). The target words of the verb and non-verb trials were matched for logarithm of lexeme frequency based on CELEX (Baayen, Piepenbrock, & van Rijn, 1993) and Francis and Kucera (1982) databases. Paired samples *t*-test revealed no significant differences in the word frequencies of verb and non-verb stimuli, using both the CELEX ($t(14) = 2.16$, $p = .24$) and Francis and Kucera ($t(14) = 2.14$, $p = .22$) word frequency counts. These 30 sentences were accurately produced by five native speakers of standard North American English. The sentences are given in the Appendix A. Three response options were listed for each sentence.

Procedure

Aphasic participants were tested individually in a quiet room. Stimuli were presented in a random sequence that was the same for all participants. Participants were first required to repeat each of three response options after the experimenter. This was done to document and rule out single word production errors attributable to phonological impairments. Response words were presented again if participants made errors in repeating them. If participants still repeated the words inaccurately, the printed words were presented for them to read aloud. Accuracy of immediate repetition and any phonological errors were noted on the score sheet. Next, the three printed response options were placed in front of the participant while the experimenter read out the incomplete sentence. Participants were instructed to repeat the sentence while using one of the three response options to complete it. Participants were assisted to a limited extent if they could not recall the sentence. The experimental trials were preceded by four practice trials.

Participant's responses were transcribed on-line as well as tape-recorded for the purpose of later verification and reliability. Any ambiguities in verbal responses were verified by asking patients to point to and read the corresponding printed response. When a response was auditorily ambiguous, as in final consonant clusters for regular past tense (*talk* vs. *talked*), the acoustic wave was examined using Praat version 4.0.49 software (Boersma & Weenink, 2005) for the presence of final consonants. Tape-recorded samples of three participants were randomly selected and transcribed by a Speech-Language Pathologist for the purpose of reliability. There were no discrepancies between the transcriptions of the primary experimenter and reliability scorer.

Data analyses

The first response that was produced was scored for accuracy, except in cases where participants made an immediate (within 2 s) and unambiguous self-correction. Responses that were produced with latencies longer than 22 s were considered non-responses. Responses were scored for accuracy of the target. Only the target auxiliary and verb were considered for accuracy scoring, and errors in producing the remainder of the sentence were ignored. When participants produced a substitution that was not among the response options provided, but was grammatically appropriate, it was scored as correct.

[5] All participants were pre-tested for comprehension of temporal adverbs by asking them to point to *yesterday*, *today*, *tomorrow*, *next month*, *etc. on a calendar.*

For example, participant B4 produced the sentence *She walked in the garden* when the options provided were *walk*, *walking*, and *walks*. This response was scored as correct since the purpose of this experiment was to test if agrammatic aphasic participants could produce verbal inflections that comply with local syntactic constraints. This happened only twice.

Errors were categorized into the following five types: stem substitutions, inflection substitutions, inflection additions, verb for non-verb, and others. *Stem substitutions* were defined as production of the verb stem for an inflected target, such as *walk* for *walks* as in the sentence *Mary walk to the store. Inflection substitutions* were defined as production of an incorrect inflectional affix, such as *locks* for *locked* as in the sentence *I locks the door*. Responses were scored as inflection substitutions only when the substitution resulted in an ungrammatical sentence *Inflection additions* involved production of inflected verbs for a verb stem, such as *shaking* for *shake* in the sentence *I will shaking the tree*. *Verb for non-verb* errors were defined as the production of an inflected verb when the target was a non-verb, as in the example *He wore a crossing around his neck*. Errors classified as *other* included no responses and responses that contained the wrong verb stem.

Results

The percent accuracy scores for verb and non-verb trials are given in Fig. 1. The mean accuracy of the verb trials was 88.6% ($SD = 7.1$; SE of Mean = 2.2, 95% CI = 83.6–93.7) and the mean accuracy of the non-verb trials was 85.9 ($SD = 8.6$; SE of Mean = 2.7; 95% CI = 79.8–92.1). There was no significant difference between the accuracies of verb and non-verb trials ($t(18) = 0.76$, $p = 0.46$, SE of the difference = 3.5). The distribution of different errors is given in Table 4. The errors were distributed across all categories and there were too few errors for a statistical analysis of error types to be meaningful.

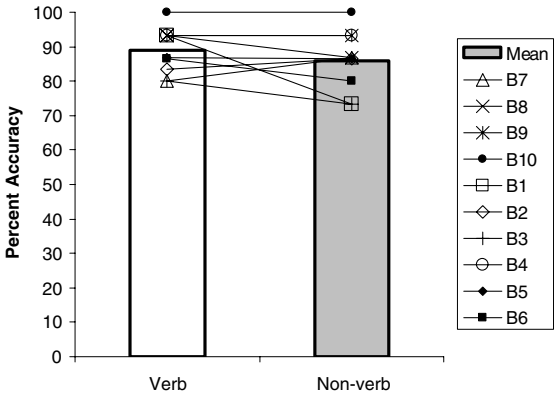

Fig. 1. Individual and mean group accuracy for verb and non-verb trials in Experiment 1. Error bars indicate 95% confidence interval of the mean.

Discussion

The data from this Experiment revealed that our Broca's aphasic participants were relatively unimpaired in their ability to select appropriate verb forms in a constrained morphosyntactic context, and that this ability did not quantitatively differ from their ability to select closely matched non-verb stimuli. If syntactic well-formedness constraints were inaccessible, agrammatic aphasic individuals would have made significantly more errors in selecting the appropriate verb form when given a syntactic context. This high accuracy of verb morphology in locally constrained contexts is consistent with previous cross-linguistic research on access to well-formedness constraints of verb morphology (Bastiaanse & van Zonneveld, 1998; De Blesser et al., 1996; Kolk & Heeschen, 1992; Lonzi & Luzzatti, 1993) and will be described in the General discussion. The findings of this Experiment are inconsistent with most syntactic accounts which propose that a deficit of the tense node in the syntactic tree representation impairs all syntactic computations of tense (Arabatzi & Edwards, 2002; Burchert et al., 2005; Friedmann & Grodzinsky, 1997; Wenzlaff & Clahsen, 2004).

The next step in investigating the psycholinguistic underpinnings of verb inflection deficits in agrammatism is to examine DER and morphological complexity. This was the objective of Experiments 2 and 3.

Experiment 2: DER versus morphological complexity

The goal of this experiment was to distinguish between DER and morphological complexity accounts of the production of verb morphology in agrammatic aphasia. This was achieved by comparing the accuracy with which (1) finite and non-finite verbs are produced, and (2) morphologically simple and complex words are produced. Finite verb stimuli consisted of sentences with verbs in either past tense or third person present tense, non-finite verb stimuli consisted of non-finite verbs in an embedded clause, morphologically complex stimuli consisted of sentences with either derivations or regular inflections, and morphologically simple stimuli consisted of sentences with either uninflected verbs or irregular verbs. It was hypothesized that a DER deficit would significantly impair performance on finite verbs compared to non-finite verbs. If verb inflection errors are associated with morphological complexity effects, then performance on morphologically complex stimuli would be significantly worse than for morphologically simple stimuli.

Table 4
Distribution of errors pooled across all agrammatic aphasic participants for Experiment 2 ($N = 10$)

	Inflection substitutions	Stem substitutions	Regular (ed, s)	Irregular	Inflection additions	Inflection for derivation	Others	Total
B1	7	8	4	4	0	1	3	
B2	5	7	5	2	0	1	0	
B3	16	1	0	1	2	0	7	
B4	9	7	7	0	7	5	3	
B5	15	6	3	3	3	0	4	
B6	10	19	13	6	4	0	4	
B7	20	3	2	1	3	0	0	
B8	5	8	7	1	0	0	8	
B9	18	3	2	1	4	1	3	
B10	15	10	8	2	0	0	3	
Total number	120	72	51	21	23	8	35	258
Percent occurrence	46.5	27.9			8.9	3.1	13.6	100

Methods

Participants

All 10 aphasic individuals from Experiment 1 participated in Experiment 2.

Stimuli

The Francis and Kucera (1982) word frequency database was used to select verbs whose lemma frequency fell in the mid-frequency range (200–650 per million). The stimuli consisted of different inflectional and derivational variants of these verbs (See also Table 1). Stimuli were developed from 75 words in six different categories: 15 verbs with regular past tense (e.g., *worked*), 15 verbs with irregular past tense (e.g., *spoke*), 15 verbs with simple present tense[6] (e.g., *follows*), 15 non-finite verbs (e.g., *to break*), and 15 derived words (e.g., *driver*). Among the non-finite verb stimuli, eight had irregular past tense forms, and seven had regular past tense forms. Derivations were all nouns with verb roots (e.g., *speak* + *er*, *appear* + *ance*). Words from each category (regular past, irregular past, etc.) were matched for lexeme frequency (logarithm) with words from the other categories using CELEX (Baayen et al., 1993) and Francis and Kucera (1982) databases.[7] A one-way ANOVA comparing the lexeme frequencies of non-finite, regular past, irregular past, third person singular and derived words revealed no significant difference ($p > 1$).

The stimuli consisted of 75 sentences that began with a word or phrase that provided a temporal context (for example, *yesterday* or *last year*). Each of the sentences had a missing word, which was either a derivation, non-finite verb, or inflected verb. When the final consonant of the target word was a stop consonant as in regular past tense verbs (e.g., *fixed*), the onset of the word that followed the target was always a vowel or semivowel. An example is *Yesterday Mary returned early*. This is because final consonant deletion is more likely if the following word begins with a consonant. An example of a sentence used to elicit an inflected verb is: *Yesterday Rob _____ at the meeting* (options provided: *speaks*, *spoke*, *speak*). Non-finite verbs were elicited within an embedded infinitive clause such as *Last year, Rob learned to _____ Russian* (options provided: *speaking*, *spoke*, *speak*). An example of a sentence that could be completed by a derived word is *Yesterday the _____ was late* (options provided: *speaks*, *speaker*, *speak*). Although temporal contexts (such as, *yesterday*, *tomorrow*, and *last year*) are required only to elicit verb inflections, a temporal context was provided for all derivation and non-finite verb trials in order to make the derivation and non-finite trials indistinguishable from the verb inflection trials. The sentences are given in the Appendix A.

Three response options were listed for each sentence. In most instances, at least two response options made a grammatical sentence if the temporal adverb was ignored. Thus in the example *Yesterday Rob _____ at the meeting* (options provided: *speaks*, *spoke*, *speak*), both *Rob speaks at the meeting* and *Rob spoke at the meeting* are acceptable sentences. However, when preceded by *Yesterday*, only *spoke* is an acceptable response. This was done to ensure that participants did

[6] For Experiment 2, we used only third person present tense since this is marked by a regular overt affix, as opposed to first person present tense, which has no overt morphological marking. In English, the verbal affix *–s* marks both tense and agreement. For the purpose of the present study, only the tense marking function was considered.

[7] Since lexeme frequencies can influence production of verb morphology (Faroqi-Shah & Thompson, 2004), we chose to match lexeme frequencies across conditions over counterbalancing verb stems across conditions (e.g., sing, sings, sang).

not rely on grammaticality of the resulting sentence to choose the right response. For the derivation trials, derivational variants were included among the response options whenever this was possible (e.g., *consideration*, *considerable*, *considered*). All 75 sentences elicited accurate responses in five normal speakers of standard North American English.

Procedure and data analysis

This was the same as for Experiment 1. During sentence production, when participants used the incorrect temporal marker (e.g., *yesterday* for *everyday*), they were stopped and presented the temporal marker again. Errors in producing the remainder of the sentence were not corrected. Percent accuracy was computed for the five word categories for each participant.

Errors were categorized into the following five types: stem substitutions, inflection substitutions, inflection additions, inflection for derivation, and others. The operational definitions of these errors are that same as in Experiment 1. Stem substitutions were further divided into stem substitutions for regular verbs, which included regular past tense and third person present tense verbs; and stem substitutions for irregular past tense verbs.[8] *Inflection for derivation* errors were defined as production of a verbal inflection for a derived word as in the example *Yesterday the speaking was late* (target → *speaker*).

Results

Accuracy

The group mean percent accuracy of derived words, non-finite verbs, regular past, irregular past and third person present tense was 93.1% ($SD = 8.3$, SE of the mean = 3.2, 95% CI = 85.4–99.9), 80% ($SD = 15.7$, SE = 5.5, 95% CI = 66.2–91.1), 51.6% ($SD = 15.3$, SE = 2.8, 95% CI = 39.4–52.5), 58% ($SD = 18.6$, SE = 5.4, 95% CI = 42.3–66.9), and 52.6% ($SD = 15.3$, SE = 8.2, 95% CI = 35.2–72.7), respectively. These are shown by the bars in Fig. 2. As is evident from Fig. 2, the accuracy of non-finite words and derived words was higher than the accuracy of regular past, irregular past and third person present tense words. The main effect for word complexity was not significant ($p > .05$). The main effect for tense marking was significant, $F_1(4,45) = 13.1$, $p < .001$, F_2 $(4,70) = 21.7$, $p < .001$, $\text{minF}'(4, 13) = 8.2$, $p < .01$. Post-hoc comparisons with a Bonferroni correction revealed no significant differences between regular past, irregular past, and third person present tense words ($p > .05$). There were significant differences between the accuracy of non-finite words and each of regular past, irregular past, and third person present tense words (in order, $p = .001, .03, .02$).

Accuracy data for individual participants are given by the lines in Fig. 2. There were two exceptions to the general accuracy pattern. B8 demonstrated above chance accuracy for irregular verbs. Secondly, the performance on V+s verbs is most variable. The likely reason for this is that, V+s conveys both tense and number (third person singular present tense) information. Hence, some aphasic participants may be successfully relying on subject–verb number agreement cues to select the correct verb form in V+s trials.

