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Effects of syntactic and semantic argument structure on sentence repetition in agrammatism: Things we can learn from particles and prepositions

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Abstract

Background—Sentence production impairment in aphasia has been attributed to several possible sources that are not mutually exclusive. Linguistic accounts often attribute the difficulty to the complexity of a verb's syntactic and/or semantic argument structure. Cognitive processing accounts emphasise the reduced processing capacity observed in agrammatic aphasia, which in turn has been attributed to reduced semantic short-term memory (STM) or slowed processing.

Aims—In this study we used verb particles and prepositions to investigate effects of differences in syntactic and semantic argument structure on sentence repetition in aphasia. We predicted that verb particles and sentences containing verb-particle constructions would be easier to repeat than prepositions and prepositional transitive sentences, as the former have a less-complex semantic and syntactic argument structure than the latter. Also, semantic and phonological spans were assessed to determine if a reduction in either capacity correlates with repetition ability.

Methods & Procedures—Participants were eight individuals with chronic aphasia. The experimental task was repetition of transitive sentences balanced for length and lexical content containing either verb particles or prepositional object structures. Accuracy of sentence repetition and repetition of verb particles and prepositions within sentences was examined. We calculated the effect of structural complexity on the sentence repetition task as the difference between proportion correct of verb-particle constructions and prepositional transitives. Semantic and phonological STM spans and word spans were also assessed and correlated with this measure of the structural complexity effect on sentence repetition.

Outcomes & Results—Verb-particle sentences were repeated correctly significantly more often than prepositional transitive sentences, and within those sentences verbal particles were repeated correctly significantly more often than prepositions. The effect was strongly associated with fluency scores: it was present in participants with low fluency scores, but not in those with high

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fluency scores. The phonological, but not the semantic, STM probe span measure correlated with both the difference in accurate repetition of verb-particle and prepositional transitive sentences and the particles and prepositions within those sentences.

Conclusions—Results indicate that differences in argument structure of particle and preposition constructions influence sentence repetition in agrammatic aphasia. The finding that lower fluency scores are associated with poorer performance on more complex structures suggests that this effect is associated with agrammatism. The impact of these structural distinctions between particles and prepositions should be taken into account during development of treatment stimuli for those with agrammatism.

Keywords

Agrammatism; Syntactic semantic argument structure; Verb particles and prepositions

Sentence processing impairments and the impact of semantic and syntactic argument structure have been studied extensively in those with agrammatic aphasia. The classic symptoms of agrammatism—nonfluency, difficulty constructing and interpreting sentence-level syntactic structures, particular difficulty with structures that are thematically opaque, and impaired use of the functional vocabulary—are clearly relevant to questions about the role of syntax, morphology, and semantics in language comprehension and production. Sentence production impairment in agrammatic aphasia has been attributed to several possible sources. Linguistic accounts implicate the complexity of a verb's syntactic and/or semantic argument structure as a key factor in agrammatism (Thompson, Lange, Schneider, & Shapiro, 1997). Cognitive processing accounts emphasise the contribution of reduced processing capacity observed in agrammatic aphasia (e.g., Kolk & Heeschen, 1992) which in turn has been attributed to slowed processing (e.g., Haarman & Kolk, 1991, 1992, 1994) or reduced semantic short-term memory (R. Martin, & He, 2004; R. Martin, Miller, & Vu, 2004). The linguistic and processing accounts are not mutually exclusive (Kolk, 1998). Verbal STM impairments are common in aphasia, and studies of STM performance in this population provide evidence for semantic and phonological STM capacities that can each be relatively impaired or spared (N. Martin, 2008; N. Martin, Kohen, & Kalinyak-Fliszar, 2010; N. Martin, Shelton & Yaffee, 1994). In this study we investigated effects of increased syntactic and semantic argument structure complexity on sentence repetition in aphasia using verb particles and prepositions. We also investigated the role of reduced verbal STM on performance on this task.

