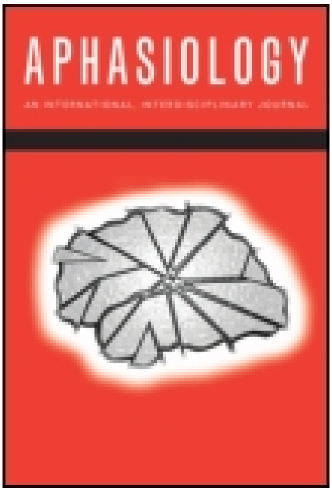

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Combining possibly reciprocally dependent linguistic parameters in the quantitative assessment of aphasic speakers' grammatical output

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Combining possibly reciprocally dependent linguistic parameters in the quantitative assessment of aphasic speakers' grammatical output

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Background: The grammatical output of aphasic speakers is often quantitatively analysed in order to establish an effect of treatment. In many methods of quantitative analysis both *the number of utterances produced* and (their) *length* are calculated. The difficulty is that these parameters may show a trade-off effect (i.e., may be inversely proportional to each other). That is, when the amount of information to be conveyed remains constant, an increase in the number of utterances may be compensated by a decrease in their length (and vice versa). As a result, a lack of increase—or even a decrease—in one of both outcome measures may be incorrectly interpreted as a lack of effect of treatment.
Aims: The current study investigated whether combining the possibly reciprocal outcome measures *percentage of utterances* and (their) *length* into a single parameter increases the interpretability of the results obtained with a quantitative analysis of aphasic speakers' spontaneous speech. In the current study the procedure of combining two possibly reciprocal linguistic variables into one dependent measure is demonstrated for the elliptical repertoire. Ellipses are grammatically well formed but incomplete utterances (e.g., *problem solved*). Contrary to sentences, ellipses lack finiteness. As will be argued in this article, the procedure of combining possibly reciprocal outcome measures could be useful in order to investigate both the sentential and elliptical repertoire produced by aphasic speakers.
Methods & Procedures: The possibly reciprocal outcome measures *percentage of ellipses* and *mean length of ellipsis*, which were used in the study of Ruiter, Kolk, and Rietveld (2010), were combined into a single parameter of elliptical style: *percentage of words*

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produced in ellipses (in comparison to words in sentences). The data obtained by Ruiter et al. (2010), who investigated the effect of a compensation therapy on the production of ellipses in 12 chronically agrammatic speakers of Dutch, were re-analysed with the new parameter.
Outcomes & Results: The parameter *percentage words produced in ellipses* was not only able to reproduce the results obtained in the previous study, but also seems to be more sensitive: It could identify significant changes in elliptical style in more participants than the two possibly reciprocal parameters could independently.
Conclusions: The data obtained in the current study may be of relevance to aphasia researchers and therapists as the new parameter provides them with a more sensitive measure to establish the effect of therapy on aphasic speakers' grammatical output.

Keywords: Quantitative analysis of spontaneous speech; Expressive aphasia; Reciprocally dependent linguistic parameters; Agrammatism; Paragrammatism.

Difficulty in producing sentences is one of the possible symptoms of spoken language breakdown in persons with aphasia. Traditionally two patterns of symptoms are distinguished: *paragrammatism* and *agrammatism*. Whereas paragrammatic sentence production is in general observed in Wernicke's aphasia, agrammatism is typically—but not exclusively—associated with Broca's aphasia. Paragrammatism is typified by fluent speech, erroneous syntactic structure, and/or grammatical morphology (e.g., *Toen ik een herseninfarct he.he.hebben gehad ik kon nog geen part of eh . . . de koningin, dat wist ik niet*, "When I ha.ha.have gotten the infarction of the brain I could not no part of er . . . the Queen, that I didn't know"). Agrammatism, on the other hand, may be depicted as non-fluency, simplified and/or reduced variety of syntactic structure, as well as the omission of morphology. Agrammatic speakers may exhibit *telegraphic style*, which constitutes a condensed style of speech (e.g., *Ik beroerte gehad. Praten lastig. Alleen korte zinnen maken*, "I suffered stroke. Speaking difficult. Producing short sentences only"). In the section below we will discuss agrammatism in more detail as this is relevant to the current study.

AGRAMMATIC LANGUAGE PRODUCTION

As observed in the spontaneous speech of English and Dutch persons with aphasia, agrammatism is usually characterised by three sets of main symptoms (Goodglass & Kaplan, 1983). The first set consists of grammatical *morphological* symptoms. The omission of free grammatical morphemes, such as determiners, pronouns, auxiliary verbs, and some prepositions, leads to ". . . [a] reduction of the sentence to its skeleton . . ." (Alajouanini, 1968, p. 84, cited in Goodglass, 1993). To put it differently, these omissions lead to *telegraphic style*. Dutch agrammatic speakers tend to produce many utterances that do not contain a verb (e.g., *Susan en ik zussen*, "Susan and me sisters"). What is more, non-finite verb forms (i.e., infinitives and past participles) are frequently used for finite verb forms (e.g., *Tim pizza eten* $_{infinitive}$, "Tim eating pizza" instead of *Tim eet een pizza*, "Tim eats a pizza"). As will be discussed in more detail below, we argue that the use of the non-finite verb form—as well as the production of utterances that contain no verb at all—results from *finiteness omission*, which in its turn reflects both syntactic processing problems and compensatory behaviour (Hofstede & Kolk, 1994; Kolk & Heeschen, 1992). The fact that finiteness omission could account for 90% of the omissions in the speech samples of Dutch non-fluent speakers that were analysed by Hofstede (1992) suggests that *finiteness omission* characterises an important aspect of agrammatic speech.

A second set of characteristics of agrammatic speakers' spontaneous speech is labelled *syntactic*, as it describes the structure of the utterances produced. Although agrammatic speakers tend to produce condense telegraphic style, they produce full sentences from time to time. However, these sentences are of a reduced variety of grammatical form. In general these finite utterances are short and lack phrasal elaboration or subordination. Passive constructions are generally absent in agrammatic production as well.

The third set of characteristics as defined by Goodglass and Kaplan (1983) consists of the *rate* symptoms. The speech of agrammatic speakers is typically slow and effortful, which is labelled *non-fluency* (e.g., *Ik . . . eh . . . I ging . . . naar de eh winkel*, "I . . . er . . . I went . . . to the er shop").

Although these three sets of main symptoms typically go together in agrammatic speakers, dissociations have been reported, especially in the presentation of syntactic and morphological symptoms (e.g., Rochon, Saffran, Berndt, & Schwartz, 2000; Saffran, Berndt, & Schwartz, 1989). These dissociations, at least in part, reflect differences in theoretical approaches to expressive agrammatism. A thorough discussion of the various theories is beyond the scope of this article (for an excellent overview, see Progovac, Paesani, Casielles, & Barton, 2006), but in essence the main difference between the several theoretical approaches is whether telegraphic style is considered to be composed of (ungrammatical) incomplete sentences or grammatical well-formed non-sentential utterances. An example of the former approach is the elliptical/deletion analysis proposed for example by Merchant (2006).

In the current study telegraphic style is considered to reflect grammatical well-formed incomplete utterances, in line with Progovac's (2006) analysis of *nonsententials*, which include both single-phrase utterances (e.g., *nice lady!*) and root small clauses (e.g., *problem solved*). What distinguishes nonsentential from sentential constructions is that they contain fewer grammatical morphemes. As Progovac argues (see also De Roo, 1999), nonsententials result from selecting lexical items with underspecified or default forms of tense and case (i.e., non-finite verb forms). As a result, the projection of the tense phrase (TP) is not required. In nonsentential utterances *time* is given pragmatically, by context or by the use of temporal adverbs. Progovac therefore considers the TP-layer to be the cut-off point between sentential and nonsentential utterances. In line with our previous work we will refer to these nonsententials as ellipses, and talk about finiteness omission, rather than tense omission.

The analysis of telegraphic style described above is consistent with the *adaptation theory* of Kolk and colleagues (e.g., Kolk, 1995, 2006), which states that telegraphic style reflects the continuous use of a normal but pre-morbidly infrequently used language routine in order to compensate for a reduced linguistic processing capacity which hampers the production of full sentences. In support of the claim that agrammatic speakers use a subset of the repertoire employed by persons without aphasia, Kolk (2006) provides a number of arguments. First, almost all the utterances produced by Dutch and German agrammatic speakers in spontaneous speech obey the grammatical rules of normal ellipses (e.g., subject-omission and sentence-final position of the verb); only 1–3% does not (Hofstede, 1992; Kolk, 2001; Kolk & Heeschen, 1992). Second, although non-aphasic speakers produce elliptical style much less frequently than agrammatic speakers the *relative* frequency in which the various types of ellipses are used is the same. In discussing the relative frequencies of ellipses produced by agrammatic speakers, a subdivision between *isolated predicates* and *subject-predicate connections* should be made (Kolk, 2006). In isolated syntactic phrases the subject is not produced (e.g., *naar de dokter geweest*, "been to the family doctor"). The listener has to derive the subject from the conversational context. In subject-predicate connections, on the other hand, isolated predicates are combined with a subject NP (e.g., *Ik naar de dokter geweest*, "me been to the family doctor"). Compared to isolated predicates, subject-predicate connections may be more difficult to produce, because the subject and predicate are not integrated in a single syntactic frame (De Roo, 1999). For that reason the subject NP is frequently added in producing the isolated predicate for a second time (e.g., *koffie drinken vrouw koffie drinken*, "drinking coffee woman drinking coffee"). The fact that subject-predicates are more difficult to produce, may explain why they occur only infrequently in agrammatic speech (e.g., Kolk, 2001).

As already implicitly stated in the preceding paragraphs, it is important to note that the adaptation theory claims that agrammatic symptoms reflect both a syntactic disorder and compensatory speech behaviour. A first form of compensation consists of *correcting* (i.e., repairing) the internal errors that result from using the reduced language production system for sentence production. By restarting the computational process a number of times, repair is possible; however, this strategy has two serious drawbacks for communication. Since agrammatic speakers tend to produce many internal planning errors, corrective adaptation is time-consuming for both the speaker and the listener. Even more importantly, success is not guaranteed: in producing a sentence of a certain complexity, the linguistic processing capacity may be too strongly reduced for the restart strategy to work successfully.

It can be argued that a second kind of compensation is more successful, because it *prevents* sentence production difficulties from the very beginning. Agrammatic speakers may adapt to the linguistic disorder by producing simple sentences that lack embedding, negation, or question form (e.g., Kolk & Van Grunsven, 1985). If the conceptual message is simplified even further, syntactic processing becomes biased towards the part of the normal repertoire that has the lowest degree of complexity, being ellipses. As such, we claim that elliptical style may be used strategically by agrammatic speakers in order to compensate for a reduced linguistic processing capacity which hampers the production of full sentences.[1]

QUALITATIVE AND QUANTITATIVE ANALYSES OF SPONTANEOUS SPEECH

Sentence production symptoms, both agrammatic and paragrammatic symptoms, are typically established on the basis of (semi)spontaneous speech, which can be elicited by instructing persons with aphasia to describe pictures or to retell a well-known story, such as a fairy tale. Role-playing and semi-standardised interviews are also commonly used to elicit discourse (e.g., Beeke, Wilkinson, & Maxim, 2003; Prins & Bastiaanse, 2004).

[1]Although we claim that elliptical style results from strategic communication behaviour, we do not postulate that each and every agrammatic speaker will apply this compensatory style of speech. Evidence is increasing that compensatory behaviour requires executive control and acceptance of elliptical style. Since both neuropsychological functions may be impaired in persons with aphasia, agrammatic speakers may not be able and/or willing to apply elliptical style. A thorough discussion of the mechanisms underlying compensation strategies is beyond the scope of this article (but for further details see, for example, Purdy, Duffy, & Coelho, 1994; Purdy & Koch, 2006; Ruiter et al., 2010)

The linguistic approaches to the analysis of morphosyntactic symptoms in spontaneous speech can be divided into *qualitative* analyses, which use rating scales, and *quantitative* analyses, which typically consist of systematically counting measurable characteristics of spoken language production (e.g., type of utterances produced and their average length). Many standardised and norm-based aphasia batteries, such as the Aachen Aphasia Test (AAT; Huber, Poeck, Weniger, & Willmes, 1983), use rating scales to score the grammatical aspects of spontaneous speech. Although this allows quick and easy scoring, the study of Grande et al. (2008) suggests that rating scales lack sensitivity to detect changes in morphosyntactic output resulting from spontaneous recovery or aphasia therapy (i.e., guided recovery). A total of 28 aphasic speakers of German participated in their study. Their age varied between 22 and 74 years ($M = 47.4$) and the average time post-onset was 18.4 months (range 1–86). A total of 14 participants exhibited non-fluency; the other participants demonstrated fluent aphasia. Spontaneous speech was elicited with the semi-standardised interview of the AAT, which was administered both before and after seven weeks of language training. The elicited speech was analysed with a quantitative method of analysis (the *Aachener Sprachanalyse*; Huber, Grande, & Springer, 2005) as well as a qualitative method of analysis (the six AAT rating scales). The quantitative method included linguistic parameters such as *syntactic completeness*, *complexity* (i.e., percentage of compound sentences), and *mean length of utterance* (MLU). A total of 20 participants demonstrated significant change in at least one linguistic parameter, while only 4 participants showed significant improvement on (at least one of) the rating scales. These results suggest that linguistic parameters are more sensitive to change in grammatical output than conventional rating scales. The sensitivity of the quantitative methods of analysis may explain why such analyses are being increasingly used in academic and clinical practice, even though such analyses typically are very time-consuming.

POTENTIAL PITFALLS OF QUANTITATIVE ANALYSES

In spite of the fact that quantitative methods appear to be sensitive to change in grammatical output and also allow grammatical symptoms to be systematically and objectively counted, there may be potential pitfalls when interpreting the results. These potential difficulties relate to the dependencies that may exist between the grammatical parameters, as the quantitative analysis of spontaneous speech proposed by Wagenaar, Snow, and Prins (1975; see also Prins, Snow, & Wagenaar, 1978) may illustrate. Among other linguistic variables, *the percentage of complex utterances*, *utterances shorter than five-words*, *MLU*, and *mean length of three longest utterances* are derived in this analysis. According to Vermeulen, Bastiaanse, and Van Wageningen (1989), both *the number of utterances shorter than five words* and *the mean length of the three longest utterances* are expected to correlate with *MLU* as the former parameters are both used to calculate the latter variable.

The Quantitative Production Analysis (QPA; Saffran et al., 1989, see also Rochon et al., 2000) may provide another example of dependencies between linguistic variables. Relevant to the discussion are the following QPA variables: *utterance type*, *sentences*, *MLU*, and *inflectable verbs inflected* (i.e., number of finite verbs). Regarding *utterance type*, the QPA distinguishes between sentences, topic-comment structures, and other utterances. Sentences are defined as consisting of: (a) a noun and a main verb, (b) a noun, copula and an adjective, or (c) a noun, copula, and prepositional phrase. Topic-comment structures include all proposition-bearing structures that do not meet the criteria for sentences (e.g., *Cinderella very pretty*, *Cinderella in the house*). Sub-sentence categories, such as Noun Phrases or Verb Phrases are scored as "other utterances". For all three classes of utterances the *MLU* is calculated. In analysing the results obtained with QPA the number of finite verbs shows a statistical dependency with the number of sentences produced.

Although it may be difficult in itself, interpretation of the dependency between two linguistic variables is relatively straightforward if the variables always show a positive or negative relationship. For example, in each and every aphasic speaker, and at each point in time at which an individual speaker's grammatical output is analysed, the number of finite verbs is positively correlated to the number of sentences produced.

We would like to add to the discussion that interpreting the results of quantitative analyses may be further complicated when variables are used that do *not* always exhibit the same direction of relationship (either negative of positive) across aphasic speakers and across points in time. The following example may illustrate how parameters that are typically used in quantitative analyses may show a trade-off effect (i.e., be inversely proportional to each other). The verbal functional communication skills of persons with aphasia are often analysed in the several phases of rehabilitation (e.g., sub-acute and chronic phase) in order to investigate the effect of spontaneous and/or guided recovery. Functional communication may be characterised by two aspects: *verbal effectiveness* and *verbal efficiency*. A method frequently used to operationally define both aspects is the Content Unit analysis proposed by Yorkston and Beukelman (1980). On page 30 of their 1980 article Yorkston and Beukelman give the following definition of a Content Unit (CU): "a grouping of information that was always expressed as a unit by normal speakers" in order to get their message across. In line the CU-analysis, verbal effectiveness may be operationally defined by *the number of CUs produced*, and verbal efficiency as *the number of CUs produced per minute*. Relevant to the discussion here is that aphasia therapy may affect both parameters of verbal functional communication differently. Whereas both verbal effectiveness and verbal efficiency may increase as a result of restoration therapy, compensation therapy may affect verbal effectiveness and efficiency in a different way, depending on the strategy used. For example, some chronically anomic speakers produce a hypernym (e.g., *animal*) when they fail to retrieve a word (e.g., giraffe). Teaching such speakers to produce a circumlocution (e.g., *A tall animal that lives in Africa. It has a very long neck and legs*) may lead to an increase in verbal effectiveness. However, verbal efficiency is likely to decrease as the speaker produces more words (Ruiter, Kolk, Rietveld, Dijksta, & Lotgering, 2011). The fact that, in this example, the use of circumlocutions leads to an increase of verbal effectiveness at the cost of a reduced verbal efficiency may indicate that the person with anomic aphasia has resorted to a kind of semiotic compensatory strategy.

As will be explained below, possible reciprocity may also hold for two dependent variables that are very often used in quantitative analyses: *number of utterances produced* and *their average length* (e.g., McNeil et al., 2007; Ruiter et al., 2010; Saffran et al., 1989; Van den Berg & Kolk, 1996).

POSSIBLY RECIPROCAL RELATIONSHIP BETWEEN NUMBER AND LENGTH OF UTTERANCES

The difficulty in using both *the number of utterances* and *their length* as dependent measures is that they may show a trade-off effect (i.e., be inversely proportional to each other) when the task to elicit spontaneous speech is repeated over time in order to investigate the effect of treatment. Since the same elicitation task is used, the amount of information to be conveyed remains the same. As we will discuss below, in that case, both variables may behave like communicating vessels: An increase in the length of utterances may be compensated by a decrease in the number of utterances (and vice versa).

Non-aphasic speakers may show variability in their sentential output across communicative settings. For example, instead of producing one complex or long sentence in a formal situation, a non-aphasic speaker may produce two short or simple sentences in a more informal communicative situation (e.g., *Since the weather was beautiful, we went to the beach yesterday* versus *The weather was beautiful yesterday. So, we went to the beach*). As this example illustrates, non-aphasic speakers may have the choice in everyday language between expressing their communicative intention by means of complex sentences with embedded clauses (i.e., hypotaxic constructions) and employing a number of separate short sentences (i.e., parataxic constructions). Whereas intra-subject variability is characteristic of the sentential output produced by non-aphasic speakers, evidence is increasing that the grammatical output of aphasic speakers also shows considerable variability, depending on the communicative setting or goals to be achieved (e.g., De Roo, Kolk, & Hofstede, 2003; Hofstede & Kolk, 1994; Kolk, 1998; Kolk & Heeschen, 1992; Ruiter et al., 2010).

The study of De Roo et al. (2003), for example, shows that intra-subject variability can be observed in the elliptical repertoire of agrammatic speakers. De Roo et al. observed that when informational demands are particularly high, agrammatic speakers aim at the lowest degree of elliptical complexity. That is, instead of communicating a relatively complex message by producing one complex elliptical utterance, they produced several relatively simple ellipses.

Not only task variation but also aphasia therapy may induce variability in the grammatical output of individual aphasic speakers. That is, when spontaneous speech is analysed at several points in time in order to evaluate the effect of therapy, intra-subject variability in grammatical output may be observed. Regarding restoration therapy, which aims at the re-automation of the pre-morbid sentence production routine, a first possible outcome is that an aphasic speaker increases both the number and length of well-formed, propositional-bearing sentences. In that case both dependent measures are *not* reciprocally dependent to each other. However, it is also likely that aphasia therapy causes sentence complexity or length to increase and the number of sentences to decrease, reflecting a trade-off effect within the sentential repertoire.[2]

Compensation therapy, aimed at the continuous production of grammatically simplified utterances such as ellipses (e.g., Ruiter et al., 2010; Schlenck, Schlenck, & Springer, 1995; Springer, Huber, Schlenck, & Schlenck, 2000; Van den Berg & Kolk, 1996) may also yield various patterns of outcome results. Whereas both the number and the length of ellipses may increase, two trade-off patterns are possible. First of all, similar to the study of De Roo et al. (2003), the number of ellipses may increase while their length or complexity decreases. However, since therapy programmes such as the Reduced Syntax Therapy (Schlenck et al., 1995; Springer et al., 2000) typically seek to expand the complexity and length of the utterances to be produced with each new

[2]A third pattern of trade-off within the sentential repertoire is that the number of well-formed sentences increases, while their length decreases. This pattern, however, is unlikely to reflect true restoration of pre-morbid sentence production skills as only simple, short sentences are produced instead of complex, long ones. This pattern rather seems to reflect an effect of preventive adaptation in order to compensate for the production difficulties: producing simple utterances without giving up finiteness (e.g., Kolk, 2006).

therapy level, it is also possible that the length of ellipses increases at the expense of the number of ellipses.

Because the number of utterances and their length may exhibit a possibly reciprocal relationship, there is a pitfall in investigating both linguistic variables independently. That is, a lack of increase—or even a decrease—in one of both outcome measures may be incorrectly interpreted as a lack of effect of treatment. The study of Ruiter et al. (2010) may illustrate this. The authors evaluated the efficacy of the Dutch and adapted version of Reduced Syntax Therapy (REST). The rationale of this therapy programme resides in providing a compensation strategy. It enhances a normal—but previously infrequently used—linguistic operation of the dominant hemisphere: the production of ellipses. It was hypothesised that the continuous use of ellipses would allow chronically agrammatic speakers to convey their message more efficiently when compared to the error-strewn production of sentences, while they would remain comprehensible to their conversational partners. In order to evaluate the efficacy of REST the authors distinguished two different but related goals: first, the enhancement of elliptical style and, second, the increase in communicative efficiency. Two dependent measures were used to evaluate achievement of the first goal: *the percentage of ellipses* (in comparison to the sentences produced) and *the length of the ellipses*, which was operationally defined as the number of constituents. In line with the expectations, almost all participants (i.e., 89%) who either significantly increased the number of ellipses or their length across communicative settings showed gains in communicative efficiency, while they remained communicative effective (i.e., they provided the listener with the same amount of information). However, the dependent measures could not establish significant effects of REST on grammatical output in each aphasic participant and in each communicative condition, possibly due to trade-off effects in the enhancement of elliptical style.

RESEARCH AIM AND RATIONALE

As illustrated in the preceding section, dependencies between grammatical outcome measures complicate the interpretability of the results obtained. This holds for non-reciprocal dependent parameters and, even more, for parameters that may exhibit a reciprocal dependency. As for the latter category, Ruiter et al. (2010) have suggested that calculating the combined effects of the percentage and length of ellipses produced might be an alternative for calculating both linguistic parameters separately. A possible approach to doing this would be the calculation of the percentage of words produced in ellipses (in comparison to the number of words in sentences). The current study investigates the hypothesis that the combination of potentially reciprocal parameters to a single parameter of grammatical output increases the interpretability of the data obtained with quantitative analysis of spontaneous speech. The current study therefore constitutes an extension of the study of Ruiter et al. (henceforward referred to as the previous study).

METHOD

Participants

The 12 chronically agrammatic speakers who had participated in the previous study were all native speakers of Dutch. All had suffered a single stroke in the left hemisphere and—except for one (participant EL)—were at least 12 months post-onset. Although all participants produced agrammatic speech output, some participants also demonstrated mild apraxia of speech (AJ, RK, PO, and TW) or mild dysarthria (GJ). However, these five participants produced at least 95% intelligible speech output (for participants' characteristics, see Table 1).

TABLE 1
Participants' characteristics

Participant		*Age (yrs)* [a]	*Post-onset (yrs)* [b]	*Syndrome AAT* [c]	*Syntactic structure* [d]	*Severity aphasia* [e]	*Aetiology* [f]	*Education* [g]
GJ	f	61.3	3.7	Broca	1	45.75	ICVA, LH, tempero-parietal area	2
EL	m	39.10	0.8	Broca	2	48.64	HCVA, LH, temporal regions	5
CP	m	36.9	4.4	Nonclass.	2	64.77	CVA, LH, exact location unknown	4
AJ	m	51.10	2.1	Broca	1	50.66	CVA, LH, exact location unknown	5
ML	f	64.11	1.1	Broca	2	56.54	ICVA, LH, arteria cerebri media	4
HK	f	66.6	4.0	Broca	2	59.99	ICVA, LH, exact location unknown	4
RK	f	35.8	1.11	Broca	1	43.52	ICVA, LH, parieto-occipital area	5
JP	m	67.2	5.8	Nonclass.	2	60.08	ICVA, LH, exact location unknown	4
PO	m	41.11	1.11	Broca	2	49.23	ICVA, LH, exact location unknown	6
AH	m	62.8	4.8	Broca	2	61.72	HCVA, LH, arteria cerebri media	4
TW	f	54.9	8.5	Broca	1	52.51	ICVA, LH, arteria cerebri media	3
WR	m	51.0	15.4	Broca	2	43.01	ICVA, LH, arteria cerebri media	5
Mean		52.10	4.6					
Range		35.8–67.2	0.8–15.4					

All participants ($N = 12$) were right-handed.
[a,b] Years (yrs) refer to the age versus time post-onset during the pre-therapy measurements.
[c] AAT diagnosis based on the nonparametric discriminant analysis programme (ALLOC).
[d] Syntactic structure of participants' speech output rated on the 6-point scale of the subtest Spontaneous Speech of the Dutch Aachen Aphasia Test (AAT; Graetz, De Bleser, & Willmes, 1992). 1 = mostly one or two word utterances; almost no inflection forms or function words; 2 = short, simple sentences, which are mostly syntactically incomplete; frequent absence of function words and inflected forms.
[e] Severity of aphasia is expressed as the average profile height of the Dutch Aachen Aphasia Test (AAT; Graetz et al., 1992).
[f] ICVA = ischaemic cerebrovascular accident, HCVA = haemorrhagic cerebrovascular accident.
[g] Level of education according to Verhage (1964).

Design and outcome measures

A multiple single-case design ($N = 12$) had been used in the previous study to investigate the efficacy of the Dutch and adapted version of REST therapy. The participants had been presented with several tasks and tests, which measured spoken language production and executive functioning, at three points in time: pre- and post-therapy (T1 and T2 respectively) as well as 6 months after ending the therapy programme (T3). Since focus in this article is on the linguistic parameters of quantitative analysis, we will elaborate on the measures of spoken language production only.

Spoken language had been elicited with several tasks and tests. First of all, the semi-standardised interview of the Dutch Aachen Aphasia Test (AAT; Graetz et al., 1992). Second, a picture description (PDT) in which the participants had to describe 40 pictures in the presence of distracting environmental stimuli (e.g., an audiotape of a group of eight adults making conversation, played over loudspeakers at a comfortable listening level, approximately 65 dB). In the third communication condition participants were engaged in conversation with a significant other. To facilitate dialogue, both interlocutors together played games of *happy families* with line drawings (HF).[3]

In the previous study the speech samples elicited with the AAT, PDT, and games of HF had been orthographically transcribed and segmented into utterances using three hierarchically ordered criteria: a syntactic, prosodic, and semantic one (De Roo, 1999; Saffran et al., 1989). Direct responses to or repetitions of the experimenter's speech, unintelligible or non-interpretable utterances, as well as participant's commentaries on the task or performance, were discarded from analysis. The remaining utterances were classified as either an *ellipsis* or a *sentence*, based on the criterion of finiteness. Whenever this criterion could not unambiguously differentiate between ellipses and sentences (as for example in *kinderen spelen*, "children playing") that utterance was labelled sentential.

In the current study we counted—for each sentence and ellipsis produced—the number of words in the utterance. Speech automatisms, stereotypical elements, and non-word fillers (e.g., "er") were excluded from the word count. This also held for corrections of words, phrases, or sentences. For example, the number of words produced was four for the ellipsis "*A man, the woman drinking coffee*". Whenever possible the narrative core consisted of at least 300 words, which is in line with the ASTA protocol (Boxum, Van der Sheer, & Zwaga, 2010, see also Brookshire & Nicholas, 1994).[4] Subsequently the *percentage of words produced in ellipses* (when compared to words in sentences) was calculated: parameter *%WIE*.

[3]For the rationale behind the PDT and the games of HF as well as the instructions, procedures, and material used in these tasks, see Ruiter (2008).

[4]At T1, T2, as well as T3, all participants ($N = 12$) produced sufficient sample sizes in the HF and across conditions. Thus these samples yielded reliable measures of language performance. However, since not all participants produced sufficient sample sizes in the AAT and PDT, the results obtained in these conditions have to be interpreted cautiously. To give an indication of the percentage of material excluded from analysis, we provide for each participant the percentage of clauses excluded across conditions (i.e., AAT, PDT, and HF) and across points in time at which the effect of REST therapy was assessed (i.e., pre, post, and follow-up): GJ: 33.23%, EL: 13.46%, CP: 6.20%, AJ: 7.30%, ML: 10.48%, HK: 8.93%, RK: 12.35%, JP: 5.99%, PO: 28.55%, AH: 12.04%, TW: 14.15%, and WR: 14.12%. The weighted mean was 18.07% (for details, see Ruiter, 2008).

Statistical analyses

For each parameter of elliptical style calculated in the three conditions as well as across conditions (i.e., AAT, PDT, and HF taken together), Likelihood Ratios ($\alpha = 0.05$, one-tailed) were calculated to investigate change over time (T1 to T2, as well as T1 to T3). The statistic *Likelihood Ratios* is a variant of the chi-square test, used in cases where the expected cell frequencies are less than five. Since four comparisons were made across time, we used the Holm method to control for inflation of the Type I error (e.g., Holm, 1979; Levin, 1996). Thus we report Holm's adjusted *p* levels for all outcome measures. Pearson's correlation coefficient, *r*, was used to indicate the strength of an experimental effect. Importance of the effect was interpreted with the criteria of Cohen (1988, 1992, p.32, cited in Field, 2005).

RESULTS

Table 2 presents the statistics for the possibly reciprocal parameters of grammatical output used in the previous study (i.e., *percentage* and *mean length of ellipses*, % and

TABLE 2
Effects of REST on grammatical output as measured with different outcome measures

	Morpho-syntactic variable		*Group level (N = 12)* Pre	*Post*	*FU*	Δ	*Wilcoxon Signed-rank*	*Effect size*	*Individual level*[a]
Overall	%	Pre-Post	58.13	71.01		12.88	$z = -2.510$, $p = .025$	$r = -.51$	8/12
		Pe-FU	58.13		67.46	9.33	$z = -2.510$, $p = .025$	$r = -.51$	6/8
	MLE	Pre-Post	1.50	1.79		0.29	$z = -2.934$, $p = .000$	$r = -.60$	6/12
		Pe-FU	1.50		1.67	0.17	$z = -1.960$, $p = .192$	$r = -.34$	5/6
	% WIE	Pre-Post	48.26	63.69		15.43	$z = -2.667$, $p = .006$	$r = -.54$	9/12
		Pe-FU	48.26		61.53	13.27	$z = -2.510$, $p = .015$	$r = -.51$	8/9
AAT	%	Pre-Post	64.91	70.04		5.13	$z = -1.490$, $p = .152$	$r = -.30$	*ns*
		Pe-FU	64.91		68.08	3.17	$z = -0.978$, $p = .366$	$r = -.20$	*ns*
	MLE	Pre-Post	1.58	1.73		0.15	$z = -1.490$, $p = .099$	$r = -.30$	*ns*
		Pe-FU	1.58		1.60	0.02	$z = -0.275$, $p = .750$	$r = -.06$	*ns*
	% WIE	Pre-Post	55.62	61.81		6.19	$z = -1.726$, $p = .046$	$r = -.35$	5/12
		Pe-FU	55.62		58.62	2.54	$z = -0.889$, $p = .207$	$r = -.18$	3/5
PDT	%	Pre-Post	39.33	65.02		25.69	$z = -2.275$, $p = .040$	$r = -.46$	7/12
		Pe-FU	39.33		55.95	16.62	$z = -2.510$, $p = .025$	$r = -.51$	4/7

TABLE 2
(Continued)

	Morpho-syntactic variable		Group level (N = 12) Pre	Post	FU	Δ	Wilcoxon Signed-rank	Effect size	Individual level[a]
	MLE	Pre-Post	1.81	2.33		0.52	$z = -2.824$, $p = .005$	$r = -.58$	5/12
		Pe-FU	1.81		2.15	0.35	$z = -2.276$, $p = .050$	$r = -.46$	3/5
	% WIE	Pre-Post	32.25	63.80		31.55	$z = -2.824$, $p = .004$	$r = -.58$	9/12
		Pe-FU	32.25		52.70	20.45	$z = -2.903$, $p = .004$	$r = -.59$	9/9
HF	*%*	Pre-Post	62.03	72.89		10.86	$z = -2.275$, $p = .040$	$r = -.46$	5/12
		Pe-FU	62.03		70.79	8.76	$z = -1.883$, $p = .096$	$r = -.38$	3/5
	MLE	Pre-Post	1.43	1.59		0.16	$z = -1.844$, $p = .099$	$r = -.38$	6/12
		Pe-FU	1.43		1.58	0.15	$z = -1.511$, $p = .222$	$r = -.31$	4/6
	% WIE	Pre-Post	52.59	65.07		12.48	$z = -2.353$, $p = .016$	$r = -.48$	9/12
		Pe-FU	52.59		66.57	13.98	$z = -2.197$, $p = .026$	$r = -.45$	8/9

% = percentage of ellipses; *MLE* = mean length of ellipsis (in constituents). Both parameters were used by Ruiter et al. (2010). *% WIE* = percentage of words produced in ellipses (in comparison to words in sentences).

[a]This column indicates how many of the 12 participants showed a significant and positive effect of REST (i.e., the enhancement of elliptical style). In the rows labelled *Pre-FU* it is indicated how many of these participants still showed a significant and positive effect 6 months after ending REST.

MLE respectively) as well as the statistics for the new parameter: *the percentage of words produced in ellipses (%WIE*). For example, Table 2 shows that the group of speakers significantly increased *%WIE* from T1 to T2 across conditions as well as in the AAT, PDT, and HF. At T3 the 12 participants still produced significantly more words in ellipses across conditions as well as in the PDT and HF. These findings suggest that the participants significantly enhanced elliptical style after therapy and could retain this effect on their style of speech quite well. Regarding the research aim it is of relevance that parameter *%WIE* could reproduce the results obtained in the previous study: The group of agrammatic speakers had shown a significant effect on the parameter *%* and/or on the parameter *MLE* in the same conditions and at the same the points in time at which a significant effect on the parameter *%WIE* was observed.

Parameter *%WIE* was not only able to reproduce the results obtained in the previous study, but also seems to be more sensitive to detect changes in grammatical output over time than parameters *%* and *MLE* independently could. For example, the group of participants significantly increased *%WIE* in the AAT from T1 to T2, whereas no significant changes were observed at the group level in the previous study. At the individual level, 5 out of the 12 participants significantly enhanced the number of words produced in ellipses in the AAT from T1 to T2 whereas, in the previous study, no significant effect of REST had been found on grammatical output in this condition. As indicated above, the results obtained with the AAT have to be interpreted cautiously as the AAT may not have yielded reliable measures. However, when considering the games of HF, which yielded reliable measures of grammatical output, parameter *%WIE* could establish significant long-term maintenance effects (i.e., Pre-FU), whereas parameter *%* could not.

DISCUSSION

The current study sought to determine whether combining two linguistic variables that may exhibit a reciprocal relationship into a single parameter increases the interpretability of the results obtained with quantitative analysis of aphasic speakers' spontaneous speech. More specifically, the possibly reciprocal parameters *%* (percentage of ellipses produced) and *MLE* (mean length of ellipsis) that were used in the study of Ruiter et al. (2010) were combined into a single parameter of elliptical style: *%WIE* (percentage of words produced in ellipses, in comparison to words in sentences).

The parameter *percentage words produced in ellipses* was not only able to reproduce the results obtained in the previous study, but also seems to be more sensitive: It could identify significant changes in elliptical style in more participants than could the two possibly reciprocal parameters independently. Regarding parameter *MLE* this is not unexpected. Ruiter et al. computed the average length of ellipses in constituents in order to control for the agrammatic speakers' tendency to leave out determiners, which may be stronger post- than pre-therapy. Although this is much more conservative than using the number of words, it has the disadvantage that increases in the length of ellipses produced are less-easily established.

Notwithstanding the fact that parameter *MLE* might not have been sensitive enough to grasp increases in the length of ellipses produced, the results of the current study show that the quantitative results of the analysis of spontaneous speech can be more easily interpreted when only one parameter is used. This is of relevance to aphasia researchers and therapists as it provides them with a more sensitive measure to establish the effect of therapy on aphasic speakers' grammatical output. By subsequently calculating the relative number of ellipses and their length separately, it can still be investigated which of the latter parameters contributes most to the enhancement of elliptical style.

A question that needs to be addressed is whether other parameters can be used to combine possible reciprocally dependent parameters into one. For example, Springer et al. (2000), who investigated the effect of the original REST programme on 11 German-speaking agrammatic speakers, calculated, among other parameters, the percentage of utterances consisting of one, two, and three (or more) constituents. In investigating the effect of REST on grammatical output the authors investigated whether the participants produced significantly more utterances consisting of two or three constituents—and therefore fewer one-constituent utterances—after therapy. Since the outcome measures *percentage of utterances produced* and *their length* are combined, this approach seems to sophisticatedly handle the issue of reciprocity; however, it is to be noted that Springer et al. computed this parameter over sentences and ellipses taken together. Such an analysis is in line with the hypothesis that morphological and syntactic aspects of sentence production can be selectively impaired in agrammatism (e.g., Rochon et al., 2000). Elliptical utterances are thus interpreted as incomplete and ungrammatical sentences. From our theoretical point of view, however, ellipses are grammatically well formed since they result from a normal but pre-morbidly infrequently used language routine (e.g., Kolk, 2006). From this perspective, ellipses and sentences should be distinguished when analysing grammatical output. The approach suggested by Springer et al. (2000) cannot be used from the theoretical point of view that the elliptical utterances should be set apart from sentences in quantitatively analysing agrammatic speakers' grammatical output. That is, in the method of analysis used by Springer et al., an increase in the number of two- and three-constituent *ellipses* could either reflect a decrease in the number of (one-, two-, or three-constituent) *sentences* produced or a decrease in the number of one-constituent *ellipses.* This example shows that, if several utterance types (e.g., both sentences and ellipses) are analysed separately, it is not straightforward to select a single parameter that validly combines two linguistic parameters that may exhibit a reciprocal relationship.

In summary, the present study shows that combining the possibly reciprocal outcome measures *percentage of ellipses* and *their length* into a single parameter increases the interpretability of the results obtained with quantitative analysis of aphasic speakers' spontaneous speech. That way, a lack of increase—or even a decrease—in the percentage of ellipses produced or their length is no longer incorrectly interpreted as a lack of effect of treatment.

Although, in the current study, the procedure of combining two possibly reciprocal linguistic variables into one dependent measure was demonstrated for the elliptical repertoire, it is to be noted that it can be applied to the sentential repertoire as well. The methods of quantitative analysis that were discussed in the Introduction (e.g., the Quantitative Production Analysis proposed by Saffran et al. (1989)) all include the parameters *number of sentences* and *their length.* As such, these methods may also benefit from adding the parameter *percentage of words produced in sentences* when investigating aphasic speakers' spontaneous speech over time. It may allow clinicians and researchers to control for possible trade-off effects between the number of sentences produced and their length, which may occur in the sub-acute as well as in the chronic phase of aphasia.

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