Error analysis

The distribution of errors for all participants is given in Table 5. The two columns give the actual number of errors out of a total of 249 error instances and the percentage occurrence of each error type. Prior to interpreting the error pattern, it should be pointed out that in this experiment, stem substitutions and inflection substitutions are possible only for words with tense marking. Inflection additions can occur only for non-finite verbs, and inflection for derivation errors can occur only for errors with derivation trials. As can be seen from Table 4, inflection substitutions constituted the largest proportion of errors. This is followed by stem substitutions, inflection additions, and inflection for derivation errors in decreasing order. It is noteworthy that stem substitutions occurred in roughly equal proportions for both regular ($n = 48$) and irregular ($n = 20$) words (refer to footnote 8).

Discussion

This experiment examined agrammatic aphasic individuals' ability to select verb forms that varied in morphological complexity and tense marking. The results revealed that accuracy of derived words was relatively high while that of inflected words was considerably reduced although both words are morphologically complex. The accuracy of irregular past tense verbs was reduced in spite of their morphological simplicity, and did not differ from the accuracy of regular verbs. Accuracy of non-finite verbs was high despite their occurrence in a more complex embedded sentence context. These results suggest that agrammatic aphasic individuals were significantly impaired in the selection of verb morphology when it entailed tense marking but not necessarily morphological complexity. The implications of these findings are discussed in the General discussion.

Errors most frequently consisted of substitutions of verb inflections, often revealing a lack of correspondence between the temporal context conveyed by the adverb and the produced verb form (e.g., *Yesterday Mary speaks to the President*). In a sentence completion task, such tense mismatch errors would occur when DER is

[8] There were twice as many regular than irregular trials since both regular past tense and third person present tense trials were included as regular verbs.

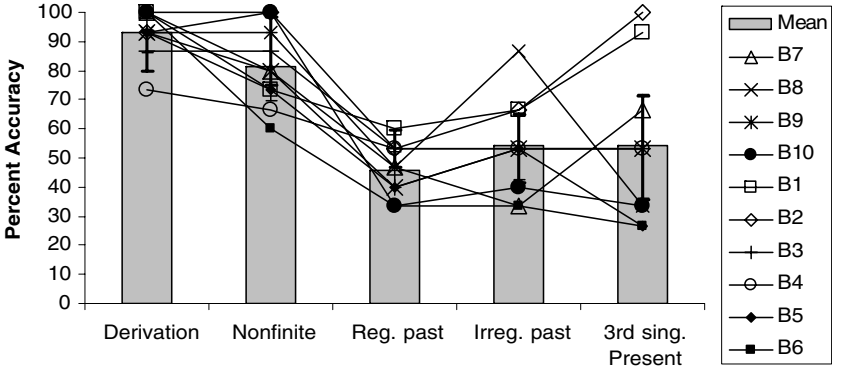

Fig. 2. Individual and mean group accuracy for Experiment 2. Error bars indicate 95% confidence interval of the mean.

impaired, that is, if the adverb (*Yesterday*) failed to elicit the relevant diacritic (+PAST) or if +PAST failed to retrieve *spoke*. Stem substitutions were the next most frequent error category, and were observed equally frequently for regular and irregular inflections. Although stem substitutions for regular verbs could occur due to an affixation failure, stem substitutions for irregular verbs (e.g., *speak* for *spoke*) cannot be explained by a failure of affixation. On the other hand, a DER deficit does not differentiate regularity and is equally likely to cause stem substitutions in regulars and irregulars.

To summarize, the combined pattern of low accuracy for finite trials, similar accuracy for regular and irregular trials, and stem substitution errors suggests impairment in encoding and/or retrieving contextually appropriate verb forms when tense marking is involved. However, there is a caveat: the interpretation of the high accuracy obtained with non-finite verb trials is confounded by the fact that the verbs that were elicited in non-finite trials were also unaffixed (e.g., *Yesterday I wanted to ask a question*). That is, non-finite verb trials lacked both tense marking and affixation. Therefore the high accuracy of non-finite trials in this experiment could have been either because tense DER operations are not required for non-finite trials or because these are morphologically simple. To confirm that the high accuracy of non-finite verb trials was indeed due to the absence of tense marking, we needed stimuli in which finite verbs occur in morphologically simple form. Unfortunately, in an inflectionally sparse language such as English, there are limited possibilities for manipulating finiteness and morphological complexity. However, some possibilities are first person present tense (e.g., *Everyday I work at the store*) and future tense (e.g., *Tomorrow he will work at the store*). These sentences were elicited in Experiment 3.

Experiment 3: verification of DER impairment

The aim of this experiment was to confirm the differential effect of morphological complexity and tense related DER processes that was observed in Experiment 2.

Table 5
Distribution of errors pooled across all agrammatic aphasic participants for Experiment 3 ($N = 9$)

	Inflection substitutions	Stem substitutions	Inflection additions	Verb for nonverb	Others	Total
B1	1				2	
B2	1	1		1		
B3	2	3			1	
B4	2	1		1		
B5	1	1	2			
B6	1	2			1	
B7	1			2		
B8					2	
B9	1	1			7	
Total number	10	9	2	4	13	38
Percent occurrence	26.3	23.7	5.3	10.5	34.2	100

This was achieved by comparing the production of morphologically simple verbs in finite (first person present tense and future tense) and non-finite contexts. It was hypothesized that a deficit in DER operations would significantly impair the selection of verbs in first person present tense and future tense contexts. However, these verbs would have high accuracy if the production of non-finite verbs was facilitated by morphological simplicity in Experiment 2.

Methods

Participants

Nine out of 10 agrammatic aphasic participants who were tested in Experiments 1 and 2 participated in this experiment (all except B10, who was unavailable at the time of testing).

Stimuli

Verbs were selected from the stimuli in Experiment 2 and developed into 45 sentences (see also Table 1). Fifteen sentences elicited verbs in the future tense context using *Tomorrow* as the temporal cue. An example is *Tomorrow John _____ a question (*response options*: will ask, was asking, is asked)*. Fifteen sentences were developed to elicit verb stems in the first person singular present tense context as in *Nowadays I _____ a mile* (response options: *was jogging*, *jog*, *will jog*). And 15 sentences elicited past tense with progressive aspect using *Yesterday* as the temporal cue. An example is *Yesterday I _____ a suitcase* (response options: *will carry, was carrying, is carried*). The past tense sentences served as fillers and also provided a context with past tense marking which could be used to replicate the findings of Experiment 2. Three response options were provided for each sentence. Since tense is marked on the auxiliary in future tense and past progressive sentences, the response options for these sentences consisted of different auxiliary-verb combinations. The stimuli are listed in the Appendix A.

Procedure and data analyses

The same as for Experiments 1 and 2. As in the earlier experiments, the first response was scored for accuracy.

Results

The mean percent accuracy for verb stems in future tense contexts was 53.3 ($SD = 7.03$, SE of mean = 2.2, 95% CI = 48.3–58.3) and in first person singular present tense contexts was 53.9 ($SD = 10.1$, SE of mean = 3.22, 95% CI = 46.7–61.2). The mean percent accuracy of inflected verbs in past progressive sentences was 44.6 ($SD = 18$, SE of mean = 5.7, 95% CI = 31.7–57.6). These values are shown in Fig. 3. The accuracy data for the three sentence conditions and the accuracy scores for non-finite verbs for the same participants (from Experiment 2) were compared by means of a one-way ANOVA. There was a main effect of word type, $F_1(3,36) = 10.9$, $p < .001$; $F_2(3,56) = 46.2$, $p < .001$, $\text{minF}'(3,61) = 8.8$, $p < .05$. Post-hoc tests with Bonferroni correction revealed a significant difference between non-finite verbs and each of the tense marked conditions ($p < .05$).

Discussion

In this experiment, we attempted to tease apart DER operations and morphological factors in the encoding of finite verbs in agrammatic aphasia by comparing the accuracy of first person present tense and future tense with the accuracy of non-finite verbs. The results revealed that accuracy was significantly reduced for first person present and future tense contexts when compared to non-finite contexts, although the verbs are unaffixed in all three conditions. Thus this experiment confirms

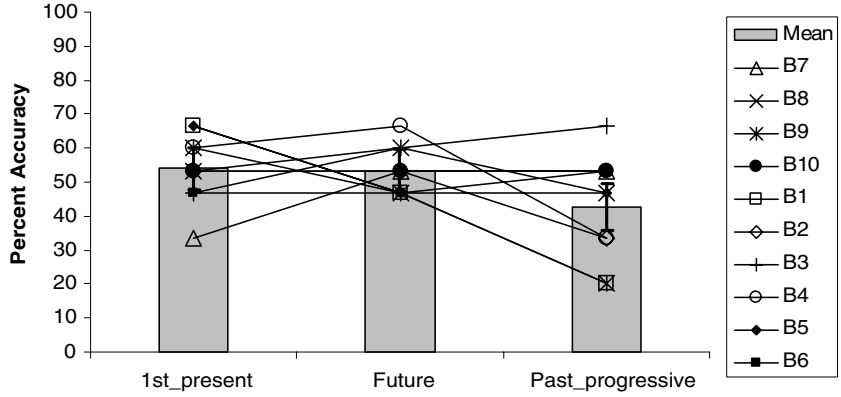

Fig. 3. Individual and mean group accuracy for Experiment 3. Error bars indicate 95% confidence interval of the mean.

the findings of Experiment 2: that is, errors in the production of verbs in agrammatic aphasia were likely to occur when tense related DER were involved and were not the direct result of morphological complexity. More specifically, in Experiments 2 and 3, we observed difficulty with using the appropriate form of a verb to convey temporal information specified by a sentence initial adverb.

These findings replicate those reported by Faroqi-Shah and Thompson (2004), who used a picture description task to investigate the production of verb stems, *V + ed*, *V + s* and *V + ing* verbs in future tense, past tense, present singular and present progressive contexts, respectively. It was hypothesized that any deficit specific to verb affixation would spare the production of future tense. However, all tenses were found to be equally impaired, and in many instances, inflected verbs were produced for the verb stem target. For example, **Tomorrow the maid wiped the table* for *Tomorrow the maid will wipe the table*. This suggested a deficit in choosing the appropriate form of a verb, rather than in affixation per se. To summarize, there is sufficient evidence from the previous two experiments to suggest that tense related DER deficits rather than rule-based morphological affixation deficits are the probable source of verb inflection errors in agrammatism. The results of these experiments may explain the frequent occurrence of infinitive verb forms across several languages in agrammatic speech (Menn & Obler, 1990). This is discussed further in the General discussion.

General discussion

We examined the production of verb inflections in individuals with agrammatic aphasia using the framework of psycholinguistic language production models as well as current linguistic theory. We specifically examined three processes: syntactic well-formedness constraints, diacritical encoding and retrieval (DER) processes, and morphological encoding. Data from the three experiments revealed that accuracy was reduced only when selection of words relied on tense processing, that is, for regular past, irregular past, and third person present tense verbs, while sparing non-finite verbs, derivations and other homophonous non-verbs. The experimental comparisons ruled out impairments in morphological affixation operations and local morpho-syntactic constraints as the source of verb tense errors in agrammatism. The predominant difficulty in verb form selection occurred when temporal adverbial constraints were placed on selection of the verb form. In other words, errors in the production of tense morphology were more apparent when semantically weighted tense diacritical features were needed to guide verb form retrieval. This pattern suggests a disruption of DER operations. In the following sections, we discuss the implications of these results and try to link our findings with previous research on agrammatism.

Verb morphosyntax and agrammatic speech

Features of agrammatic speech are traditionally considered to be the result of syntactic breakdown, and so the high accuracy on the syntactic task in Experiment 1 may be surprising at first glance. However, this finding is consistent with previous studies that have examined local syntactic constraints for verb morphology. For example, De Blesser et al. (1996) examined the production of verb participles in the context of two different auxiliaries in Italian, *essere* (be) and *avere* (have). In Italian, *essere* is used with unaccusative, reflexive and passivized verbs, and needs to agree with the subject noun phrase. The *avere* auxiliary occurs with intransitive and active transitive verbs and need not agree with the subject noun phrase, but needs to agree with a clitic if it is used. Two agrammatic aphasic individuals were given a variety of *essere* and *avere* auxiliary contexts and asked to inflect verb stems. Both patients were unimpaired in this task, leading to the conclusion that agrammatic aphasic patients have "*an awareness of elementary syntactic relations as long as they are determined by a narrow enough context*" (De Blesser, Bayer, & Luzzatti, p. 181). Their study indicated that syntactic well formedness constraints between auxiliaries and inflected verbs may be retained in aphasia, and is consistent with what we found with auxiliaries and verb forms in Experiment 1. Other studies that have investigated language specific syntactic constraints of verb tense, included the position of adverbs relative to verbs in finite and non-finite Italian clauses (Lonzi & Luzzatti, 1993), and the relationship between the position of finite and non-finite verbs in Dutch matrix and embedded clauses (Bastiaanse & van Zonneveld, 1998; Kolk & Heeschen, 1992). Both these studies have revealed relatively intact performance by agrammatic aphasic individuals.

Another domain in which the ability to utilize syntactic constraints in producing verbal morphology has been extensively examined in agrammatism is subject–verb agreement. Subject–verb agreement (SVA) data show relatively unimpaired performance when required to inflect a verb based on the number, case, and gender marking on the subject noun as in sentences like *The boys _____ at this restaurant (eat)*, versus *He _____ at this restaurant (eats)* (Spanish and English: Benedet et al., 1998; Italian: Debleser & Luzzatti, 1994; French: Nespoulous et al., 1988; Hebrew and Arabic: Friedmann, 2001; German: Janssen & Penke, 2002; Wenzlaff & Clahsen, 2004, 2005; Greek: Nanousi, Masterson, Druks, & Atkinson, 2006; Stavrakaki & Kouvava, 2003). Using a fragment completion task, Hartsuiker, Kolk, and Huinck (1999)

manipulated conceptual and syntactic number on the subject noun and found that fragment completions produced by individuals with Broca's aphasia were more likely to conform to grammatical number constraints rather than conceptual number constraints. To summarize, previous research is consistent with our finding that agrammatic aphasic individuals are able to access local morphosyntactic constraints for the production of verbal morphology, at least for constrained sentence production tasks.

The high accuracy of verb form selection obtained in Experiment 1 is not explained by current syntactic theories of verb inflection impairments in agrammatism because these accounts propose that a deficit of the tense node in the syntactic tree representation impairs all syntactic computations of tense but not agreement (Arabatzi & Edwards, 2002; Tree-Pruning Hypothesis (TPH): Friedmann & Grodzinsky, 1997). Hence, these accounts need to be revised to specify exactly what kinds of syntactic operations of tense are impaired or spared. Other syntactic accounts of agrammatism have been framed within Chomsky's (1992) minimalist program in order to explain the differences in error rates between tense and agreement morphology (Nanousi et al., 2006; Wenzlaff & Clahsen, 2004). The minimalist program differentiates between interpretable and non-interpretable morphosyntactic features. Interpretable morphosyntactic features are those that require semantic interpretation, such as tense, while non-interpretable features, such as agreement, do not have semantic implications. It has been proposed that morphosyntactic features that do not have semantic implications (e.g., agreement) are intact, while those that have semantic reference (e.g., tense) are impaired in agrammatism. This raises the question of whether a more "semantic" account might better represent the verb inflection deficit in agrammatism when compared to existing syntactic accounts. The processes outlined under DER include selection of semantically appropriate diacritical features and linking these features to the correct verb form. Hence, a DER deficit may not be incompatible with an impairment of *interpretable* morphosyntactic features. Before we discuss the evidence for a DER impairment, we will examine the role of morphological affixation in the production of verb inflections in agrammatism.

Morphological affixation

Morphological complexity was manipulated to test the notion of impaired morphological processing in agrammatic aphasia (Ullman et al., 1997, 2005). Two dimensions of morphological complexity were examined in Experiment 2: inflectional versus derivational morphology and verb regularity. First we discuss the comparison between derivations and inflections.

Derivations vs. inflections

Psycholinguistic research suggests that lexical representations of both derivations and inflections are morphologically decomposed (Pillion, 1998; Raveh & Rueckl, 2000; Sanchez-Casas, Igoa, & Garcia-Albea, 2003). Given this, a deficit in morphological processing should impair the production of both inflected and derived words, and is also likely to affect derived words to a greater extent because these are semantically less transparent and less productive than inflected words. However, we observed the opposite pattern of greater difficulty with inflected words and normal or near normal performance for derived words. Our finding of unimpaired performance for derived words is in agreement with previous descriptions of aphasic patients who produced few errors with derived words and a large number of errors with inflected words (Miceli & Caramazza, 1988; Tyler & Cobb, 1987). The relative sparing of derivations indicates that agrammatic aphasics' difficulty with verb inflections is not entirely a manifestation of morphological complexity.

Regular vs. irregular morphology

We found that selection of regular and irregular verbs was equally impaired. These findings are in agreement with Bird et al. (2003), who elicited regular and irregular verbs in a group of 10 agrammatic aphasic individuals using sentence completion, reading, and single word repetition tasks. When regular and irregular verbs were matched for phonological variables such as syllable structure and consonant cluster status, both regular and irregular verbs were produced with approximately 30% accuracy in sentence completion, and 65% accuracy in word repetition. Since irregular verbs are morphologically simple in English, these similarities in regular and irregular verb production cannot be easily explained by any theory that implicates a morphological affixation deficit in agrammatism. Our data are also in agreement with data from a German study that found no differences between regular and irregular verbs for eight agrammatic aphasic individuals (Wenzlaff & Clahsen, 2004) and another study of English speaking agrammatic aphasic individuals (Fix, 2005).

In contrast to our findings, Ullman and colleagues (Ullman et al., 1997, 2005) reported a greater deficit for regular than irregular verbs. The reverse pattern of greater deficits with irregular verbs compared to regular verbs, has also been reported (Balaguer et al., 2004 (in Spanish); Laiacona & Caramazza, 2004 (in Italian); Penke et al., 1999 (in German); Shapiro & Caramazza, 2003, (in English); and Tsapkini, Jarema, & Kehayia, 2002 (in Greek)). Possible explanations for these contradictory patterns include interactions between morphological processing and phonological complexity, as well as interactions between regularity and tense marking.

Morphophonological complexity

Ullman and colleagues (Ullman et al., 1997, 2005) attributed the greater deficit for regular than irregular verbs to a failure of the grammatical process of affixation. However, it has been previously pointed out that in Ullman, Corkin et al.'s study, regular and irregular verbs were not matched for frequency and phonological complexity and may have influenced accuracy (Bird et al., 2003; McClelland & Patterson, 2002). A large proportion of regular past tense verbs in English end in consonant clusters, such as *stabbed*, *stopped*, *kicked*, *kissed*, *named*, *seemed*, etc. Further post-lexical phonological processes such as alveolar voicing (*stopped* vs. *stabbed*) and syllabic past tense (*painted*) operate for regular past tense verbs. These phonological factors are likely to undermine regular verb production in English. Thus, the morphological complexity effect observed by Ullman et al., may be a confound of phonological complexity differences between regular and irregular stimuli. Indeed, Bird et al. (2003) used Ullman et al.'s stimuli and demonstrated that differences between regular and irregular verbs disappeared when the stimuli were matched for phonological complexity. Similarly, using a single word delayed repetition task Faroqi-Shah and Thompson (2003b) found that production latencies of phonologically matched regular and irregularly inflected verbs did not differ in their production latencies. Furthermore, a morphological affixation deficit does not entirely account for Ullman et al.'s own data because their non-fluent patients performed poorly on both irregular verbs (sentence production: 47% correct, reading: 51% correct) and regular verbs (20% and 31% for sentence production and reading, respectively) although the accuracy of regular verbs was somewhat lower (Ullman et al., 2005). Thus, phonological variables can influence morphological production and need to be considered while interpreting regularity effects in agrammatic aphasia.

Other studies have also reported a close correspondence between phonological and morphological production. For example, Miceli, Capasso, and Caramazza (2002) found that all aphasic patients who produced morphological errors also produced phonological errors during repetition, while there were some patients who exclusively produced phonological errors and not morphological errors. Miceli et al.'s data demonstrate that morphological encoding relies heavily on phonological processes. In another study of both fluent and non-fluent aphasic individuals with phonological deficits, Kohn and Melvold (2000) found performance on regulars to be worse than irregulars for both fluent and non-fluent aphasic patients with phonological deficits. This demonstrates the role of phonological processes in morphological production. To summarize, previous studies that have reported worse performance on regular verbs in languages such as English may need to be re-examined within the context of phonological complexity in the stimuli and phonological deficits in aphasic participants (Lambon-Ralph, Braber, McClelland, & Patterson, 2005).

Worse performance on irregular inflections compared to regulars has generally been reported for languages other than English (with the exception of Shapiro & Caramazza, 2003) such as Greek, Italian, and Spanish. Typically in these other languages, irregular verbs have a different structure from English irregulars, including identifiable non-default affixes and often allomorphic stems. For example in Spanish, irregular verbs have identifiable affixes as well as two stems: a regular stem that is used in the infinitive and an irregular stem. There seems to be no obvious principle that predicts which verb form requires the irregular stem (Balaguer et al., 2004). Hence, lexical entries of irregular verbs represent idiosyncratic stem change information as well as a non-default affix. This has the potential effect of more complex mental representations and retrieval mechanisms for irregular verbs (Allen & Badecker, 2002; Marslen-Wilson & Tyler, 1998). Hence, it is possible to have retrieval deficits specific to irregulars in these languages.