There is a vast literature on the effects of argument structure complexity on sentence processing in aphasia. In a variety of experimental paradigms, effects have been shown in the linguistic performance of people with aphasia that are related to the distinction between transitive and intransitive structures, ditransitive and transitive structures, passive and active transitives, and different subtypes of so-called “psychological” predicates. (e.g., Bastiaanse & van Zonneveld, 2005; Collina, Marangolo, & Tabossi, 2001; Friederici & Frisch, 2000; Lee & Thompson, 2004; Shapiro, 2003; Thompson, 2003; Thompson & Lee, 2009; Thompson, Lange, Schneider, & Shapiro, 1997). We have chosen to investigate effects of argument structure complexity on sentence processing in agrammatism using a pair of English constructions that are of particular interest because they appear almost identical, but

have demonstrably different syntactic and semantic argument structures. These are the verb-particle construction, sometimes also called the phrasal verb construction, and the prepositional transitive construction. Examples of the verb-particle construction are given in (1) and (2) and the prepositional transitive construction in (3) and (4).

1. The driver turned off the lights.
2. The secretary crossed out the names.
3. The driver turned off the road.
4. The secretary crossed over the bridge.

Despite the superficial similarity of these sentences, even cursory inspection shows verb-particle constructions have quite different properties from prepositional transitives. One indication of this is that if certain conditions of prosody are satisfied, the constituents of verb particle sentences (1–2) can be reordered in a consistent way to produce well-formed paraphrases, while an analogous reordering is impossible in prepositional transitives (3–4).

- 1a The driver turned the lights off.
- 2a The secretary crossed the names out.
- 3a *The driver turned the road off.
- 4a *The secretary crossed the bridge over.

The structure of prepositional transitives (3–4) is straightforward and well understood: the complement of the verb is a prepositional phrase. The structural analysis of verb-particle constructions is less well established. For current purposes, we will assume that expressions such as “turn off” and “cross out” in examples like (1–2) are single lexical items akin to phrasal idioms such as “run out of” or “miss out on”. This seems plausible in view of the fact that many such expressions are idiomatic in meaning and that they often have single-word synonyms, such as “extinguish” for “turn off”, and “strike” or “delete” for “cross out”.

While a number of studies have investigated the properties of prepositions in production and comprehension behaviour in aphasia (Bennis, Prins, & Vermeulen, 1983; De Roo, Kolk, & Hofstede, 2003; Friederici, 1982; Friederici, Schönle, & Garrett, 1982; Grodzinsky, 1988; Salis & Edwards, 2004; Tesak & Hummer, 1994) we are not aware of any prior investigation in which prepositional transitives and verb-particle constructions have been directly contrasted.

This contrast should provide an interesting probe into the contribution of syntactic and/or semantic complexity to sentence processing impairments in aphasia. It is easy to construct contrasting pairs of stimuli of this sort that are identical in length and very nearly identical in lexical content, thus avoiding many potential confounds involving sentence length, word frequency, etc. Yet the structural differences between the two sentence types provide a clear expectation of a difference between them in degree of processing complexity. Prepositional transitive constructions have a more intricate syntactic structure than verb-particle constructions, due to the embedding of a prepositional phrase within the verb phrase. It also seems clear that there is an analogous increase in complexity in semantic structure. In

prepositional transitives, the preposition provides an independent contribution of semantic information (about direction or location in the examples reviewed above), whereas verb particles do not in general have independent semantic force, but rather are parts of unitary predicates. Consequently, verb particle constructions contain essentially only three semantic elements, whereas prepositional transitives contain four distinct semantic elements. Thus, considering either syntactic or semantic argument structure or both, we are led to expect that these two sentence types, so very similar in superficial appearance, will show a difference in processing complexity, and that greater complexity will inhere to the prepositional transitive type.

Additionally, since we view this difference in complexity as affecting sentence processing and sentence processing as being dependent on verbal short-term memory, we expect that the adverse effects of greater complexity on sentence production will be most evident in persons who have reduced verbal STM capacity.

Another reason that these constructions make an interesting object of study is that prepositions typically are not easily produced in cases of agrammatic aphasia and thus are commonly a focus of clinical intervention. Often, however, prepositions and particles are not differentiated from one another in clinical treatment stimuli. If these two structures in fact present different degrees of difficulty to persons with aphasia, the distinction between them should be taken into account in the construction of treatment materials.

In this study we examined differences between particle and preposition constructions in the context of a sentence repetition task. Sentence repetition has been used to prime the use of particular syntactic structures in adults without brain damage (e.g., Bock, 1986; Potter & Lombardi, 1998), adults with aphasia (Saffran & Martin, 1997) and to assess children's syntax (Lust, Flynn, & Foley, 1996). The purpose of this study was to investigate the effect of the verb particle and prepositional transitive sentence structures on accuracy of repetition by persons with aphasia. The following were the specific predictions:

- Verb particles will be repeated correctly more often than prepositions.
- Verb particle sentences will be repeated more successfully than prepositional transitive sentences.
- Verbal STM measures will correlate with repetition accuracy and the effect of argument structure complexity, as defined by the difference in performance between verb particle and prepositional transitive constructions.

METHOD

Participants

Eight monolingual English-speaking individuals with chronic aphasia resulting from left hemisphere neurological damage participated in this study. All were at least 36 months post onset (mean = 123 months), with a mean age of 56 years (range = 51–63), and all had at least a high school education (mean = 14 years). All had received varying amounts of speech-language treatment, but none was receiving treatment for agrammatism at the time of the study. All were right-handed prior to their neurological incident.

The diagnosis of aphasia was determined by the administration of the *Western Aphasia Battery* (WAB; Kertesz, 1982). In addition, we derived severity levels of agrammatism based on the 10-point fluency scale outlined in the WAB for *Scoring Fluency, Grammatical Competence, and Paraphasias of Spontaneous Speech Tasks*. Four participants scored 4.5 or below and were rated as severely agrammatic, two participants who had a fluency score of 5.5 were rated as moderately agrammatic, and the two participants who had fluency scores above 6.0 were rated non-agrammatic. Demographic, stroke-related, and cognitive-communication characteristics of the participants are listed in Table 1.

Stimuli

Stimuli consisted of 30 paired transitive sentences equally divided into verb-particle and prepositional transitive constructions. Paired sentences were balanced for length, and lexical content was controlled for frequency as much as possible. Frequency counts (Pastizzo & Carbone, 2007) obtained for words in both stimulus sets indicated that prepositional transitive sentences contained words of higher average frequency (15,120), compared to words in the verb particle sentences (3289), thereby biasing against our results. Sentences were constructed so that identical subjects and verbs were followed by either a prepositional phrase (prepositional transitive construction) or a particle and direct object noun (verb-particle construction). For example, “*The driver is turning off the lights*” represented a verb-particle construction and would be balanced with the prepositional transitive construction, “*The driver is turning off the road*”. The 30 paired transitive sentences are listed in the Appendix.

It should be noted that post-hoc analysis of the sentences revealed that among the prepositional transitives there were seven sentences whose prepositional phrase constituents were adjuncts rather than arguments (see items 4, 11, 15, 17, 21, 23, and 26 highlighted in Appendix). When these sentences were removed from the data set, the difference between the particles and prepositions approached significance, and the difference between verb-particle and prepositional transitive sentences remained significant. Data from both analyses are reported.

Experimental task

Participants were asked to repeat all 60 sentences presented in randomised order by live voice. Each sentence was presented only one time. The examiner did not provide any feedback.

Span tasks

Prior to the sentence repetition task, participants were administered four span tests: word span repetition, word span pointing, semantic probe span, and phonological probe span.

Word span tests were similar to traditional span tests; the participant listened to word lists of increasing length then either repeated the lists of words (repetition span) or pointed to pictures corresponding to the word lists (pointing span). This test was designed as a companion to traditional digit span tasks. Thus, words in the strings were drawn repeatedly from a finite pool of nine words high in frequency (Francis & Kucera, 1982) and

imageability (Pavio, Yuille, & Madigan, 1968). Span was calculated as string length at which no less than 50% of the word strings were repeated or identified correctly in serial order plus the proportion of strings correct at the next longest string length divided by .50 (Shelton, Martin, & Yaffee, 1992).

For the semantic and phonological probe spans, strings of words from one to seven words in length were presented auditorily followed by a spoken probe word. The task was to judge whether the probe was related to one of the words in the string. In the semantic probe, a matching probe word was a member of the same category as one of the words in the string; in the phonological probe span, a matching probe rhymed with one of the words in the string. Half of the trials were matches. Span was calculated by string length at which no less than 75% of the strings were answered correctly plus the proportion of strings correct at the next longest string length divided by .75.

Data analysis

All participant responses were recorded (Marantz Professional PMD620 digital recorder). After each sentence was transcribed, data were analysed for two dependent measures:

- Number of correct verb particles and correct prepositions during sentence repetition.
- Number of correct verb particle and prepositional transitive sentences repeated during sentence repetition.

Finally, for each participant we calculated the difference between proportions of correctly repeated particle constructions and prepositional transitive constructions. These difference scores were then correlated with our measures of span.

Reliability

All of the participants' sentence repetition responses were recorded on audiotape and the responses were also transcribed on-line by the clinician. Responses were then scored for the two dependent variables. A second independent rater transcribed and scored 40% of the responses using the audio recordings. Inter-rater agreement between the two transcribers ranged from 85% to 100% with a mean agreement of 95%.

RESULTS

Accuracy of verb particle and preposition production during sentence repetition

Verb particles were repeated correctly significantly more often than prepositions during sentence repetition (with adjuncts included: $t(7) = 2.776$, $p = .027$; without adjuncts: $t(7) = 2.276$, $p = .057$). This was true even though in some instances the identical word was used in both sentences of the pair, for example:

“The driver is turning *off* the road” (preposition).

“The driver is turning *off* the lights” (verb particle).

Chi-square analyses, two-tailed, with Yates correction, indicated that four participants demonstrated significantly better repetition of verb particles than prepositions, three with severe agrammatism, DD6: $\chi^2(1) = 4.63, p = .031$; EC25: $\chi^2(1) = 6.857, p = .008$; GI24: $\chi^2(1) = 4.706, p = .030$, and one with moderate agrammatism, MI10: $\chi^2(1) = 13.819, p = .001$. The other participant with moderate agrammatism whose results were not significant still demonstrated the same trend of producing more correct particles than prepositions, VA3: $\chi^2(1) = 3.403, p = .065$. This effect was not observed among the participants without agrammatism.

Accuracy of repetition of verb particle and prepositional transitive sentences

Significantly more verb particle sentences were repeated correctly than prepositional transitive sentences: with adjuncts included: $t(7) = 2.768, p = .028$; without *adjuncts*: $t(7) = 3.391, p = .012$. This was true even though sentences were balanced for length and lexical content. All participants demonstrated the trend towards better repetition of verb particle than prepositional transitive constructions (see Table 2). Chi-square analysis indicated a significant difference in correct repetition of verb particle sentences compared to prepositional transitives for one participant with moderate agrammatism, MI10: $\chi^2(1) = 11.736, p = .001$. Two other participants with severe agrammatism, GI24: $\chi^2(1) = 3.00, p = .083$; EC25: $\chi^2(1) = 2.773, p = .096$, still demonstrated a strong trend of producing more correct verb-particle sentences than prepositional transitives.

Correlations between repetition of particles and prepositions and spans

As proposed in the background section, both semantic and syntactic complexity are increased in the prepositional transitive sentences compared to the verb particle constructions, increasing processing load and consequently taxing verbal short-term memory. For each participant we calculated the difference between proportions of correctly repeated verb particle constructions and prepositional transitive constructions, as well as the correct repetition of particles and prepositions within those constructions. These difference scores were then correlated with our measures of span. A significant negative correlation was found between the phonological probe span scores and these difference scores for both the sentence comparisons ($r = -.888, p = .003$), and the particles and prepositions within those sentences ($r = -.706, p = .050$). That is, the bigger the difference between the correct particle and preposition score, the lower the phonological spans.

