Training verb and sentence production in agrammatic Broca’s aphasia

Petra Links
University Medical Center Groningen (UMCG), The Netherlands

Joost Hurkmans
Rehabilitation Centre “Revalidatie Friesland”, Beetsterzwaag, The Netherlands

Roelien Bastiaanse
University of Groningen, and University Medical Center Groningen (UMCG), The Netherlands

Background: Many aphasic speakers have problems producing verbs at both the word and the sentence level. A treatment programme called ACTION (Bastiaanse, Bunge, & Perk, 2004; Bastiaanse, Jonkers, Quak, & Varela Put, 1997) has been developed to train verb production of both fluent and non-fluent aphasic speakers. It consists of four levels: single verbs, filling in infinitives, filling in finite verbs, and sentence construction. For the present study the efficacy of the programme for agrammatic speakers with Broca’s aphasia was tested.

Aims: The aim of the study was to measure the effects of treatment with ACTION on non-trained infinitives and finite verbs, and to analyse the generalisation effects on spontaneous speech and verbal communication in daily life.

Methods & Procedure: ACTION was used to train 11 agrammatic patients with Broca’s aphasia, following the multiple baseline across behaviours design. The patients were tested weekly on untreated items. Two follow-up assessments were done, 1 and 3 months post-treatment. Generalisation to related and unrelated materials was measured with subtasks of the Aachen Aphasia Test (AAT). Spontaneous speech was analysed, and verbal communication was measured before and after treatment and 3 months post-treatment by the Amsterdam-Nijmegen Everyday Language Test (ANELT).

Outcomes & Results: There was improvement on the untrained infinitives and finite verbs. The improvement on infinitives was relatively minor; finite verbs, which were more impaired than the infinitives prior to treatment, improved up to the level of the infinitives. The improvement generalised to the related tasks of the AAT, but not to the unrelated task; verbal communication improved significantly. This improvement was reflected in relevant variables of spontaneous speech (mean length of utterances,
proportion of finite verbs and verb diversity), but not in an unrelated variable (diversity of nouns).

**Conclusions:** Treatment with ACTION resulted in better production of finite verbs. The effects generalised to spontaneous speech. Most importantly, it was shown that communication in daily life improved.

**Keywords:** Aphasia treatment; Verb therapy; Agrammatic aphasia; Broca’s aphasia; Recovery.

Agrammatic Broca’s aphasia is characterised by telegraphic speech. Although telegraphic speech was originally described as the use of mainly content words, and content words were defined as nouns, verbs, and adjectives, it is now generally acknowledged that agrammatic speakers have severe problems with verb production. They use relatively fewer lexical verbs (Saffran, Berndt, & Schwartz, 1989; Thompson, Shapiro, & Schendel, 1994), and/or the diversity of the produced lexical verbs is lower than normal (Bastiaanse & Jonkers, 1998). The verbs that are produced are often uninflected. These problems with verbs are evident in spontaneous speech, and in naming and sentence construction tests (see, e.g., Lee & Thompson, 2004, for English; Bastiaanse, Hugen, Kos, & Van Zonneveld, 2002, for Dutch). Verb problems in aphasia are not just restricted to individuals with agrammatic symptoms; fluent aphasic speakers are often impaired in the production of lexical verbs as well (Bastiaanse & Edwards, 2004; Berndt, Mitchum, Haendiges, & Sandson, 1997; Jonkers & Bastiaanse, 2007).

Data on the effects of verb treatment are relatively scarce. In the 1990s several studies were done to examine the effects of mapping therapy, in which the verb and its argument structure play a central role (e.g., Marshall, 1995; Mitchum & Berndt, 1992; Schwartz, Saffran, Fink, Myers, & Martin, 1994). More recently, several verb treatment studies have been performed, very nicely reviewed by Conroy, Sage, and Lambon Ralph (2006). In some of these studies (Pashek, 1998; Wambaugh, Doyle, Martinez, & Kalinyak-Flishar, 2002) verb retrieval was trained in a similar way to noun retrieval; that is, by using phonological, semantic, and gestural cueing. The researchers found improvement on trained items, but no generalisation to untrained items. Rodriguez, Raymer, and Gonzalez Rothi (2006) and Rose and Sussmilch (2008) also described the effects of semantic, semantic-phonologic, and gesture (plus verbal) treatments on verb production. Rodriguez et al. (2006) found no generalisation to untreated verbs, and modest generalisation was found in the study of Rose and Sussmilch (2008).

The other studies reviewed by Conroy et al. (2006) did not just target verb naming but also examined the effect of therapy on sentence production. Four of them focused on aspects of verb argument structure and sentence production (Fink, Martin, Schwartz, Saffran, & Myers, 1992; Murray & Karchner, 2000; Schneider & Thompson, 2003; Webster, Morris, & Franklin, 2005). In several of these studies better verb retrieval after training was reported. In some participants therapy resulted in a better sentence production, but generalisation to untreated verbs was not always found. Remarkably, generalisation to spontaneous speech and to verbal communication in daily life has been given little attention. Two studies on “constraint-induced aphasia therapy” focused on communicative and behaviourally relevant actions (Pulvermüller & Berthier, 2008) or verb production (Goral & Kempler, 2009) were...
documented. Pulvermüller and Berthier reported significant increase in language performance, on both clinical tests and a questionnaire targeting everyday language and communication activities. The effect of therapy on verb use was not reported by Pulvermüller and Berthier, but the patient described by Goral and Kempler used more verbs and more different verbs after therapy and the communicative efficacy had increased.

In 1997 a Dutch verb production programme was published (Bastiaanse, Jonkers, Quak, & Varela Put, 1997), which has been adapted to German (Bastiaanse, Bunge, & Perk, 2004). Here the German name of the programme is used: ACTION. This programme has been developed to train verb and sentence production in individuals with aphasia. The present study was done to evaluate the effectiveness of ACTION in a group of agrammatic speakers with Broca’s aphasia. In the next section the programme will be discussed, followed by the design of the study.

