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1 Running head: CIAT versus semantic treatment in fluent aphasia

2 **Title: Constraint-Induced Aphasia Therapy versus Intensive Semantic Treatment in**  
3 **fluent aphasia**

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## ABSTRACT

- Objective: To compare the effectiveness of two intensive therapy methods: Constraint-Induced Aphasia Therapy (CIAT) and semantic therapy (BOX).
- Method: Nine patients with chronic fluent aphasia participated in a therapy programme to establish behavioral treatment outcomes. Participants were randomly assigned to one of two groups (CIAT or BOX).
- Results: Intensive therapy significantly improved verbal communication. However, BOX treatment showed a more pronounced improvement on two communication measures, namely on a standardized assessment for verbal communication, the Amsterdam Nijmegen Everyday Language Test (Blomert, Koster, & Kean, 1995) and on a subjective rating scale, the Communicative Effectiveness Index (Lomas et al., 1989). All participants significantly improved on one (or more) subtests of the Aachen Aphasia Test (Graetz et al., 1992), an impairment-focused assessment. There was a treatment-specific effect. Therapy with BOX had a significant effect on language comprehension and on semantics, while of CIAT affected language production and phonology.
- Conclusion: The findings indicate that in patients with fluent aphasia (1) intensive treatment has a significant effect on language and verbal communication, (2) intensive therapy results in selective treatment effects and (3) an intensive semantic treatment shows a more striking mean improvement on verbal communication in comparison to communication-based CIAT-treatment.

## 1 1. INTRODUCTION

2 There has been increasing evidence that short term, intensive aphasia therapy in the chronic  
3 stages of aphasia recovery has a beneficial effect irrespective of the type of treatment.  
4 However, it is not clear what the optimal therapy content, intensity and setting may be to  
5 deliver aphasia therapy across a variety of aphasia profiles in terms of aphasia severity,  
6 aphasia type/linguistic impairment, recovery stage and lesion site (for a review see Robey,  
7 1998; Basso, 2005; Berthier, 2005; Brady, Kelly, Godwin & Enderby 2012). Aphasia  
8 therapies can either be based on a cognitive linguistic approach (Patterson & Shewell, 1987)  
9 or a communicative approach (Davis & Wilcox, 1985; Holland, 1991).

10

11 The cognitive linguistic approach is based on the theoretical framework of cognitive  
12 neuropsychology (Ellis & Young, 1996). In this approach aphasia therapies focus on the  
13 language deficit itself in order to restore the linguistic processes involving semantics,  
14 phonology, morphology and syntax. The improvement of linguistic skills will also improve  
15 patients' verbal communication ability (Visch-Brink, Bajema & Van de Sandt-Koenderman,  
16 1997; Doesborgh et al., 2004; Whitworth, Webster & Howard, 2005). An example of a  
17 cognitive linguistic therapy is the Dutch drill-based lexical-semantic therapy programme  
18 BOX (Visch-Brink & Bajema, 2001).

19

20 While the cognitive linguistic approach focuses on the language deficit, the emphasis of the  
21 communicative approach is on the communicative aspects of language. Important issues in  
22 this perspective are the compensation strategies in communicative settings and the application  
23 of residual skills in communication (Holland, 1991; Croteau & Le Dorze, 2006; Simmons-  
24 Mackie, Kearns & Potechin, 2005). A typical communicative based approach is 'Promoting  
25 Aphasic Communicative Effectiveness' (PACE: Davis & Wilcox, 1985): patients are

1 permitted to communicate in any and all modalities (e.g. gesturing, pointing, writing)  
2 throughout the therapy session.

3  
4 A communicative therapy which is currently gaining ground is ‘Constraint-Induced Aphasia  
5 Therapy’ (CIAT). The main difference between PACE and CIAT is the availability of  
6 alternative methods to support communication. CIAT is based on work which explores the  
7 use of constraint-induced movement therapy in the rehabilitation after stroke (Taub, Uswatte  
8 & Pidikiti, 1999). These studies have shown that motor behavior of an impaired limb can be  
9 modified by a short period of intensive constraint practice (Meinzer, Rodriguez, Gonzalez &  
10 Rothi, 2012; for a review see Taub et al., 1999; Taub, Uswatte & Elbert, 2002).

11  
12 Constraint-Induced Aphasia Therapy was introduced in 2001 in a randomized clinical trial  
13 with 17 chronic aphasia patients (Pulvermüller et al., 2001). CIAT is also known as CIAT  
14 plus (Meinzer, Djundja, Barthel, Elbert & Rockstroh, 2005), Constraint-Induced Language  
15 Therapy (CILT; Maher et al., 2006) or Intensive Language Action Therapy (ILAT;  
16 Pulvermüller & Berthier, 2008). This programme consists of four major components: (1)  
17 massed practice (30 to 35 hours of speech therapy in two weeks), (2) shaping of responses  
18 (gradually increasing task and stimulus complexity), (3) constraint of compensatory (non-  
19 verbal) communication strategies and (4) socially driven communication tasks (therapy tasks  
20 involving interaction-based games) (DiFrancesco, Pulvermüller & Mohr, 2012).

21  
22 Although CIAT is appropriately defined as a communication-based approach, some elements  
23 of cognitive linguistic treatment might be incorporated in relation to the shaping of the  
24 patient’s responses. But the main aspect of CIAT is the communicative load, since it involves  
25 the exchange of new information between participants in dialogues (Hengst, Duff & Dettmer,

1 2010). CIAT does not only improve verbal communication, but also leads to a clinical  
2 improvement of language functions as it might entail the re-learning of word-concept links  
3 and the re-wiring of neuronal connections in language networks (Difrancesco et al., 2012).

4  
5 The introduction of constraint-induced (CI) principles in aphasia rehabilitation has also  
6 created a renewed interest in issues like therapy intensity and massed practice (Bhogal,  
7 Teasell & Speechley, 2003; Basso, 2005; Hinckley & Carr, 2005; Raymer et al., 2008). The  
8 beneficial effect of an intensive treatment in the chronic stage of aphasia is consistent with  
9 recent work in neuroscience which supports several principles of experience-dependent neural  
10 plasticity in the rehabilitation after brain injury, including sufficient treatment intensity and  
11 the forced use of cognitive capacities (Raymer et al., 2008; Kleim & Jones, 2008; