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Measuring the lexical semantics of picture description in aphasia

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Abstract

Background—Individuals with non-fluent aphasia have difficulty producing syntactically laden words, such as function words, whereas individuals with fluent aphasia often have difficulty producing semantically specific words. It is hypothesised that such dissociations arise, at least in part, from a trade-off between syntactic and semantic sources of input to lexical retrieval.

Aims—The aims of this study were (a) to identify quantitative measures of the semantic content of narrative for people with aphasia that are reliable indicators of semantic competence, independent of overall aphasia severity; (b) to determine whether these measures distinguish between fluent and non-fluent aphasia; and (c) to assess whether individuals with fluent and non-fluent aphasia show a trade-off between measures of syntactic and semantic production.

Methods & Procedures—Connected speech samples were elicited from 16 participants with aphasia, 8 fluent and 8 non-fluent. The semantic sufficiency of the samples was analysed by measuring the proportion of correct information units (CIUs), the type–token ratios (TTRs) of content words, and the proportion of semantically specific (“heavy”) to semantically general (“light”) verbs produced. These measures were then correlated with syntactic measures from the QPA (Berndt, Wayland, Rochon, Saffran, & Schwartz, 2000) across and within participant groups.

Outcomes & Results—CIUs were found to reflect primarily aphasia severity, and not to differentiate between fluent and non-fluent groups. TTRs were also strongly influenced by severity among fluent, but not non-fluent, participants. The ratio of heavy to light verbs reliably distinguished the groups, and showed different patterns of correlation with the syntactic measures.

Conclusions—Results show some evidence for a trade-off between syntactic and semantic inputs to word retrieval, at least among non-fluent participants. The heavy–light verb ratio provides information about semantic specificity, beyond what is provided by the CIU or TTR measures.

Keywords

Aphasia; Narrative; Semantics; Agrammatism; Anomia

Since the earliest descriptions of aphasia, neurolinguists have focused on dichotomous language patterns to investigate the underlying nature of aphasic deficits. One such example is word retrieval deficits in fluent and non-fluent aphasia syndromes. Individuals with non-fluent aphasia have particular difficulty producing function words (e.g., determiners, prepositions, pronouns), often rendering their expression “telegraphic”; consisting largely of content words without the connecting syntactic framework (Goodglass, Kaplan, & Barresi,

2001). By contrast, individuals with fluent aphasia demonstrate more difficulty with content words (e.g., nouns, verbs, adjectives), frequently rendering their output “empty”, or lacking in meaningful content.

This pattern of dissociations has been attributed to deficits in different language production mechanisms—syntagmatic processes on one hand, which involve the sequencing of elements, and paradigmatic processes on the other, involving the selection of linguistic representations (Jakobson, 1971). A similar hypothesis from a connectionist perspective is referred to here: that words vary in the extent to which they learn to rely on syntactic or semantic contributions for production, and that dissociations in lexical retrieval arise from disruptions to these syntactic or semantic inputs (the “division of labour” hypothesis, Gordon & Dell, 2003). If this is true, then the words retrieved by individuals with fluent and non-fluent aphasia during generative connected speech tasks should show different syntactic and semantic characteristics. Speakers with fluent aphasia are expected to rely more on words available through syntagmatic processes, i.e., those serving a primarily syntactic purpose, at the expense of semantic sufficiency. On the other hand, those with non-fluent aphasia are expected to rely more on words available through paradigmatic processes, i.e., those containing semantic content, at the expense of syntactic structure. This study entails an analysis of the degree of semantic sufficiency of aphasic speech, and is intended to complement an earlier study of syntactic factors in speech production in the same subjects (Gordon, 2006). Semantic “sufficiency” will be captured using three existing measures that have precedence in the literature: the proportion of words constituting correct information units (CIUs, Nicholas & Brookshire, 1993), a measure of semantic accuracy and relevance; the type–token ratio for content words, a measure of lexical diversity; and the ratio of semantically rich (or “heavy”) verbs, relative to semantically empty (or “light”) verbs, a measure of semantic specificity.

THE DIVISION OF LABOUR HYPOTHESIS

As noted above, different speech production patterns in fluent and non-fluent aphasia are proposed to arise, at least in part, from a division of labour between semantic and syntactic input cues to speech output (Gordon & Dell, 2003). Some support for this division of labour hypothesis has already been demonstrated. In addition to the commonly observed content word–function word dissociation mentioned above, more specific dissociations have been noted within the category of content words. Non-fluent speakers, particularly those with agrammatism, have more difficulty producing verbs than nouns, whereas those with fluent aphasia often show the opposite pattern (e.g., Berndt, Mitchum, Haendiges, & Sandson, 1997; Zingeser & Berndt, 1990). The agrammatic pattern can be attributed to the fact that verbs, which determine the argument structure of the utterance, are considered to carry more syntactic weight than nouns. Kim and colleagues have found that syntactic complexity affects verb retrieval in non-fluent aphasia (Kim & Thompson, 2004) but to a lesser extent in fluent aphasia (Kim, 2004), supporting the idea that it is the syntactic specification of verbs that causes disruption in those with non-fluent aphasia.

Other studies have examined the influence of both syntactic and semantic characteristics of verbs in those with fluent aphasia. Bastiaanse and colleagues (Bastiaanse, Edwards, & Kiss, 1996) measured the diversity of verb production in conversational speech, and the distribution of argument structure in the verbs produced. Their six participants with fluent aphasia showed a reduction in lexical diversity, i.e., lower type–token ratios for lexical verbs (mean = .47) compared to 20 non-brain-damaged (NBD) comparison participants (mean = .63). In terms of syntactic complexity, however, the participants with aphasia showed the same distribution of verb types as the control participants, producing mostly one-argument verbs, followed by verbs with no arguments. Edwards and Bastiaanse (1998) replicated this

analysis with a larger group of participants and showed similar results. Noun and verb production during spontaneous speech by 20 participants with fluent aphasia (FA) were compared to 20 NBD comparison participants. Although there was some overlap between the two groups, the participants with aphasia produced significantly fewer noun and verb types overall than the comparison participants. Mean differences in type–token ratio were greater for verbs (FA = .52 vs NBD = .69) than for nouns (FA = .68 vs NBD = .75). As found by Bastiaanse and colleagues (1996), participants with aphasia showed the same distribution of verb argument complexity as the NBD comparison participants.

Both studies illustrate that, unlike those with non-fluent aphasia who appear to have difficulty processing the syntax of verbs (Kim, 2004), speakers with fluent aphasia show reductions in the semantic diversity of their verb production, but not in their syntactic complexity. One limitation of these studies is that they did not control for the size of the corpus from which the type–token ratios were calculated. Although the total speech sample size was controlled (either in text units or words), the numbers of nouns and verbs differed across samples, and this might have contributed to the lower TTRs among the participants with aphasia.

Another line of research has more directly addressed semantic specificity. There is evidence to suggest that individuals with fluent aphasia have more difficulty retrieving semantically specific (or “heavy”) verbs such as *run*, than semantically general (or “light”) verbs such as *go* (Berndt et al., 1997; Breedin, Saffran, & Schwartz, 1998; Kim, 2004), whereas individuals with agrammatism may show the opposite pattern (Barde, Schwartz, & Boronat, 2006; Breedin et al., 1998; Kim & Thompson, 2004). “Light” verbs are those identified by linguists as having relatively impoverished semantic representations, and containing core predicates of many other, more richly specified verbs (Jespersen, 1965). In addition, light verbs occur with greater frequency than heavy verbs, and co-occur with more noun subjects (Boronat, Barde, & Schwartz, 2004).

Breedin and colleagues (1998) assessed the production of verbs in eight participants with non-fluent aphasia, all with verb naming impairments. Six of these were categorised as agrammatic. The participants were asked to listen to a short story containing either a specific or a general verb, then answer a question that required reproducing the target verb (e.g., “The bar closed at 2:00 AM. Henry CAME/DROVE home. Nobody saw him come in. What did Henry do?”). The agrammatic participants were significantly more likely to substitute specific verbs for general verbs than vice versa. The two non-agrammatic participants did not show this pattern. Barde and colleagues (2006) replicated this study with more participants, this time including participants with fluent aphasia in the non-agrammatic group. The agrammatic and non-agrammatic groups were equated on measures of semantic processing and verb comprehension. Again, the agrammatic group showed a significantly lower rate of accuracy for light than heavy verbs, whereas the non-agrammatic group did not show a significant difference.

These observations find a coherent explanation in the hypothesis that there is a continuum of dependence by lexical production processes on syntax and semantics, with words like determiners at one end (almost purely syntactic), concrete nouns and heavy verbs at the other (almost purely semantic), and light verbs somewhere in between. It has been hypothesised that, linguistically, light verbs “straddle the divide between the functional and lexical” (Butt, 2003, p. 4). In addition to finding behavioural support in the studies mentioned above, this trade-off between syntactic and semantic information was illustrated in a connectionist simulation of light and heavy verb production in sentences (Gordon & Dell, 2003). Simply by setting up the relative characteristics of heavy and light verbs to be representative of actual language use (frequency, co-occurrence in noun contexts, number of

semantic features), the method by which words were activated in sequence (see also Dell, Oppenheim, & Kittredge, in press), and an error-driven learning algorithm, the model learned to produce heavy and light verbs accurately, by differentially weighting the connections from the lexical representations to their respective syntactic and semantic inputs. Importantly, this division of labour was not stipulated a priori, but emerged through the process of learning to produce sentences from input cues. Because of these learned weights, when the model's syntactic or semantic inputs were subsequently lesioned, it behaved very much like speakers with agrammatic or anomia, respectively.

The division of labour model predicts not only that agrammatic speakers should have greater difficulty retrieving light than heavy verbs (Barde et al., 2006; Breedin et al., 1998), but also that fluent anomia speakers should have disproportionate difficulty retrieving heavy verbs. However, because Barde and colleagues controlled for semantic abilities across their agrammatic and non-agrammatic groups, there exists only preliminary evidence for a heavy-verb deficit in anomia (Breedin et al., 1998). In the current study, speech samples from participants with a variety of aphasic profiles were analysed, with the two-fold aim of identifying measures that reflect semantic inputs to lexical retrieval, and comparing these to syntactic measures in order to test the hypothesised trade-off of semantic and syntactic information. It was expected that participants with fluent aphasia would demonstrate poorer performance on measures of lexical semantics—lower proportions of correct information units, lower type–token ratios, and lower heavy–light verb ratios—than participants with non-fluent aphasia, as a consequence of their hypothesised deficits in retrieving semantically laden words. Furthermore, performance on semantic measures was expected to be inversely related to performance on syntactic measures, providing evidence of a semantic/syntactic trade-off. Before making these comparisons, however, the variables of interest were each correlated with a measure of severity, in an effort to factor out the influence of this variable.

METHOD

A total of 16 individuals with aphasia, 8 fluent and 8 non-fluent, participated in the current study. All were right-handed native English speakers at least 3 months post-onset of a left hemisphere stroke. Fluency and severity were determined using criteria outlined by Goodglass and colleagues (2001). The participants in each group are listed in Table 1, along with their demographic information, lesion site and time post-onset, and language characteristics. The two groups did not differ significantly in age, education, time post-onset, overall severity of aphasia, auditory comprehension percentile, or naming percentile.

Spontaneous speech samples were collected by asking participants to describe 10 Norman Rockwell pictures. In a previous study (Gordon, 2006), these samples were analysed using the Quantitative Production Analysis (Berndt et al., 2000), and some of those data are reproduced later in Table 2 for reference. (Please note the correction to the data described in the footnote below the table.) Although the QPA protocol characterises syntactic adequacy well, it is not designed to assess the semantic appropriateness of the output (Saffran, Berndt, & Schwartz, 1989). In the current study, therefore, samples were analysed using three new measures: the proportion of correct information units (Nicholas & Brookshire, 1993), the ratio of types to tokens for content words, and the ratio of heavy verbs to light verbs.

Semantic measures

Although methods of analysing the syntactic adequacy of connected speech in aphasia abound (e.g., Berndt et al., 2000; Saffran et al., 1989), there has been relatively little effort to characterise the semantic adequacy of aphasic output, and there is no agreed-upon method to do so. Studies that do address this issue often focus on the cohesion and coherence of discourse (e.g., Christiansen, 1995; Glosser & Deser, 1990), the salience, accuracy and/or

completeness of story elements (e.g., Ernest-Baron, Brookshire, & Nicholas, 1987), or the number of informational units, main concepts, or propositions (e.g., Doyle, Goda, & Spencer, 1995). However, because lexical retrieval was the domain of interest here, single-word measures were used. In addition to corresponding to the unit of analysis of interest, single-word measures avoid the problem of having to define the unit.

CIUs—One of the most commonly used measures of the informativeness of single words is the correct information unit, or CIU (Nicholas & Brookshire, 1993). According to these authors, CIUs are defined as those words (both content and function words) that are intelligible in context, accurate, relevant, and informative about the eliciting stimulus. In this study, CIUs were measured as a proportion of the total words produced by each speaker. Nonwords, word fragments, and unintelligible utterances were first removed from the total word count. This measure was intended to capture the general semantic efficiency of expression; that is, the proportion of words conveying relevant information, relative to the total number of words produced. As such, it captures the degree to which words were consistent with the overall semantic content of the sample, but not the specificity of those words.

TTRs—A second commonly used measure, which captures the diversity of lexical production, is the type–token ratio, or TTR. In calculating TTRs, each occurrence of a word is considered a separate token, but only unique lexical representations, or lemmas, are counted as separate types. For example, the three tokens *go*, *going*, and *went* are considered to be the same type. In this study, TTRs were calculated from narrative word samples (i.e., with repetitions, repairs, and filler words removed), and included content words only (nouns, verbs, adjectives, and –ly adverbs). As noted above, the type count disregards inflectional variations. In this analysis, a further step was taken—removing “Level 2” derivational affixes: those generally considered to be more productive, and which do not distort the phonology of the stem to which they attach (e.g., –er, –ful, –ness, –less, un-) (Kiparsky, 1982, as cited in Gordon, 1985). Removing these helped to ensure that the analysis captured repetitions of words derived from the same stem within each content word set (e.g., *wash* and *washer*). Because the TTR is strongly influenced by sample length (e.g., Richards, 1987; Wright, Silverman, & Newhoff, 2003), samples were truncated to equalise the number of content word tokens across participants. The first 200 content word tokens produced by each participant were included, a criterion chosen because all participants except two produced at least 200 content words. Both of the exceptions were non-fluent speakers (A21 produced 187 content words; A3 only produced 64). One measure that has been proposed to overcome the confound of sample size is *D*, an index derived by calculating average TTRs from sub-samples of increasing size, plotting them, and fitting a model to the resulting curve (Richards & Malvern, 1997). However, I decided against using *D* in the present study for two reasons. First, *D* is not transparently interpretable. Second, as Wright and colleagues noted, “as long as the decision is made to limit samples to a particular length, any of the three analyses [TTR, NDW and *D*] might be used to arrive at similar conclusions about conversational vocabulary for adults with aphasia” (2003, p. 450).

H–L ratio—An additional measure that reflects semantic specificity within a given category (verbs), and which has precedence in the literature in discriminating aphasic deficits, is the relative use of light and heavy verbs. Although the dimension of semantic “heaviness” is undoubtedly continuous, it is also treated here as a categorical variable (heavy vs light) for the sake of simplicity. For this study, the set of light verbs included the main verbs *be*, *have*, *come*, *go*, *give*, *take*, *make*, *do*, *get*, *move*, and *put*. No auxiliary verbs were included in the analysis. In calculating heavy verb–light verb ratios, samples were also truncated, this time to 300 narrative words, as the influence of sample size on this ratio is

unknown. As with the lexical ratios in the QPA, heavy–light verb ratios were calculated using token (not type) verb counts. All of these analyses were conducted by trained Masters-level speech-language pathology students. Counts of word types and word tokens are relatively straightforward, so were not subjected to reliability analyses. Similarly, the set of light verbs was prescribed and limited, so the classification of verbs as light or heavy was clear-cut. By contrast, CIU counts require several subjective decisions. For this reason, a randomly chosen subset of the samples (one picture from each of the 16 participants, for a total of 1557 narrative words) were independently re-analysed by second student. Across these samples, the rate of agreement between the two student raters was 89.3%, which was judged to be acceptable.

RESULTS AND DISCUSSION

Relationship to aphasia severity

As in the companion paper to this one (Gordon, 2006), the first step of the analysis was to examine the relationship between aphasia severity and the measures of interest. Measures that are strongly related to the severity of aphasia within a diverse group of participants (i.e., those with a variety of aphasia profiles) are less likely to be able to account for much variance in the underlying deficits which distinguish different types of aphasia. In order to address this, each of the semantic measures was correlated with participants' aphasia severity ratings from the BDAE (Goodglass et al., 2001), which in this group ranged from 1 (more severe) to 4 (less severe). The proportion of CIUs was significantly related to aphasia severity for both fluent ($r = 0.847$) and non-fluent participants ($r = 0.844$), and TTRs were significantly correlated with severity for those with fluent aphasia ($r = 0.929$), but not those with non-fluent aphasia ($r = 0.176$). Differences in heavy–light verb ratio were not significantly related to severity for either group (fluent: $r = 0.118$; non-fluent: $r = 0.323$).

Comparison of participants with fluent and non-fluent aphasia

The second step of the study was to determine the extent to which each semantic variable would differentiate fluent and non-fluent participants. It was hypothesised that, as a group, participants with fluent aphasia would show lower proportions of CIUs and lower TTRs, demonstrating a pattern of speech that is less efficient and productive semantically than that of participants with non-fluent aphasia. It was further expected that fluent speakers would produce a lower ratio of heavy–light verbs, indicating that, even among the content words produced, the two groups show different levels of semantic specificity.

Average values on each of the semantic measures are shown for the two groups of participants in Table 2, along with syntactic measures from the QPA reproduced from Gordon (2006). Using t -tests ($p < .05$), the fluent and non-fluent groups were significantly differentiated on most of the QPA measures. (Note that, because they are shown here for comparison purposes only, these p -values were not corrected for multiple comparisons as they were in the Gordon, 2006, analysis.) In addition, the groups were significantly different on two of the three semantic measures. Contrary to predictions, the proportion of CIUs did not differentiate the two groups. However, this is not surprising given the finding that this measure is dominated by the influence of aphasia severity. As predicted, content-word TTRs were higher for non-fluent than for fluent participants, indicating greater lexical diversity relative to the amount of content produced. However, the one participant (A3) who did not produce close to the criterion 200 content words showed the highest TTR (.781), and it was suspected that this value was skewing the results because of the smaller sample size. Therefore, the t -test was re-run without A3's data, and the difference was no longer statistically significant ($p = .75$). Because of this, all further analyses involving TTRs were conducted without A3's TTR. (Note: A3's CIU data were kept because, despite having the

smallest sample—121 narrative words—A3's proportion of CIUs—41%—fell close to the middle of the range for the non-fluent group. A3 did not contribute data to the heavy–light verb analysis, because he produced no heavy verbs.) The H–L verb ratio showed the predicted difference, with non-fluent speakers using relatively more heavy verbs than fluent speakers. This finding accords with previous work showing dissociations in heavy and light verb usage by agrammatic and non-agrammatic speakers (Barde et al., 2006; Breedin et al., 1998).

Relationship of syntactic and semantic variables

In the third analysis, the semantic measures were correlated with QPA measures, to assess the hypothesised trade-off between syntactic accuracy and semantic sufficiency. It was predicted that such a trade-off would be evident in predominantly negative correlations between the semantic and syntactic measures across participants with aphasia. Negative correlations were expected particularly among those variables not shown to be dominated by severity influences.

The three right-most columns of Table 2 show correlations between each semantic measure and each syntactic measure for the group of participants as a whole. Contrary to predictions, the proportion of CIUs shows predominantly positive correlations with the syntactic measures. These were significant for several QPA measures determined to reflect discourse and sentence productivity (e.g., proportion of narrative words, MLU, and sentence elaboration), measures that show strong relationships to aphasia severity (Gordon, 2006). Given that the CIU measure was also found to correlate strongly with severity, this finding, in retrospect, makes sense. Unexpectedly, significant positive correlations were also found between % CIUs and two of the grammatical measures—auxiliary score and determiner index—suggesting that correct function word production was related to greater semantic accuracy and relevance in the samples.

Unlike the CIU measure, type–token and heavy–light verb ratios showed negative correlations with a number of QPA measures, significantly so with all of the QPA lexical ratios (closed–open class ratio, pronoun–noun ratio, and verb–noun ratio). In other words, more function words and verbs corresponded to reduced lexical diversity, and less specific verbs. All of these measures can be interpreted to reflect different aspects of lexical variability and specificity. Significant positive relationships were also found between TTR and % Narrative Words and % Sentences Well-Formed. The former is likely due to the correlation of both TTR and % Narrative Words with aphasia severity. The latter was somewhat surprising, since it was expected that telegraphic speech among the non-fluent speakers would result in fewer well-formed sentences but greater lexical diversity (but more on this later). The heavy–light verb ratio was also significantly negatively correlated with the production of obligatory determiners and the proportion of words produced in sentences, reflecting the expected pattern that participants who produced more semantically specific (heavy) verbs also produced relatively fewer function words and, correspondingly, had more difficulty producing complete sentences.

These general patterns were further investigated by examining the correlations among the measures *within* each group, in order to explore some of the unexpected findings. Table 3 shows the correlations separately for fluent and non-fluent participants. Surprisingly, dividing the groups did not result in fewer significant correlations (40% of the correlations were significant in both analyses), even though this reduced the power of the analysis. Upon examination of the correlations, it is apparent that this arose because many of the correlations in the larger group were driven by just one of the sub-groups—usually the participants with fluent aphasia. Within the fluent group, variability on the semantic measures was more closely related to aphasia severity. More interesting, however, is the

observation that, for many of the measures, the correlations for the fluent and non-fluent groups occurred in opposite directions, presenting evidence of the sought-after trade-off.

Correlations were examined to see if these group differences revealed meaningfully distinct patterns. A significant difference ($p < .05$) was found between the correlations of TTR and severity for the two groups, illustrating that the relationship between TTR and severity was driven by the participants with fluent aphasia. The lack of a significant relationship in the non-fluent group suggests that severity judgements of non-fluent aphasia are not as heavily dependent on lexical diversity as they are in fluent aphasia. It may be that, in non-fluent participants, re-using vocabulary (e.g., in stereotyped phrases) allowed a greater degree of fluency and thus a seemingly less severe deficit.

All three of the semantic measures showed significantly different correlations with the proportion of well-formed sentences for the two groups. In each case, the fluent participants showed a positive relationship between semantic sufficiency and sentence well-formedness, whereas the non-fluent participants showed a negative relationship. Additional significant differences between fluent and non-fluent participants were found for the correlations between heavy–light verb ratios and both speech rate and the proportion of closed class (function) words, as well as a trend towards significance for utterance length. Again, for all of these measures, the correlation was positive for fluent participants and negative for non-fluent participants. Thus, it appears that fluent participants used more specific verbs in conjunction with better syntactic performance, whereas for non-fluent participants specificity in verb use came at the expense of syntactic performance. To state this differently, the findings suggest that using light verbs seems to be facilitative for speakers with non-fluent aphasia, but not for those with fluent aphasia.

It should be acknowledged that not all of these correlations were significantly different from zero, a limitation that is no doubt related to the low power of having only eight participants per group. Nevertheless, the different correlational *patterns* in the two groups, particularly where they differ in direction, are provocative, and suggest that further study is warranted.

SUMMARY AND CONCLUSIONS

These analyses explored the semantic characteristics of words produced in a connected speech task (picture description) by participants with fluent and non-fluent aphasia. Three lexical measures of semantic sufficiency—the proportion of correct information units produced, the type–token ratio of content words, and the ratio of heavy verbs to light verbs—were compared to measures of aphasia severity, discourse and sentence productivity, syntactic accuracy, and lexical distribution calculated for a previous study (Gordon, 2006). Results showed that the CIU count, like the proportion of narrative words from the QPA (Berndt et al., 2000), largely reflects aphasia severity. TTRs were also strongly related to severity, but only for participants with fluent aphasia. The H–L verb ratio was not significantly correlated with severity for either group.

The two groups were reliably distinguished only by the H–L ratio, with fluent participants producing a significantly greater proportion of light verbs than non-fluent participants, as predicted. This finding supports previous results (Barde et al., 2006; Breedin et al., 1998), but does not clarify whether the difference reflects a pathological over-reliance on light verbs in fluent aphasia, or a pathological under-use of light verbs in non-fluent aphasia. Samples from non-brain-damaged speakers are currently being analysed to provide evidence on this issue.

Preliminary analyses of the patterns of correlations between semantic and grammatical measures in the two groups suggested that lexical semantic measures may reflect different

things in fluent and non-fluent aphasia. Predominantly positive relationships within the fluent group appear to reflect severity effects: participants whose speech samples were more lexically diverse and semantically specific also produced longer and more accurate grammatical constructions. On the other hand, negative correlations within the non-fluent group illustrate that greater lexical diversity and more specific verb usage can go hand-in-hand with a reduced speech rate, shorter utterances and fewer complete sentences, and fewer function words. This trade-off is consistent with Kolk's theory that agrammatic speech reflects an adaptive strategy to compensate for a disruption in the temporal synchrony of language production (e.g., Kolk, 1995). Following this hypothesis, the telegraphic nature of the speech sample, illustrated by such measures as the proportion of complete sentences and the function–content word ratio, is a by-product of the effort to produce more meaningful speech. This is supported in the present study by the finding that more meaningful speech production tends to be grammatically less well formed among individuals with non-fluent aphasia. On the other hand, such telegraphic characteristics are reduced in non-fluent speakers who can retrieve (or perhaps choose to use) light verbs to help form syntactic constructions. In this sense, light verbs serve as default verbs, what Butt calls a “verbal licenser for nouns” (2003, p. 1). While such light verbs seem to facilitate grammaticality, they do not contribute much to (and may in fact reduce) the specificity of the semantic content of the message.

The measures analysed here provide only a preliminary analysis. The lack of consistent patterns across the two groups may be due to several factors. First, the participant groups in the current study were less restrictive than in previous studies; participants were not selected a priori for the presence of agrammatism or anomia, which no doubt introduced variability within the groups. In addition, many of the measures used in this study and by Gordon (2006) cannot be unambiguously designated as “semantic” or “syntactic”. This is particularly so for the lexical distribution measures, as noted above. Nevertheless, although the relationship between syntactic and semantic measures is complex across individuals with aphasia, these results suggest some degree of trade-off between semantic and syntactic input. In particular, many non-fluent speakers who demonstrate difficulty producing syntactically complete and complex utterances also show better performance on measures of semantic content. Efforts are on-going to find more sensitive measures of semantic specificity, including a measure of semantic weight for nouns analogous to the light-heavy dimension used here for verbs, and a more continuous measure of semantic weight. In addition to illustrating the nature of syntactic deficits in non-fluent aphasia, such measures may be helpful in quantifying the so-called “emptiness” of speech in fluent aphasia.

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TABLE 1

Information for participants with fluent and non-fluent aphasia

Partic. Code	Demographics				Lesion Information		Language Profile (BDAE)			
	Gndr	Age (yr.)	Hand	Educ. (yr.)	TPO (mo.)	Lesion Site	AC %ile	Name %ile	Sev.	Diagnosis
Fluent Aphasic Subjects										
A1	M	70	R	7	28	L CVA	86	98	4	mild conduction aphasia
A10	F	81	R	12	39	L posterior temporal hemorrhage	79	74	3	moderate anomia
A24	M	79	R	11	N/A	bilateral basal ganglia hyperdensity	65	90	3	mild-moderate Wernicke's aphasia; moderate hearing impairment
A31	M	53	R	6	129	N/A	66	35	2	moderate-severe Wernicke's aphasia
A32	F	85	R	12	74	N/A	74	90	4	mild mixed F anomia
A38	F	58	R	14	47	L temporo-parietal subarachnoid hemorrhage	78	78	3.5	mild-moderate anomia
A39	M	61	R	11	31	L MCA	15	45	1	severe Wernicke's/TCS saphasia
A42	F	68	R	12	119	L fronto-temporal	86	95	4	mild anomia
Mean		69.4		10.6	66.7		68.6	75.6	3.1	
Max		85		14	129		86	98	4.0	
Min		53		6	28		15	35	1.0	
Non-Fluent Aphasic Subjects										
A3	F	81	R	12	33	L fronto-parietal	67	67	2	Broca's aphasia
A18	F	75	R	13	4	L temporo-parietal subarachnoid hemorrhage	77	50	2	moderate-severe TCM/Broca's aphasia
A21	F	66	R	9	62	L fronto-temporo-parietal	60	66	1	severe Broca's aphasia
A22	F	70	R	12	63	L parietal hemorrhage	89	99	3.5	mild Broca's aphasia, with apraxia
A25	F	64	R	9	14	L frontal	91	97	3.5	mild-moderate Broca's aphasia with mild dysarthria
A40	F	75	R	8	15	L CVA	91	93	3.5	mild mixed NF aphasia with apraxia
A41	M	68	R	13	107	L fronto-temporo-parietal, basal ganglia	71	80	2.5	moderate-severe Broca's aphasia
A43	F	81	R	10	45	N/A	74	98	4	mild-moderate Broca's aphasia
Mean		72.5		10.8	42.9		77.5	81.3	2.8	
Max		81		13	107		91	99	4.0	
Min		64		8	4		60	50	1.0	

TABLE 2

Mean values of, and correlations between, QPA and semantic measures for fluent and non-fluent groups

	<u>Fluent (n = 8)</u>		<u>Non-fluent (n = 8)</u>		<u>t-test</u>	<u>p-value¹</u>	<u>Correlations</u>		
	<u>Mean</u>	<u>(SD)</u>	<u>Mean</u>	<u>(SD)</u>			<u>with %CIUs²</u>	<u>with TTR²</u>	<u>with H:L²</u>
Severity rating	3.06 (1.08)		2.75 (1.04)			0.565	** 0.899	* 0.632	0.316
<i>Discourse Productivity Measures (QPA)</i>									
Total Narrative Words	1250.5 (793.2)		610.9 (442.9)			* 0.036	* 0.442	0.040	-0.391
% Narrative Words	0.65 (0.13)		0.62 (0.15)			0.326	** 0.919	* 0.556	0.386
Speech Rate (wpm)	93.80 (43.82)		37.59 (25.63)			** 0.005	0.318	-0.101	-0.296
<i>Sentence Productivity Measures (QPA)</i>									
% Words in Sentences	0.80 (0.12)		0.47 (0.34)			* 0.015	0.353	-0.260	* -0.458
Median Utterance Length (MLU)	5.75 (1.04)		3.75 (2.66)			* 0.039	* 0.551	-0.006	-0.364
Sentence Elaboration Index	2.14 (0.64)		1.70 (1.06)			0.171	** 0.739	0.423	-0.013
Embedding Index	0.14 (0.07)		0.08 (0.08)			* 0.048	0.286	0.103	0.140
<i>Grammatical Accuracy Measures (QPA)</i>									
% Sentences Well-Formed	0.74 (0.13)		0.81 (0.10)			0.134	0.239	* 0.529	0.245
Auxiliary Score	1.15 (0.19)		0.71 (0.54)			* 0.029	* 0.509	-0.027	-0.042
Verb Inflection	0.94 (0.07)		0.70 (0.35)			* 0.047	0.423	-0.003	-0.197
Determiner Index	0.92 (0.04)		0.62 (0.32)			* 0.017	* 0.454	-0.266	* -0.446
<i>Lexical Distribution Measures (QPA)</i>									
% Function Words	0.57 (0.05)		0.47 (0.09)			** 0.009	-0.153	* -0.538	* -0.532
% Pronouns/ Nouns + Pronouns	0.45 (0.15)		0.25 (0.22)			* 0.025	-0.337	** -0.811	* -0.508
% Verbs/ Nouns + Verbs	0.50 (0.12)		0.27 (0.21)			* 0.012	-0.125	** -0.778	* -0.437
<i>Semantic Measures</i>									
% CIUs	0.530 (0.15)		0.500 (0.21)			0.377	1.000	** 0.646	0.351
TTR	0.464 (0.12)		0.583 (0.13)			* 0.039			
TTR (without A3)	0.464 (0.12)		0.555 (0.11)			0.075		1.000	** 0.575
H:L Verb Ratio	0.658 (0.37)		1.144 (0.49)			* 0.028			1.000

Note: In Gordon (2006) the values for determiner index and % closed class words were inadvertently exchanged. The correct values are shown here.

¹ One-tailed unpaired *t*-tests (* $p < .05$; ** $p < .01$); severity is two-tailed.

² Criterion value for directional significance is $r > .57$ (** $p < .01$) or $r < .43$ (* $p < .05$).

TABLE 3

Correlations between semantic and syntactic measures by group (fluent vs non-fluent); significance of the difference between correlations is also shown

Measure:	Correct Information Units				Type-TOKEN Ratio				Heavy:Light Verb Ratio			
	F ^I	NF ^I	Diff.	p ²	F ^I	NF ^I	Diff.	p ²	F ^I	NF ^I	Diff.	p ²
Severity	** 0.920	** 0.919	0.002	0.496	** 0.964	0.420	0.544	* 0.010	0.344	0.523	-0.179	0.363
<i>Discourse Productivity Measures (QPA)</i>												
Total Narrative Wds	0.544	0.466	0.078	0.433	0.361	-0.024	0.385	0.274	-0.043	-0.566	0.523	0.145
% Narrative Wds	** 0.934	** 0.917	0.016	0.425	** 0.796	0.438	0.358	0.179	0.584	0.401	0.183	0.350
Speech Rate (wpm)	0.332	0.436	-0.104	0.428	0.280	-0.027	0.307	0.319	0.409	-0.552	0.961	* 0.048
<i>Sentence Productivity Measures (QPA)</i>												
% Wds in Sentences	0.307	0.405	-0.098	0.429	0.343	-0.283	0.626	0.166	0.330	-0.451	0.781	0.095
MLU	0.590	0.598	-0.008	0.492	* 0.724	-0.041	0.765	0.076	0.484	-0.423	0.907	0.061
Sentence Elaboration Index	** 0.802	* 0.723	0.079	0.382	** 0.807	0.262	0.544	0.102	0.270	-0.064	0.335	0.295
Embedding Index	0.144	0.369	-0.225	0.352	0.220	0.381	-0.161	0.397	* 0.780	0.126	0.654	0.149
<i>Grammatical Accuracy Measures (QPA)</i>												
% Sentence Well-Formed	** 0.848	-0.222	1.070	* 0.010	** 0.826	-0.362	1.188	* 0.010	0.557	-0.493	1.051	* 0.032
Auxiliary Score	0.276	* 0.630	-0.354	0.152	0.401	0.100	0.301	0.316	* 0.675	0.118	0.556	0.136
% Inflected Verbs	0.063	0.529	-0.465	0.203	-0.180	0.413	-0.593	0.176	-0.417	0.166	-0.583	0.833
% Obligatory Determiners	* 0.679	0.545	0.135	0.367	* 0.719	-0.195	0.914	0.051	0.138	-0.270	0.408	0.255
<i>Lexical Distribution Measures (QPA)</i>												
% Function Wds	-0.420	-0.198	-0.222	0.348	-0.524	-0.406	-0.118	0.409	0.514	* -0.692	1.206	* 0.012
% Pronouns/ Nouns + Pronouns	* -0.654	-0.343	-0.311	0.251	* -0.787 **	-0.807	0.020	0.468	0.039	-0.610	0.649	0.119
% Verbs/ Nouns + Verbs	* -0.755	-0.005	-0.750	0.061	** -0.822	* -0.735	-0.087	0.371	-0.013	-0.333	0.320	0.299
<i>Semantic Measures</i>												
% CIUs					** 0.925	0.601	0.324	0.084	0.446	0.439	0.007	0.496
TTR									0.413	0.558	-0.144	0.390

¹ Criterion value for directional significance is $r > .79$ (** $p < .01$) or $r > .62$ (* $p < .05$).

² Difference between F and NF correlations significant at ** $p < .01$ or * $p < .05$.