**ACTION**

ACTION has four steps; they parallel the four steps that have been distinguished in theories of sentence production. According to Bastiaanse, Hurkmans, and Links (2006) four stages are necessary for producing a verb correctly in the sentence:

1. Retrieval of the verb lemma, with all grammatical information, from the lexicon.
2. Building a sentence frame around the verb: the thematic roles have to be mapped onto the grammatical roles; that is, for a simple transitive verb the agent should be mapped onto the subject role and the theme onto the object role.
3. Inflection of the verb for tense and agreement.
4. For languages like Dutch, “moving” the verb to the second position in the main clause.\(^1\)

ACTION is based on the idea that individuals with aphasia who have verb problems should be made aware of the important role of the verb in a sentence by training the verb in different forms and in different positions in the sentence. The programme reflects the four steps of sentence production mentioned above and each step can be trained separately. The steps in ACTION corresponding to the four stages are:

- **Step 1:** Lexical level: action naming. Verb retrieval at the word level is trained with action naming in response to pictures.
- **Step 2:** Syntactic level: retrieval of infinitives in sentence context. Again, a picture is shown, with a sentence printed underneath in which the verb, in infinitival form, is left out. The participant reads the sentence (if necessary with the help of the therapist) and has to fill in the missing verb orally; which, in Dutch, is at the end of the sentence (e.g., *de jongen is een appel aan het eten*; “the boy is an apple eat”, see Figure 1a).
- **Step 3:** Morphosyntactic level: retrieval of finite verb in sentence context. Same as Step 2, but now the verb has to be inflected for tense and agreement and has to be

\(^1\)Base word order in Dutch is subject – object – verb. The infinitives and participles are always at the end and finite verbs in embedded clauses are also in final position. Only in main clauses is the finite verb in second position. In UG theory the finite verb is supposed to “move” to second position, which is notoriously difficult for agrammatic speakers (Bastiaanse et al., 2002). The difference is illustrated in the examples given in Figure 1a and 1b below.
“moved” to the second position of the sentence (e.g., de vrouw dans in de kamer: “the woman dances in the room”; see Figure 1b).

• Step 4: Sentence construction. A picture is presented to the participant and he/she has to construct a grammatical sentence.

All steps contain the same 60 verbs. Half of the verbs are transitive (such as to eat) and half are intransitive (such as to dance). An adjunct has been added in all sentences with an intransitive verb, to ensure that sentences with transitive and intransitive verbs are the same length. The frequency band of the verbs is large: both high-frequency verbs (to walk, to eat) and low-frequency verbs (to saw, to ski) are included, and the number of high-, mid-, and low-frequency verbs is balanced. All pictures have high name agreement: only when at least 18 out of 20 age-matched non-brain-damaged speakers had named the picture with the target verb was the item included in ACTION. Because the verbs are trained in sentences, nouns are used as well, but they are given in the sentence printed under the picture in steps 2 and 3. Since all verbs are action verbs, the subject is always an agent and to avoid extra complexity, this agent is always a human being. The noun in the object or adjunct is always easily compatible with the verb and is never a human being.

The programme consists of three booklets: one with 60 pictures (to be used for steps 1 and 4), another that has 60 pictures with sentences printed underneath in which infinitives have to be filled in and another in which the finite verbs have to be filled in. Additionally there are sentence anagram cards for sentences with infinitives and finite verbs. These can be used for an intermediate step. Further printed sentences are provided that can be used underneath the pictures for training sentences in perfect tense.

In principle, the therapist is free to use the materials in the way s/he prefers. For the efficacy study, however, some constraints were introduced (see below in the Method section). Step 1 was skipped because we believe that in agrammatic aphasia verbs should be trained at the sentence level. It has been shown that action naming, which is trained in step 1, is not related to verb production in spontaneous speech in Dutch agrammatic speakers (Bastiaanse & Jonkers, 1998; but see Edwards & Tucker, 2006, on verb training at the word level in a fluent aphasic speaker). Therefore it was
decided to train infinitives and finite verbs at the sentence level, followed by sentence construction.

In a previous paper the first results of training with the ACTION programme in two patients with Broca’s aphasic were described (Bastiaanse et al., 2006). Both participants performed better after treatment: they showed significant improvement in filling in untreated finite verbs in sentence frame. This improvement was reflected in a test for verbal communication in daily life and in spontaneous speech. This improvement was still evident 3 months post-treatment.

Thus far, 16 patients with agrammatic Broca’s aphasia have been treated with the programme, of whom 11 completed the entire protocol. The present group study concerns these 11 patients. In the next section the framework of the study is discussed.

THE PRESENT STUDY

To test the efficacy of ACTION, a multiple baseline across behaviours design was used. This design has proved to be very useful for evidence-based aphasia treatment, not only in an academic setting but also in clinical practice (Fucetola, Tucker, Blank, & Corbetta, 2005). The idea behind the design is that a participant is used as his/her own control, and that, by carefully choosing the tests, generalisation to related and unrelated materials can be established. By using multiple baseline measurements it can be determined how stable the participant’s behaviour is without training.

The main goal of the present study is to determine whether treated patients actually speak better after treatment with ACTION. This should be reflected in production of more lexical verbs, more finite verbs, and longer sentences in spontaneous speech, resulting in more effective communication in daily life. In the next section both the way the participants were treated and how generalisation was measured are discussed.

METHOD

Participants

As stated above, 11 out of 16 participants successfully finished the treatment protocol. Their demographics and medical history are described in Appendix 1. All participants suffered from left hemisphere lesions, which resulted in Broca’s aphasia. Remarkably, none of the patients has a lesion exclusively in or around Broca’s area. Most lesions are more posterior, according to the descriptions based on MRI-scans completed between 1 and 3 months post-onset. Nevertheless, all patients had a right-sided hemiplegia. The participants were included because they had serious verb production problems, both in spontaneous speech and on the Dutch version of the Verb and Sentence Test (Bastiaanse, Maas, & Rispens, 2000; Bastiaanse, Edwards, & Rispens, 2000).

The participants were treated in one of the two rehabilitation centres involved in the project. They took part in an intensive rehabilitation programme, which meant that they were also participating in group therapy on writing and general communication. In these group therapies, attention to verbs and sentences was actively avoided.

Before treatment started, all participants were diagnosed using the Dutch version of the Aachen Aphasia Test (AAT; Graetz, De Bleser, & Willmes, 1992). According
to the classification of the AAT, all patients were classified as 99% or 100% Broca’s aphasic. We would like to mention here that ACTION is not meant exclusively for agrammatic aphasia. These are just the patients who fulfilled all inclusion criteria and were willing to participate in the project in the two rehabilitation centres, during the course of 3 years. At present we have documented the results of the patients with non-fluent aphasia. The data from the first patients with fluent aphasia will be presented in a separate paper.

Design of the study

The entire study consisted of the following stages:

1. Pre-treatment testing (AAT, Amsterdam-Nijmegen Everyday Language Test; ANELT, spontaneous speech).
2. Baseline testing.
3. Treatment with ACTION for 12 weeks (3 sessions of 30 minutes per week, total 18 hours) + weekly testing:
   a. 4 weeks training of infinitives or finite verbs + weekly testing related and unrelated materials;
   b. 4 weeks training finite verbs or infinitives + weekly testing related and unrelated materials;
   c. 4 weeks training sentence construction + weekly testing related and unrelated materials.
4. Post-treatment testing:
   a. immediate, 1 month and 3 months post treatment testing on related and unrelated materials;
   b. immediate and 3 months post treatment testing (AAT + ANELT + spontaneous speech).

Stage 1: Pre-treatment testing

The following testing was done prior to baseline testing and treatment:

- **Aachen Aphasia Test (AAT):** (Graetz et al., 1992; see Miller, Willmes, & De Bleser, 2000). This test includes the following subtasks: Token Test, Repetition, Written Language, Naming (confrontation naming of objects and colours; sentence construction), Language Comprehension.
- **Amsterdam-Nijmegen Everyday Language Test (ANELT):** (see Blomert, Kean, Koster, & Schokker, 1994). This test measures verbal communicative abilities on two scales: “intelligibility” (= articulation) and “understandability”. Improvement can reliably be established. Only “understandability” was considered to be relevant for the present study. There are two parallel versions of the ANELT and a different version was used before and directly after treatment. The version used 3 months after treatment was the same as the one used prior to treatment.
- **Spontaneous speech:** A spontaneous speech sample was elicited with a semi-standardised interview, for which the participant was asked about his/her illness, the speech problems, family, and daily life. A total of 300 words were transcribed and analysed, according to the methods described by Bastiaanse and Jonkers (1998). The following variables were scored:
• Verb Diversity: the number of different lexical verbs in 300 words;\(^2\)
• Verb Inflection Index (proportion of finite verbs divided by the total number of clauses containing a verb);
• Mean Length of Utterances (MLU);
• Noun Diversity: the number of different nouns in 300 words, which used as a control measure.

All testing was done by clinical linguists, who were experienced in aphasia testing, and treatment was given by experienced speech and language therapists; the therapist and the person administering the test were never the same person. Spontaneous speech was analysed by someone who did not know the patients and did not know whether it was the first, second, or third sample. All samples were analysed by the same person (RB). The ANELT was scored by someone who did not know the patient and who was absent when the ANELT was administered (PL or JH).

Stage 2: Baseline testing

There were six measuring points over a period of 2 weeks for baseline testing. The participants were tested with 20-item tests, one for filling in infinitives and one for filling in finite verbs. The tests were similar to steps 2 and 3 of the programme, but the verbs on these two tests were not in the training programme. As in ACTION, half of the items were transitive, the other half intransitive. The frequency distributions of the verbs in ACTION and the test were the same. All items of these tests had been named by at least 40 control participants, who were matched for age and social status to an average group of people with aphasia. The name agreement was almost perfect; therefore it was decided to count only target verbs as correct. As a consequence, the reliability of scoring was high. In the few cases of doubt, three judges (the authors of this paper) discussed the participant’s answer and decided whether to count it as correct or not. If participants were capable of reading the sentences aloud they were asked to do so. Otherwise the experimenter read the sentences aloud and the participants were asked to fill in the missing word (verb). The participants received no feedback, but spontaneous corrections were allowed. The participants’ answers were scored online and checked using the audio recordings that were made during every session.

At the first and last baseline session, an unrelated control test was administered as well (a subtask of the Dutch PALPA; Bastiaanse, Bosje, & Visch-Brink, 1995, which was either reading or repetition of nonwords).

Stage 3: Treatment with ACTION + weekly testing

The treatment study was conducted during the regularly scheduled therapy time; thus there were certain constraints resulting from clinical schedules that are inevitable in clinical studies. Therapy sessions always lasted 30 minutes, which did not allow enough time to test both treated and untreated items. It was decided to test untreated items only, because improvement of untrained items was goal of the study. The entire treatment lasted a fixed period of 12 weeks, in which the patients were treated with

\(^2\)The total number of lexical verbs, at the group level, was not different from normal, as in Bastiaanse and Jonkers (1998). Therefore this was not a suitable variable to use. The number of different verbs produced is significantly lower than normal before treatment.
ACTION for 18 hours. Half of the participants were first trained on infinitives for 4 weeks. This was followed by a similar block for training of production of sentences with finite verbs. During another 4 weeks, general sentence production was trained. The other half of the participants were first trained on finite verbs, followed by infinitives; otherwise the protocol was similar. Participants were tested weekly with the two 20-item tests and also with the test with nonwords that had been used for baseline testing, to assess the progress they had made.

Stage 4: Post-treatment testing

Immediately post-treatment, 1 month later, and 3 months later, the tests used for measuring weekly progress were administered again. The Aachen Aphasia Test (AAT), the Amsterdam-Nijmegen Everyday Language Test (ANELT), and the spontaneous speech interview were repeated immediately after treatment stopped and 3 months later to measure generalisation to (1) related material (Sentence Construction and, possibly, Confrontation Naming of the AAT); (2) language use in daily life (ANELT); (3) spontaneous speech (Mean Length of Utterances; Verb Inflection Index; Diversity of Verbs). The subtest Language Comprehension and the spontaneous speech variable Diversity of Nouns were used to demonstrate that improvement was general and not treatment specific. In Table 1 a summary of the tests is given with predictions for improvement.

Procedure

Since none of the participants scored at ceiling on the different steps of ACTION, the full 4 weeks were used to train each step. During training of the infinitives and finite

<table>
<thead>
<tr>
<th>Administered →</th>
<th>Prior</th>
<th>Baseline</th>
<th>Weekly</th>
<th>Post</th>
<th>1m. post</th>
<th>3m. post</th>
<th>Improvement expected</th>
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<td>Confrontation naming</td>
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<td>–</td>
<td>+</td>
<td>–</td>
<td>+</td>
<td>?</td>
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<tr>
<td>Sentence construction</td>
<td>+</td>
<td>–</td>
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<td>+</td>
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<tr>
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<tr>
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<td>–</td>
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<td>–</td>
<td>+</td>
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<tr>
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<td>MLU</td>
<td>+</td>
<td>–</td>
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<td>+</td>
<td>–</td>
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<tr>
<td>Verb inflection index</td>
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<td><strong>Weekly control tests</strong></td>
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<td>+</td>
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<td>yes</td>
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<tr>
<td>Filling in finite verbs</td>
<td>+</td>
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<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>yes</td>
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<tr>
<td>Nonwords</td>
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<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>no</td>
</tr>
</tbody>
</table>

Overview of the tests and spontaneous speech variables used to measure generalisation and the expected outcomes. + = administered, – = not administered. “Prior” = prior to baseline testing; “baseline” = during baseline period (week 1–6); “weekly” = used for weekly evaluation (week 6 – end of treatment); “post” = immediately after treatment ended; 1m. post = 1 month after treatment ended; 3m. post = 3 months after treatment ended.
verbs, the therapist was allowed to facilitate retrieval if the participant could not produce the intended response. The following cues were allowed to be used in the given order: (1) Semantic cueing; (2) Phonemic cueing; (3) Writing down or repetition of the target. At the level of sentence construction the participant was free to make a sentence with the infinitive at the end or a finite verb in second position. When an infinitive construction was used, the participant was encouraged to transform the sentence to a construction with a finite verb. During training of sentence construction cues were given in the following order:

- The therapist asked the participant to name the agent (and theme) and the verb of the sentence, and the participant was then asked again to form a sentence.
- The therapist wrote down the incorrect sentence produced by the participant and asked him/her to correct it orally.
- In cases of verb-finding problems the therapist would provide a sentence in which the infinitive was missing; the participant was asked to complete the sentence with the infinitive and then to form a sentence with a finite verb.
- Using sentence anagram cards (included in ACTION), these were presented to the participant in random order and s/he was asked to put the cards in the correct order and to read the sentence aloud; then the cards were removed and the participant was asked to make a sentence.

During the sentence construction step the participant was also encouraged to use correct sentences during conversations.

Statistical analysis

The data were analysed both at the group level and, if there was a significant change, at the individual level. For group comparisons between two test moments, paired $t$-tests were used. Individual performance on the weekly tests was analysed by Fisher’s exact tests. For individual comparisons on the AAT subtests and the ANELT, the norms of the tests were used. For individual analysis of the spontaneous speech variables, the following procedures were used:

- Mean Length of Utterances (MLU): for each of the utterances of the 300 words samples, the number of words was counted. This resulted in a list of number of words per utterance. These lists (pre-treatment, immediately post-treatment, and 3 months post-treatment) were statistically compared with $t$-tests. For the Verb Inflection Index an increase from below to within the normal range was considered to be measurable improvement; for participants who were below the normal range before and after treatment, Fisher’s exact tests were used. For the diversity of verbs and nouns, no statistical testing can be used. A change from without to within the normal range or an increase of 50% or more was considered to reflect improvement.

RESULTS

In this section the results will be presented in the following order. First, the changes in the tests with untrained infinitives, finite verbs, and nonwords will be given, followed by the results on the tasks of the AAT. Then we will examine whether language use in daily life (ANELT) improved, followed by the results of the spontaneous speech analyses.
Generalisation to untrained verbs and nonwords

To test whether the training of verb production resulted in improvement of untrained verbs in similar constructions during the 3 months of treatment, and whether the improvement was the result of the training with ACTION, we compared the scores before and after treatment on the test for infinitives and finite verbs and on the unrelated nonword test of the PALPA.

The results are given in Table 2, together with the test statistics. They are graphically represented in Figure 2. During baseline testing there was no significant improvement on either test. When the scores at the end of baseline were compared to the scores directly after treatment and 3 months post-treatment, the following pattern emerged: for the whole group, production of untrained infinitives improved significantly. At the individual level only one patient was significantly better after treatment. For the finite verbs there was also a significant improvement for the group, but here five out of eleven patients were significantly better in producing finite verbs; for four patients there was little room for improvement (ceiling effect) because they scored quite high at the end of baseline testing ($\geq 14$). The improvement on both the infinitives and the finite verbs remained stable once treatment stopped: there was no decline in scores at the group or individual levels.

The question is whether this improvement on untrained infinitives and finite verbs was the result of training with ACTION or of a more general recovery. This was checked by using the control task from the PALPA. This test was conducted during the first and last baseline session, and every week thereafter. At the group level there was a significant improvement during training. This improvement was only significant for one individual. After the second week of training she suddenly seemed to understand the task (in her case repetition of nonwords) and her score raised from 2 to 18 and remained at that level. All other patients completed 0 to 7 items more correctly (out of 30) resulting in a significant group result, but none of the patients improved significantly at the individual level.

Half of the participants were first trained on infinitives, half were first trained on finite verbs. Since several participants did not finish the protocol, the group sizes are unequal: four participants were first trained on infinitives, seven first on finite verbs. The order of training did not influence the performance of the participants. Therefore the data of both groups were collapsed and analysed to explore whether improvement on infinitives and finite verbs was related to a specific step in therapy. The results showed that when infinitives were trained, non-trained infinitives improved only marginally ($t = -2.143$, $df = 10$, $p = .059$), but untrained finite verbs did not improve ($t = -1.173$, $df = 10$, $p = .255$). When finite verbs were trained, using untrained finite verbs in sentences improved significantly ($t = -2.909$, $df = 10$, $p = .017$), but this did not generalise to non-trained infinitives ($t = 0$, $df = 10$, $p = 1$). When sentence construction was trained, using untrained finite verbs in sentences improved significantly ($t = -2.959$, $df = 10$, $p = .016$), but using infinitives in sentences only improved marginally ($t = -2.206$, $df = 10$, $p = .054$).

From these results we can conclude that overall training of infinitives did not result in significant improvement on untrained infinitives. Training of finite verb production and sentence construction seemed to be more fruitful: there was significant improvement on untrained finite verbs and there was no decline after 3 months.
<table>
<thead>
<tr>
<th></th>
<th>Baseline 1</th>
<th>Baseline 6</th>
<th>t</th>
<th>p</th>
<th>Post treatment</th>
<th>t</th>
<th>p</th>
<th>Follow up 1</th>
<th>t</th>
<th>p</th>
<th>Follow up 2</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
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<td>10,6</td>
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<td>12,9</td>
<td>-3,148</td>
<td>0,01</td>
<td>13,7</td>
<td>-0,897</td>
<td>0,39</td>
<td>14,1</td>
<td>-0,536</td>
<td>0,60</td>
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<td>6,8</td>
<td>-1,551</td>
<td>0,15</td>
<td>12,5</td>
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<tr>
<td>Nonword tests</td>
<td>10,8</td>
<td>11,2</td>
<td>-0,547</td>
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<td>15,6</td>
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<td>-0,294</td>
<td>0,77</td>
<td>17,2</td>
<td>-1,813</td>
<td>0,10</td>
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</table>

Paired $t$-tests, $df = 10$, for all comparisons. For infinitives and finite verbs maximum = 20, for nonword tests maximum = 30.
Generalisation to the subtests of the AAT

The interesting question is, of course, not whether patients improved on the three tests that were presented weekly, because a retest effect is expected, at least at the group level, even when no feedback is given. First of all, improvement on a related test that was not used weekly should be found in combination with a lack of improvement on an unrelated test. Therefore, subtests of the Aachen Aphasia Test (AAT) were administered before, directly after, and 3 months after treatment. The results are shown in Table 3. The group improved significantly on Confrontation Naming and Sentence Construction. At the individual level, using the norms of the AAT, significant improvement was seen for four patients on the naming task and for eight patients on Sentence Construction. This improvement remained stable after treatment ended. No improvement was found on the unrelated subtest (Language Comprehension), neither at the group nor at the individual level.

<table>
<thead>
<tr>
<th></th>
<th>Maximum</th>
<th>Pre-treatment</th>
<th>Post-treatment</th>
<th>t</th>
<th>p</th>
<th>Follow-up</th>
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<tr>
<td>Confrontation naming</td>
<td>90</td>
<td>64,8</td>
<td>81,1</td>
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<tr>
<td>Sentence construction</td>
<td>30</td>
<td>12,0</td>
<td>19,5</td>
<td>−5,671</td>
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<td>20,2</td>
<td>0,717</td>
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<tr>
<td>Language comprehension</td>
<td>120</td>
<td>85,1</td>
<td>89,6</td>
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<td>Understandability</td>
<td>50</td>
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<td>−6,473</td>
<td>0,000</td>
<td>38,6</td>
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Follow-up score is 3 months post treatment. Paired t-tests, df = 10 for all comparisons.
Generalisation to ANELT and spontaneous speech

The main question of this study was whether systematic training with ACTION following a protocol that mimics the average treatment regime in The Netherlands results in improvement of verbal communication in daily life and in linguistic aspects of spontaneous speech.

To analyse whether the patients’ speech in daily life improved, the ANELT was used (see Table 3). As stated before, the rater did not know the participant, nor which sample s/he was rating. There was a significant improvement for the group: according to the norms of the ANELT, all participants but one improved significantly. The only participant whose change did not reach significance had scored quite high before treatment (47/50) resulting in a ceiling effect: no improvement was possible. Again, the improvement remained stable after 3 months.

Spontaneous speech also improved on relevant factors. At the group level (see Table 4), the Mean Length of Utterances, the Verb Inflection Index, and the Diversity of Verbs increased significantly. The Diversity of Nouns did not change. There was no decline after ending treatment with ACTION.

At the individual level there was a significant increase of the “mean length of utterances” for nine out of eleven patients. The two participants who did not improve had the highest MLU before treatment started; for one of them the MLU was at the lower end of the normal range. On the “verb inflection index”, five participants showed clear improvement: one patient’s verb inflection index was significantly higher after treatment (Fisher’s exact, \( p = .05 \)); for four other participants the verb inflection index was lower than normal before treatment and within the normal range after treatment. Furthermore, four participants had a normal verb inflection index before treatment started and this was still the case after treatment. Two participants who had a low verb inflection index before treatment did not show any improvement.

On the variable Diversity of Verbs three participants were outside the normal range before treatment and within it after treatment; for three other participants the Diversity of Verbs increased more than 50%, but was still not within the range of normal speakers. One participant was already within the normal range before treatment. For four participants the number of different verbs did not show relevant changes.

In Appendix 2 excerpts of the spontaneous speech before and after treatment of two participants are given, one in which the utterance length and verb inflection

---

<table>
<thead>
<tr>
<th>Range of variables</th>
<th>control</th>
<th>Pre-treatment</th>
<th>Post-treatment</th>
<th>t</th>
<th>p</th>
<th>Follow-up</th>
<th>t</th>
<th>p</th>
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<td>4.76</td>
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<td>0.84</td>
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<td>0.59</td>
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<td>14.5</td>
<td>–2.210</td>
<td>0.05</td>
<td>16.8</td>
<td>–0.907</td>
<td>0.39</td>
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<tr>
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<td>22.2</td>
<td>0.401</td>
<td>0.70</td>
<td>21.2</td>
<td>0.434</td>
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</table>

Paired t-tests, \( df = 10 \) for all comparisons. Follow-up is 3 months post treatment.
index improved (#1), and one in which utterance length and the number of different verbs increased (#2).

Bastiaanse and Jonkers (1998) mention that there is quite some variation in agrammatic spontaneous speech in relation to the variables “verb diversity” and “verb inflection”. Their study showed that Dutch agrammatic speakers (1) use a normal number of lexical verbs; (2) have reduced verb diversity; (3) have a reduced proportion of finite verbs. The agrammatic speakers in the present study also (1) produce a number of lexical verbs within the normal range (mean agrammatic speakers = 22.73, mean non-brain-damaged speakers 26.75; \( t = 1.261, df = 17, p = .22 \)); (2) exploit little diversity in their verbs (mean number of different verbs agrammatic speakers = 11.9, mean non-brain-damaged speakers 20.0; \( t = 4.139, df = 17, p = .001 \)); (3) have a reduced proportion of finite verbs, but this difference fails to reach significance (mean verb inflection index agrammatic speakers = 0.75, mean non-brain-damaged speakers 0.91; \( t = 1.579, df = 17, p = .12 \)).

Bastiaanse and Jonkers (1998) also showed that those agrammatic speakers who produced a relatively large proportion of inflected verbs had relatively low verb diversity, and likewise that high verb diversity accompanied fewer inflected verbs. This difference has been reported not only at the group level, but also within an agrammatic individual (Bastiaanse, 1995). These results were interpreted in terms of Kolk’s adaptation theory (see, e.g., Kolk & Heeschen, 1992). Agrammatic speakers have a grammatical processing deficit that prevents them from retrieving a normal variety of verbs and using finite verbs at the same time. The adaptation theory states that the agrammatic speakers may use different registers to deal with this. If an agrammatic speaker focuses on lexical (in this case verb) retrieval, this results in more grammatical deviations, among which is a lower proportion of finite verbs. Other agrammatic speakers, or the same agrammatic speaker on another occasion, may be more focused on producing grammatical sentences, but this will diminish his/her ability to retrieve a normal range of different verbs. So, there appears to be a “trade off” between verb retrieval and verb inflection in agrammatic speech. Since in the present study some participants improved only on one of these variables, it was important to analyse whether higher verb diversity was accompanied by a lower proportion of finite verbs or vice versa, because in that case there is no improvement, only variation of registers. In Figure 3 the results of this analysis are graphically represented.

This figure shows the following. There was one participant (#1) who produced a normal diversity of verbs but no finite verbs before treatment; after treatment, his verb inflection was significantly higher while his number of different verbs was still within the normal range. For one participant (#3) the inflection index was significantly higher after treatment while the number of different verbs before and after treatment was similar. Three participants (#4, #6, #10) had higher verb diversity after treatment while the proportion of inflected verbs remained the same. Three participants improved on both variables (#2, #8, #11). For three patients both variables remained the same (#5, #7, #9). For two of them (#7, #9), language use in daily life did improve, but this was not reflected in spontaneous speech. Their MLUs were the highest of the group, their inflection index was normal, but their number of different verbs was reduced, which did not change after treatment. In one of these participants (#9) the number of different nouns increased more than 50%; for the other participant (#7), the total number of lexical verbs (a variable that was normal for the group before treatment and was therefore not included in
the analysis) increased 40%. For these participants, these variables might reflect the improvement on the ANELT.

**Summary**

Overall, treatment with ACTION resulted in significant improvement on untrained infinitives and finite verbs. The improvement was related to specific training, especially for the finite verbs. Production of untrained finite verbs improved significantly when finite verbs and sentence construction were trained. The improvement on infinitives was more modest, but also occurred after these forms were trained and after sentence construction training.

There was a generalisation to “confrontation naming” and “sentence construction” of the AAT. Language use in daily life improved significantly, which was reflected in spontaneous speech: the “mean length of utterances” and the “proportion of finite verbs” increased and more “different verbs” were used. There was no improvement on “language comprehension” as measured with the AAT, which was used as a control test, nor did the “number of different nouns” produced in spontaneous speech increase. However, the group improved on an unrelated nonword test that was used weekly, but at the individual level, this held for only one patient.

At the individual level, the patterns of improvement differ. An overview is given in Table 5.

Not all participants improved on untrained infinitives and finite verbs, but it appears that building sentences gets better after treatment: the scores on the “sentence construction” task of the AAT increased significantly for most participants.
# TABLE 5

## Individual performance patterns

<table>
<thead>
<tr>
<th>Improvement expected</th>
<th>Unrelated tests</th>
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<tr>
<td></td>
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<tr>
<td>Infinitives</td>
<td></td>
</tr>
<tr>
<td>Finite verbs</td>
<td></td>
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<tr>
<td>Sentences AAT</td>
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<td>MLU</td>
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<td>Verb inflection</td>
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<td>Verb diversity</td>
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<tr>
<td></td>
<td>Nonwords</td>
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<td>Comprehension AAT</td>
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<td></td>
<td>Noun diversity</td>
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<table>
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<th>Finite verbs</th>
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<th>ANELT</th>
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</table>

- = no significant improvement; + = significant improvement.
This is reflected in spontaneous speech: the sentences were longer and more finite verbs were used. Most participants who had used a reduced number of different verbs in spontaneous speech improve on this variable. This improvement, on sentence construction and the use of (finite) verbs, resulted in an improvement of the participants’ language use in daily life.

DISCUSSION

In this section three issues will be addressed: (1) the (lack of) generalisation to untrained infinitives and finite verbs at the individual level; (2) performance on the nonword tests of the PALPA; (3) generalisation to AAT, ANELT, and spontaneous speech.

Generalisation to untrained infinitives and finite verbs

After treatment with ACTION, the production of non-trained infinitives and finite verbs was better than at the end of the baseline period. This effect was treatment specific: the use of finite verbs in sentences only improved during training of these forms and training of sentence construction. Similarly, the improvement of infinitives only occurred when infinitives and sentence construction were trained. This means that there is no crossover effect: when finite verbs were trained, the less complex infinitives did not improve, nor the other way around. The lack of crossover effect has been reported in other studies as well. Thompson, Shapiro, Tait, Jacobs, and Schneider (1996), for example, reported that training-induced improvement of who-questions generalised to untrained what-questions (both derived by argument movement), but did not generalise to when- and where-questions (derived by adjunct movement). More recently, Thompson et al. (2006) showed that training of verb inflection did not result in better production of, for example, complementisers or vice versa. Both finite verbs and complementisers are so-called “functional categories”, but they are in different positions in the sentence. In syntactic terms, finite verbs are in the “inflectional phrase” (IP), whereas complementisers are in the “complementiser phrase” (CP). Apparently, treatment that targets one functional category has no effect on other functional categories. For the present study, infinitives and finite verbs were trained. Infinitives are in the verbal node (V) and the finite verbs are in I. In line with the findings of the Thompson group, there was no generalisation from the lexical category V to the functional category I or the other way around, even though both involve verbs.

Although there was a significant improvement on the use of untrained infinitives, the effect at the individual level was disappointing. Apparently, training infinitives in sentence context does not generalise to untrained items. There might be several reasons for this. One is the poor retrieval of lexical verbs in general. It was decided not to test trained items, so it is impossible to say whether these improved, but it is unlikely that they did not: the same 60 verbs were trained for 12 weeks, three times a week. What the lack of generalisation does suggest is that verbs that are useful for daily life should be trained. In ACTION, this is not a factor that is controlled for. Many verbs are useful for daily life (verbs like washing, cooking, eating, reading), whereas others are not (skiing, swinging, milking, bouncing).
The improvement on untrained finite verbs was more impressive. Five patients improved significantly, for four the score was already quite high at the end of baseline testing, leaving little room for significant improvement. The group data in Table 2 showed that the agrammatic patients were very poor in producing finite verbs compared to their production of infinitives (after baseline 6: 6.8/20 finite verbs and 10.6/20 infinitives correct). When treatment ended, the mean number of correct finite verbs was more or less equal to the number of correct infinitives (12.5/20 finite verbs and 12.9/20 infinitives correctly). Basically, the (untrained) infinitives hardly improved and the (untrained) finite verbs improved up to the level of the infinitives. From this it is concluded that training infinitives with ACTION did not help in learning to use infinitives in general. However, training finite verbs was effective: after treatment, the production of untrained finite verbs was as good as the production of infinitives.

Performance on the nonword tests of the PALPA

Depending on the abilities of the patients, different PALPA tasks were used: either the repetition of nonwords or the reading aloud of nonwords. Overall, there was a significant improvement on this task at the group level, but only one patient improved significantly at the individual level. There are two possible explanations for this effect. First of all, since it was intended to mimic the normal clinical situation, all patients participated in group therapy. It was explicitly stated that no verbs could be trained in these groups to avoid interference with the ACTION therapy. However, during this group therapy, reading and writing (phoneme-to-grapheme conversion and vice versa) and articulation were addressed and this might have affected the performance on the control task.

Another explanation is that the improvement was a retest effect. The gradual improvement in scores supports this idea. In fact, the pattern of improvement on the PALPA tasks was not different from the infinitives task (see Figure 2 above). Hence, it cannot be excluded, and is actually quite likely, that the improvement on the infinitives and on the PALPA tasks was due to a retest effect. Moreover, only the improvement on the finite verbs, up to the level of the infinitives, was caused by treatment with ACTION. This improvement was larger than in the infinitives task and seen in 5/11 individual patients.

The significant effect on the PALPA tasks, which were included to control for retest effects and spontaneous recovery, means that the improvement on the finite verbs might also be related to retest effects or spontaneous recovery. This is not very likely, however. The improvement on untrained finite verbs was related to training of finite verbs and sentence construction and did not show when infinitives are trained, which excludes a retest effect. If the improvement on finite verbs was due to general recovery, then language comprehension should have been improved as well, which was not the case, as will be discussed in the next section.

Generalisation to AAT, ANELT, and spontaneous speech

Three subtests of the AAT were included: “confrontation naming”, for which it was unsure whether an effect should be expected; “sentence construction”, to measure generalisation to untreated materials; and “language comprehension” on which no generalisation was expected. There was no change in performance on the “language
comprehension” subtest, at the group, or individual level. This means that the results on other tasks cannot be explained by spontaneous or more general recovery. There was, however, significant improvement on the production tasks (“confrontation naming” and “sentence construction”) of the AAT. Improvement on subtest “sentence construction” was expected, since sentence construction was trained during the final 4 weeks. The improvement on “confrontation naming” is interesting, since nouns had not been specifically trained. However, all 60 sentences included in ACTION contain two nouns, which might explain the improvement.

A treatment-related effect was also visible in spontaneous speech: verb diversity increased, more finite verbs were produced, and the sentences got longer. This reflects exactly what had been trained: verb retrieval, verb inflection, and sentence construction. There was no improvement on the diversity of nouns, which had not been treated specifically. Although the ability to name objects and colours improved, which might be due to the nouns trained in the programme, the diversity of nouns in spontaneous speech did not increase. This improvement of a related word class on a naming test but not in spontaneous speech has been shown before. In Bastiaanse, Bosje, and Franssen (1996) a therapy study on noun production was conducted. The patient was trained on noun retrieval, and both naming of objects and naming of actions improved significantly. There was generalisation to spontaneous speech for noun diversity, but not for verb diversity.

The most important question of the study was whether training with ACTION would improve verbal communication in daily life. This is a delicate point in all aphasia treatment studies, because improvement in the understandability of aphasic patients is notoriously hard to measure objectively. Fortunately, there is a reliable and standardised test for verbal communication in daily life for Dutch, the ANELT. As stated above, we tried to avoid any halo effect by using different scales (ANELT-A and ANELT-B) to circumvent the retest problem and by having the samples judged by persons who did not know the patients and did not know whether they were rating the pre- or post-treatment session. A significant improvement was found both at the group and at the individual level. It is therefore safe to conclude that the patients’ verbal communication was significantly better after training with ACTION.

Since the generalisation was restricted to trained language skills and since untrained skills did not improve (“language comprehension” of the AAT and “number of different nouns” in spontaneous speech), it is unlikely that the effects were due to an extended period of spontaneous recovery. All patients were at least 3 months post-onset, but it might be that spontaneous recovery lasted a bit longer. However, three patients (Table 5: #1, #4, and #10) were more than 6 months post-onset. Their pattern was very similar to that of the other patients. In spontaneous speech their MLU increased significantly and one patient’s proportion of finite verbs was significantly higher, whereas the other two patients’ verb diversity increased with more than 50%. It is therefore concluded that spontaneous recovery cannot account for the improvement on treatment-related variables.

Conclusions

The study was designed in such a way that treatment-related effects could be distinguished from spontaneous recovery, by selecting patients who were at least 3 months post-onset and by including unrelated control tests. After treatment the patients, as a group, were significantly better in using both untrained finite verbs and untrained
infinitives in sentences. However, the improvement on infinitives was not very large and only one patient improved significantly. Also, the improvement was not different from that found in the unrelated nonword tests. The improvement on untrained finite verbs was more robust and was also related to the period in which finite verbs and sentences were trained. After treatment, the participants’ use of finite verbs was as good as their use of infinitives. It is therefore concluded that training of infinitives did not help to retrieve untrained infinitives, but training finite verbs improved the use of untrained finite verbs. In fact, the effect of ACTION in agrammatic aphasia was grammatical in nature: the use of finite verbs improved and this was reflected in the relevant variables in spontaneous speech.

In the Introduction a model of verb production in sentence context was presented, consisting of four steps: (1) retrieval of the verb lemma; (2) building a sentence frame; (3) inflection for tense and agreement; (4) for Dutch, “moving” the finite verb to the second position of the main clause. These processes have been trained with ACTION. The results were that verb retrieval as such did not improve; that is, there was no generalisation to untrained infinitives and the untrained finite verbs improved up to the level of the infinitives. In this group of agrammatic speakers the improvement was mainly gained at the levels (3) and (4): the use of untrained finite verbs improved and so did sentence construction on the AAT and the verb inflection index and verb diversity in spontaneous speech.

Because the study was meant to fit into the daily routine in the rehabilitation centre, and because it was expected that the participants would improve on trained items, it was decided not to test these weekly (it would have required an extra therapy session, which was not available). Looking back, it might have been better to have included these in order to get better insight into the recovery pattern. For the same reasons, group therapy could have been left out; it would have then been easier to indicate the improvement on the PALPA tasks. However, it was considered to be unethical to deprive the patients of their group therapy, which was also meant to work on acceptance of the changed life due to the aphasia. The group therapy might have interfered with the nonword tests, but in daily clinical practice the patients are getting group therapy, so it fulfilled the requirement of mimicking daily clinical practice.

All in all, we conclude that ACTION is effective for training verb and sentence production; moreover, it improves the verbal communication.

REFERENCES


APPENDIX 1

Demographics of the participants

<table>
<thead>
<tr>
<th>Age</th>
<th>Gender</th>
<th>Handedness</th>
<th>Mpo</th>
<th>Aetiology</th>
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Mpo = months post onset.

APPENDIX 2

Excerpts of spontaneous speech before and after treatment (*italics* = interviewer)

Notice that the excerpts of participant #1 have been translated literally to English; hence the non-finite verb is at the end of the clause, as is grammatical in Dutch. (subscripts verbs: inf = infinitive; fin = finite; part = participle)

Participant #1 before treatment (MLU = 1,5, verb inflection index = 0,00, number of different verbs = 21)

*What do you do during the day?* Newspaper read<sub>inf</sub>, books read<sub>inf</sub> Reading newspapers, how is that? Yes yes good *Are you going out* Yes *How do you manage to do that?* Walkgarden Everyday? Yes *And when are you here?* Wednesday, Thursday and . . . *What do you do during speech therapy?* Verbs train<sub>inf</sub> and sentences sentences. *And during occupa-

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3Before treatment the spontaneous speech of this patient is very limited. Some “longer” utterances have been chosen to illustrate that he is able to use verbs, but cannot inflect them.
What kind of work did you use to do? Draw inf sketch inf Do you have children? Two boys eh girl and boy Are they living nearby? Yes in Roden in Peize Does your daughter have a job? Yes.

Participant #1 after treatment (MLU = 3.6, verb inflection index = 0.31, number of different verbs = 20)

What do you usually do during the day? I havefin yesterday walkinf done on the garden path back and forth And what else? Sleepinf eatinf because five times that I round come part are (=that I came around) What do you do during speech therapy? I havefin words in sentences, three four times a week What else? Two times physical therapy, Tuesday and Thursday And what do you do? Takeinf that and putinf there again and [rideinf a bike] And you will get a scooter? Yes but two weeks, then you wantfin to rideinf but not comes not because it is not there yet And what are you going to do his afternoon? Goinf home as soon as I can and cigaret smokeinf. Okay and then? Sleepinf and car driveinf Son and I quickly to the animals and cows Can you tell me about your son? That I . . . no, I havefin a son and a daughter. Daughter lives in Roden, two, two grandchildren and the daughter, no the son, he lives in Peize. The daughter lives eh works in hospital and the daughter, the son, he works in, yes samples letinf makeinf

Participant #2 before treatment (MLU = 4.2, verb inflection index = 0.89, number of different verbs = 11)

Could you tell me something about your work? Yes that is possible, I work at bank. The job hold is insurance consultant. It is that I go to the clients to information. It is very often with the client, also a lawyer and an accountant. Often the client and the accountants and I to advise. It is that I lovely village. . . Salary is perfect and again, I I think that I in in the insurance How did you get into insurances? Yes again when I when school I I teacher and says that man says that that man gave insurances. I always wished to be to become an agent but at a certain moment yes, that that, on a certain moment, okay this is it, so yes then should yes learn learn learn and now it is ready

Participant #2 after treatment (MLU = 5.1, verb inflection index = 1.00, number of different verbs = 18)

What are you main problems right now? I myself think that I about with talking about a percentage 80 percent. Again, I can just name each material, things, I know it but then at a certain moment a sentence. At a certain moment those words, they are there, but at a certain moment formed into a sentence and then and then it is ready. Okay, on the other hand, if you consider the aphasia forms factors, talking is one, second is writing. Again, I mail with my colleagues and according to me that goes well, of course it is not yet a 100 percent. Reading, I think that I around also 85 percent. Again, I understand all the words and also the context.