Morphology and tense marking

Some differences between studies of verb regularity in agrammatic aphasia are also explained by the type of information conveyed by the verb morphology. For example, Penke and Westerman (2006; see also Penke, Janssen, & Krause, 1999), reported normal or nearly normal performance with regular verbs but impaired performance with irregular verbs in Dutch and German Broca's aphasic participants, when they examined regularity in participle verbs. Affixes of participle verbs typically do not convey tense information, and therefore may not directly involve tense related DER processes. Instead tense is conveyed by other verbal materials such as auxiliaries and modals. The likely reason for normal or nearly normal performance on regular participles may be because tense related DER was not involved (unlike the regular verbs used in our Experiment 2). This argument is consistent with the findings of another study of tensed regular and irregular verbs in German agrammatic individuals (Wenzlaff & Clahsen, 2004). The authors failed to find any differences between regulars and irregular (modal) verbs. This pattern of impaired performance on tense conveying regular verbs and spared performance on regular participle verbs in German provides supportive evidence for a tense-related DER deficit in agrammatic aphasia. Unfortunately, there are no data comparing regular tensed verbs and regular participles in the same patients in any language. In other words, interpretations of regularity effects may be obscured by tense deficits and vice versa.

To summarize, although a variety of production patterns have been observed for regular and irregular verb inflections, the majority of studies have found at least some deficit for the production of both regular and irregular tense morphology. This finding, together with the relatively spared performance on derivational morphology, suggests that morphological complexity may not be a major determinant of verb inflection errors observed in sentence production in agrammatic aphasia. Further, we did not find a consistent pattern of omissions or substitutions in our error analysis, a finding that is not easily accommodated by morphological accounts that propose a failure of affixation as the source of agrammatic verb inflection errors. Studies that examine verb inflections in agrammatism need to further explore the interactions between regularity, tense marking, phonological impairments, and language specific lexical representation.

Diacritical encoding and retrieval operations

Several sources of evidence point towards impaired DER operations as the source of errors with verb tense morphology in agrammatism: first, the data from the three experiments revealed that accuracy was reduced only when selection of words relied on tense processing, that is, for regular past, irregular past, and third person present tense verbs, while sparing non-finite verbs, derivations and other homophonous non-verbs. A pattern of difficulty with inflected verbs that is not influenced by morphological complexity or local syntactic well-formedness constraints supports difficulties with tense related DER operations. As mentioned earlier, a review of literature of regularity effects for tensed verbs in non-fluent aphasia reveals that, in a vast majority of studies, both regular and irregular inflections are impaired, although authors have typically focused on the relative differences. Differences between overall impairments of regular and irregular verbs in the presence of a DER deficit may occur due to superimposing phonological or lexical retrieval deficits. What is incompatible with a DER deficit is normal performance on only either regularly or irregularly inflected tensed verbs.

A second source of evidence comes from error patterns. A majority of the verb form errors in Experiments 2 and 3 as well as in a previous picture description study (Faroqi-Shah & Thompson, 2004) were substitutions that involved tense mismatches between the adverb and verb morphology, such as *Yesterday Mary speaks to the President* (Experiment 2), *Tomorrow the maid wiped the table* (Faroqi-Shah & Thompson, 2004), and *Yesterday the man calls a woman* (Lee & Thompson, 2005; see also Druks & Carroll, 2005). Such errors suggest that individuals with agrammatic aphasia are unable to select the appropriate verb form when given a temporal context. This explanation is consistent with a study with another group of five English speaking individuals with agrammatic aphasia, where it was found that the ability to select verb morphology when given a temporal context was significantly impaired (*After Mary moved the sofa, she _____ her back*. Response options: *sprained*, *sprains*, *will sprain*), while the ability to select a temporal adverb when given an incomplete sentence was relatively spared (*The tourist from France ate pizza _____* response options: *everyday*, *yesterday*, *next week*) (Faroqi-Shah, 2006). The high accuracy in selecting temporal adverbs and the low accuracy in selecting verb forms suggests that the specific difficulty lies in verb form retrieval rather than selecting tense diacritics. Similar conclusions were drawn by Tyler, Behrens, Cobb, and Marsel-Wilsonn (1990) after studying the word monitoring data for a patient with non-fluent aphasia and by Weinrich and colleagues after conducting treatment studies where tense production was trained (Weinrich, Boser, & McCall, 1999; Weinrich, Shelton, Cox, & McCall, 1997).

Can DER account for agrammatic features?

In the following sections, we discuss ways in which assuming a DER deficit in agrammatism presents advantages over previous accounts. We will discuss how the findings of this study have implications for the classic features of so-called "agrammatic" speech, namely overuse of infinitives, progressive verb forms (*-ing* forms), and copular constructions in narrative speech, morphological errors, paucity of verbs, and fragmented speech.

A frequently observed aspect of agrammatic speech is the high incidence of infinitive verbal forms in most languages studied (Menn & Obler, 1990). Interestingly, high infinitive use has been observed even in languages which have verb forms that are shorter and morphologically simpler than the infinitive. For example, in German, the infinitive verb is affixed with *en*, and imperatives are unaffixed, consisting of only the verb stem. In spite of being morphologically more complex, infinitives predominate in German agrammatic speech (De Blesser et al., 1996). Similarly, Kolk and Heeschen (1992) reported that 53% of the verbs produced by German agrammatic patients were infinitives. Given that tense marking was impaired in Experiments 2 and 3, it is likely that when there is a derailment of DER processes during an attempt to produce a tensed verb, agrammatic aphasic individuals produce infinitives or other verbal forms that do not entail tense marking. A similar explanation can be made for the overuse of progressive verb forms in English (e.g., *He smiling*) and other languages because these verbs mark progressive aspect, while tense is marked on a modal or auxiliary (*is*/*was*) (Druks & Carroll, 2005). During encoding for speech production, a failure of tense DER may be compensated by retrieving verb forms that are relatively unmarked for tense such as infinitives, aspectual forms,

and participles. This would account for the occurrence of at least some morphological paraphasias in agrammatism, such as **He smiling* for *He smiled*. The same argument could be used for verb stem substitutions[9] in English: verb stems are less likely to be marked for tense because they are used in a wide variety of contexts such as in non-finite clauses (see Experiment 2), embedded under auxiliaries and modals (see Experiments 1 and 3) and nominals.