DISCUSSION

This study showed that verb-particle sentences were repeated correctly significantly more often than prepositional transitive sentences, and within those sentences, verb particles were repeated correctly significantly more often than prepositions. Other findings of interest concern the correlation of span measures with the difference scores between particle and preposition constructions. We observed a negative correlation with phonological STM span, indicating that larger differences between the correct particle and preposition score were associated with the lower phonological STM spans.

These results are interesting on several levels. A first point is that essentially all the variance in this experiment was contributed by the participants who exhibited moderate or severe nonfluency, according to the *Western Aphasia Battery* fluency rating scale. Participants with high WAB fluency scores were essentially unaffected by the difference between the sentence types we investigated. Thus the data suggest that the difference in processing complexity between the two sentence types will most likely be observed in nonfluent, agrammatic aphasia. This is not unexpected, as agrammatism is the syndrome in aphasia that is most clearly related to some disability in the computation of structural information. Similar results have been reported by Shapiro, Gordon, Hack, and Killackey (1993).

In the background section we argued that prepositional transitives are more complex than verb-particle structures on both syntactic and semantic grounds. Therefore it is not clear whether the results of the experiment should be attributed to syntax, semantics, or both. Additionally, there is a third possible account that would attribute the results neither to semantic nor to syntactic structure, but to properties of the lexicon. Bradley, Garrett, and Zurif (1980) claimed that the central property of agrammatism is impaired access to the functional vocabulary. Similarly, Bates, Wulfeck, and MacWhinney (1991) note that functional elements are particularly vulnerable to impairment in aphasia in a number of languages. From this point of view, prepositional transitives should be more difficult than verb-particle constructions, since the former include lexically independent prepositions, access to which is by hypothesis difficult. By contrast, the particle in a verb-particle construction is, as noted above, only a part of the lexical entry of a verb, and probably does not require independent lexical search through the functional vocabulary. The data from this study do not discriminate among these three accounts. Future studies could shed light on this if they demonstrate that semantic STM is indeed a factor in the argument structure complexity effect that we observed in particle and preposition constructions

Finally, we note some clinical implications of our results. More complex argument structures that appear similar on the surface to simpler argument structures may increase memory load and impact performance for those with reduced verbal STM. There are two considerations relating to this point. The first is the need to assess verbal STM in clinical evaluations of language impairment. Considerable research in the last few decades indicates an intimate relationship between verbal STM impairments and processing of words (e.g., N. Martin, 2008; N. Martin & Ayala, 2004) and sentences (R. Martin et al., 2004). The data reported here provide additional support for this model and make clear that reduced verbal STM could affect a person's response to treatment if targeted sentence structures exceed processing capacity.

The second clinical consideration is the implication of these results for development of new treatment approaches for sentence processing disorders in aphasia. Some recent approaches draw from linguistic theory and principles of learning as a framework for development of sentence level treatments. Thompson et al. (2003), for example, have shown that training-induced improvements on a syntactic structure of a certain complexity (e.g., object-relative clause structures) will generalise to improved performance on simpler structures that are related linguistically to the more complex structure (e.g., matrix *who*-questions). The two structures examined in our study are not related linguistically, but are very similar in

superficial appearance. It is worth investigating in future studies whether this superficial similarity will promote generalisation of training effects from the prepositional transitive structures to the simpler verb particle structures or even vice versa despite their lack of linguistic relationship.

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APPENDIX

Paired verb particle and prepositional transitive sentences

	Particles	Prepositions
1	The woman is checking out the book.	The woman is checking on the baby.
2	The man is looking up the address.	The man is looking down the street.
3	The man is knocking down the wall.	The man is knocking on the door.
4	The boy is washing off the dirt.	The boy is washing with a sponge.
5	The man is blowing up the balloon.	The man is blowing on the tea.
6	The man is running up a bill.	The man is running up a hill.
7	The woman is working out the answer.	The woman is working on the answer.
8	The teacher is calling off the meeting.	The teacher is calling on the phone.
9	The driver is turning off the lights.	The driver is turning off the road.
10	The boy is cheering up his friend.	The boy is cheering for his team.
11	The man is chopping down a tree.	The man is chopping with an axe.
12	The woman is thinking up a story.	The woman is thinking of a story.
13	The boy is puking up the food.	The boy is puking out the door.
14	The woman is giving up her house.	The woman is giving to her church.
15	The man is dreaming up an excuse.	The man is dreaming in his bed.
16	The teacher is pointing out a star.	The teacher is pointing to a star.
17	The cook is leaving out the sugar.	The cook is leaving in the evening.
18	The boy is asking out the girl.	The boy is asking for a loan.
19	The student is turning over the paper.	The student is turning to the right.
20	The teacher is passing out the exams.	The teacher is passing on dessert.
21	The girl is coughing up the popcorn.	The girl is coughing in the office.
22	The father is picking up the baby.	The father is picking on the boy.
23	The priest is crossing out the name.	The priest is crossing at the light.
24	The nanny is laying out the clothes.	The nanny is laying on the bed.
25	The dog is pulling down the curtains.	The dog is pulling on the leash.
26	The maid is ironing out a wrinkle.	The maid is ironing for her boss.
27	The brother is throwing out the garbage.	The brother is throwing to his sister.
28	The boy is seeing off the guests.	The boy is seeing up her dress.
29	The idiot is holding up the line.	The idiot is holding onto the rail.
30	The neighbour is giving up the house.	The neighbour is giving to the cause.

TABLE 1
Demographic, stroke-related, and cognitive-communication data for the eight participants

Participant	Age	Educ	Sex	Aetiology	Years post onset	WAB Aphasia Quotient	WAB Fluency score	Semantic span probe	Phonological span probe
DD6	63	16	M	L abscess	10	55.6	4.0	2.97	2.97
VA1	63	12	M	encephalomyelitis	10	58.1	4.0	2.93	2.97
EC25	63	14	F	L CVA	26	66.6	4.5	3.93	1.80
GI24	49	12	M	L CVA	9	70.0	4.5	3.86	3.75
MI10	51	19	F	L CVA	10	71.5	5.5	2.80	0.93
VA3	50	15	M	L CVA	9	60.9	5.5	2.84	2.93
VA4	54	12	M	L CVA	3	66.7	6.0	2.93	3.86
FS1	57	12	F	L CVA	5	70.6	8.0	1.67	3.97
AVG	56.25	14	3F 5M		10.25	65.0			

TABLE 2
Measures of verb particle and preposition production during sentence repetition (proportion correct)

Participant	Verb particles	Prepositions	Difference verb particles – prepositions	Verb particle sentences	Prepositional transitive sentences	Difference verb particle – prepositional transitive sentences	Severity of agrammatism	WAB Fluency score
DD6	0.20	0.00	0.20	0.00	0.00	0.00	severe	4.0
VA1	0.40	0.27	0.13	0.27	0.17	0.10	severe	4.0
EC25	0.60	0.23	0.37	0.43	0.20	0.23	severe	4.5
GI24	0.97	0.73	0.24	0.93	0.73	0.20	severe	4.5
VA3KC	0.53	0.27	0.26	0.17	0.10	0.07	moderate	5.5
MI 10	0.87	0.37	0.50	0.83	0.37	0.46	moderate	5.5
AVG	0.60	0.31	0.28	0.44	0.26	0.18		
VA4TB	0.17	0.23	-0.06	0.07	0.03	0.04	none	6.0
FS 1	0.53	0.57	-0.04	0.40	0.23	0.17	none	8.0
AVG	0.35	0.40	-0.05	0.24	0.13	0.11		