However, as mentioned earlier, not all morphological errors result in substitutions by verb forms unmarked for tense. It is not uncommon for morphological paraphasias to involve tense mismatches such as those in Experiment 2 (e.g., **Yesterday Mary speaks to the President*) (see also Druks & Carroll, 2005). It is possible that when aphasic individuals experience difficulty with tense DER, their language production system produces a verb form that is most easily accessible instead of the verb form that conveys the appropriate diacritical features. As per certain linguistic accounts of morphologically complex words, there is a competition between various verb forms during encoding for production (e.g., Halle & Marantz, 1993). In normal circumstances, the verb form with the best match for diacritical features would "win" the competition and be produced. However, for a patient with a tense DER deficit, such verb form competition may result in the production of the most accessible verb form rather than the best diacritical match, resulting in morphological errors. Multiple variables influence lexical accessibility, including frequency of occurrence, preceding context, individual language experience, and semantic markedness. Some previous studies have found an influence of various frequency measures on morphological production in agrammatic aphasia (Faroqi-Shah & Thompson, 2004; Meth et al., 1995). Using a sentence priming paradigm with agrammatic aphasic participants, Marin and Schwartz (1998) found that the target verb tense (e.g., *painted*) was more likely to be accurate when preceded by a congruent prime (e.g., *pushed*) when compared to an incongruent prime (e.g., *pushes*). This finding suggests that preceding context may play a role in the production of verb inflections due to ease of accessibility.

Difficulty with tense operations could also have other consequences on the production of verbs in sentences. In most languages, tense information needs to be conveyed not only for semantic reasons, but also for syntactic well-formedness, even when tense is not inherently a part of the message. For example, a temporally constant comment about the sky such as, **The sky be blue* is unacceptable primarily because the verb is unmarked for tense. Is it possible that at least some aphasic patients abandon the production of verbs in sentences (e.g., *...sky...blue*) because of difficulties with tense marking? Druks and Carroll (2005) demonstrated this possibility in their aphasic patient (DOR). Using a variety of tasks such as confrontation naming, sentence generation with picture description, sentence generation when provided with a verb form (either verb stem, past tense or progressive form), tense sorting, and word repetition, Druks and Carroll provided evidence that DOR produced very few verbs in sentences (80 lexcial verbs out of 2132 words) although he was relatively less impaired in the production of isolated verbs in confrontation naming (62% accuracy). Crucially, in the sentence generation task, DOR produced grammatically correct sentences 79% (19/24) of the time when the progressive form was provided while he was unable to produce even a single sentence (0/24) when the past tense form was provided. A similar pattern was observed for sentence completion. DOR did not have a deficit in producing isolated past tense verb forms in word repetition. In addition, DOR was unable to sort tense. DOR demonstrated awareness of certain grammaticality constraints, such as, sentences require verbs and that verbs need tense marking. On the basis of DOR's pattern of performance across various tasks, Druks and Carroll argued that DOR was severely impaired in abstract tense marking and that he avoided producing verbs in spontaneous speech because verbs unmarked for tense in obligatory tense contexts make the sentence ungrammatical. Instead, he used the copula *is* as a sentence facilitator, even in contexts that required the past tense (e.g., *He is 28 weeks premature*: Appendix C). Kegl (1995) also made a similar suggestion for patient FOK. In other words, aphasic individuals who demonstrate some preserved sensitivity to grammaticality constraints may avoid producing verbs in sentential contexts in spontaneous speech when they experience difficulty with tense marking. This difficulty is relatively independent of the limitations imposed by verb retrieval deficits on sentence formulation (Berndt, Haendiges, Mitchum, & Sandson, 1997; Thompson, Lange, Schneider, & Shapiro, 1997). For example, Druks and Carroll's (2005) patient, DOR had fairly preserved verb retrieval in confrontation naming tasks. Hence, one of the many reasons for the paucity of verbs in agrammatic speech and fragmented utterances could be difficulties in tense DER. Weinrich et al. (1997) conducted a treatment study in which participants were trained on tense production. There was a noticeable increase in the production of verbs after

[9] There are also other reasons for the verb stem substitutions that are not being considered here: verb stems are morphologically simple, and in many cases phonologically simpler than inflected verb forms. Hence, morphological affixation as well as phonological deficits could result in stem substitutions independent of DER.

treatment, suggesting that tense training facilitated production of verbs in sentential contexts.

To conclude, the process of diacritical encoding and retrieval (DER) for tense marking, particularly verb form retrieval, is the most likely source of verb inflection deficits in individuals with agrammatism. DER seems to operate outside of syntactic constraints and morphological operations. A DER deficit not only provides a satisfactory explanation for the findings of this study, but also for previous empirical observations related to verbs and verb morphology in agrammatism, such as the paucity of verbs, overuse of infinitives, and frequency effects in morphological substitutions. Although it is acknowledged that agrammatic aphasic individuals have syntactic deficits such as those with complex sentence formulation, future research needs to examine the extent to which tense operations outside of syntax contribute to verb inflection errors in agrammatic speech.

Our study focused on tense related DER since verb inflections in English are most prominently marked for tense. However, it is not impossible to conceive that some agrammatic aphasic individuals may have other DER deficits, such as those with aspect, gender, or plural marking on nouns. The crucial indication for such DER deficits is dissociation between conceptual-semantic and syntactic constraints during production. In fact, the disparity between conceptual-semantic and syntactic aspects of inflections was previously revealed for number marking by Hartsuiker et al. (1999) and for gender marking by Vigliocco and Zilli (1999).[10] In both studies, agrammatic aphasic individuals' productions showed evidence of greater adherence to syntactic constraints rather than conceptual implications. Of course, this proposal warrants further examination.

Implications for language production models

Although this study illustrates that psycholinguistic models provide a valuable framework for investigating aphasic deficits, it also raises questions which need to be addressed by existing language production models, particularly with respect to tense marking. For instance, Levelt et al. (1999) and Roelofs (2000) outline diacritical and morphophonological processes involved in the isolated production of inflected words, but do not specify the manner in which inflected words are integrated into sentence structure (see also Janssen, Roelofs, & Levelt, 2004). Bock and Levelt (1994), while focusing on production of verbs in sentential contexts, do not specify the exact mechanisms by which this is accomplished. Little is known about the manner in which morphosemantic, morphosyntactic, and morphophonological processes interact in normal speakers when tense marking inflected words are encoded for sentence production. Given that aphasic participants produce ungrammatical speech in free conversation despite access to local syntactic constraints, the relationship between these two aspects of syntax in normal speakers needs further exploration. This question also arises because, in normal speakers, the structural priming paradigm has failed to elicit tense priming, although syntactic structure can be primed (Bock & Loebell, 1990). In contrast, there is some evidence that both tense and syntactic structure can be primed in aphasic speakers (Hartsuiker & Kolk, 1998; Marin & Schwartz, 1998). The exact scope of DER operations also needs empirical investigation. DER, as we have interpreted it, includes two theoretically distinguishable processes: selecting diacritics (+PAST, +PLURAL, +MASCULINE, etc.), and selecting verb forms that correspond to these diacritics. The psycholinguistic reality of these two processes needs to be investigated, although there is some preliminary indication of their dissociability from agrammatic speakers (Faroqi-Shah, 2006). Recent psycholinguistic work has focused more on number and gender agreement than on tense marking, and it is worthy of investigating whether theories of agreement, notably, meaning, marking and morphing (Bock, 2004) can be extended to tense marking.

[10] We thank Rob Hartsuiker for pointing out this connection.

Appendix A. Sentences used in Experiment 1

Verb trials

1. The girl is *drawing* a tree.
2. The waiter is *serving* the guests.
3. The hunter is *shooting* wolves.
4. She is *crossing* the Canadian border.
5. The ship will *sink* in the storm.
6. I will *shake* the tree.
7. I will *fly* to London.
8. We will *cross* the Canadian border.
9. Tom *injured* his finger.
10. She *devoted* the whole day for charity.
11. I *locked* the door.
12. My dog *fights* with my cat.
13. She *calls* her mother often.
14. She *walks* in the garden.
15. The mailman *drops* the mail in the mailbox.

Noun trials

1. The engineer made a *drawing* of the building.
2. I want a *serving* of the pie.
3. The children witnessed the *shooting*.
4. They stopped me at the railroad *crossing*.
5. The dishes are in the kitchen *sink* since last week.

6. I drank a *shake* at the restaurant.
7. The cat chased the *fly*.
8. He wore a *cross* around his neck.
9. The *injured* soldier went home.
10. He is a *devoted* husband.
11. I tried to open the *locked* door.
12. My cat and dog had many *fights*.
13. He made many *calls* from the hotel room.
14. I go for long *walks* in the garden.
15. There are *drops* of water on the floor.

Appendix B. Sentences used in Experiment 2

Sentences used to elicit non-finite verbs

1. Yesterday I wanted to *ask* a question.
2. Yesterday I wanted to *speak* with the President.
3. Last year I wanted to *build* a house.
4. Everyday I like to *begin* with a prayer.
5. Today Mary refused to *allow* anyone inside.
6. Tomorrow I want to *send* a parcel.
7. Everyday I want to *return* the book.
8. Everyday John wants to *break* the law.
9. Today I want to *sit*.
10. Tomorrow she wants to *eat*.
11. Everyday I want to *write* a letter.
12. Tomorrow I want to *change* a flat tire.
13. Everyday Mary likes to *carry* a bag.
14. Next year John wants to *learn* Arabic.
15. Today Mary wants to *follow* Alice.

Sentences used to elicit regular past tense verbs

1. Last year I *tried* a makeover.
2. Yesterday Mary *appeared* ill.
3. Yesterday Mary *returned* early.
4. Last year I *lived* in New York.
5. Yesterday I *opened* a window.
6. Yesterday I *worked* until midnight.
7. Yesterday John *played* ice hockey.
8. Yesterday I *showed* her the book.
9. Yesterday I *changed* a flat tire.
10. Yesterday the dog *followed* a rabbit.
11. Yesterday John *carried* a patient.
12. Yesterday I *walked* away.
13. Yesterday a cop *stopped* a car.
14. Yesterday it *started* raining.
15. Last year Mary *moved* in the summer.

Sentences used to elicit irregular past tense verbs

1. Yesterday the mother *held* a baby.
2. Yesterday Mary *kept* a secret.
3. Yesterday I *met* with the President.
4. Yesterday Mary *spoke* with the President.
5. Yesterday Mary *meant* to call John.
6. Yesterday Mary *fell* down.
7. Yesterday John *sent* a parcel.
8. Yesterday Mary *drew* a picture.
9. Yesterday John *broke* a cup.
10. Yesterday Mary *lost* a book.
11. Yesterday John *sat* in the hallway.
12. Yesterday Mary *spent* a hundred dollars.
13. Yesterday John *stood* in the hallway.
14. Yesterday he *wrote* to the President.
15. Last year Mary *drove* to Colorado.

Sentences used to elicit third person singular present tense verbs

1. Everyday John *asks* a question.
2. Everyday Mary *works* at the store.
3. Everyday the hotel *provides* breakfast.
4. Everyday John *runs* five miles.
5. Everyday Mary *holds* a flag.
6. Everyday the lamb *follows* Mary.
7. Everyday the baby *starts* to cry.
8. Everyday John *stands* in the hallway.
9. Everyday the baby *begins* to cry.
10. Everyday the weather *changes*.
11. Everyday Mary *brings* her lamb to school.
12. Everyday the banner *falls* down.
13. Everyday the dog *keeps* barking.
14. Everyday John *helps* an orphan.
15. Everyday John *lives* in a trailer.

Sentences used to elicit derivations

1. Everyday I learn the *meaning* of a new word.
2. Everyday I thank John for his *consideration*.
3. Yesterday John was happy in the *beginning*.
4. Last year there was *unity* among the workers.
5. Yesterday Mary's *appearance* was surprising
6. Everyday the *driver* is late.
7. Yesterday I paid the *builder*.
8. Yesterday the *speaker* was late.
9. Yesterday the *player* was late.
10. Yesterday I met a *writer*.
11. Last year John was the *leader*.
12. Everyday Mary has a *follower*.
13. Yesterday I wrote an *application*.
14. Yesterday Mary was a *beginner*.
15. Yesterday I bought a *freezer*.

Appendix C. Sentences used in Experiment 3

Sentences used to elicit verb stems in future tense contexts

1. Tomorrow John *will ask* a question.
2. Tomorrow I *will send* the parcel.
3. Next year I *will build* a house.
4. Tomorrow I *will begin* school.
5. Tomorrow the worker *will break* the rules.
6. Next month Mary *will return* from France.
7. Tomorrow I *will sit* on the stage.
8. Tomorrow we *will ea*t at the restaurant.
9. Next month I *will write* the exam.
10. Next year Mary *will change* her name.

11. Tomorrow John *will carry* my suitcase.
12. Next month the workers *will follow* the new rules.
13. Next year I *will learn* to drive.
14. Tomorrow John *will talk* to the President.
15. Tomorrow the President *will allow* us to speak.

Sentences used to elicit verb stems in first person singular present tense contexts

1. Everyday I *allow* the dogs to play.
2. Everyday I *ask* the students a question.
3. Everyday I *send* Mary flowers.
4. Everyday I *build* a sand castle.
5. Everyday I *begin* the day with a prayer.
6. Everyday I *return* home at 5 o' clock.
7. Everyday I *break* the package seal.
8. Everyday I *sit* in the hallway.
9. Everyday I *eat* at the restaurant.
10. Everyday I *change* my driving route.
11. Everyday I *carry* my bag to work.
12. Everyday I *follow* the road map.
13. Everyday I *learn* French.
14. Everyday I *talk* to the students.
15. Everyday I *write* a letter.

Sentences used to elicit inflected verbs in past progressive tense contexts

1. Yesterday Mary *was talking* to the President.
2. Yesterday I *was sitting* on the stage.
3. Yesterday John *was eating* at the restaurant.
4. Yesterday Mary *was changing* the curtains.
5. Last year John *was learning* to drive.
6. Last year I *was writing* a book.
7. Yesterday the guard *was allowing* everyone inside.
8. Yesterday the tourist *was following* the map.
9. Yesterday John *was sending* the package.
10. Last year the king *was building* a castle.
11. Yesterday I *was carrying* a suitcase.
12. Yesterday John *was standing* in the hallway.
13. Yesterday Mary *was asking* for money.
14. Yesterday I *was returning* from France.
15. Yesterday I *was helping* John.

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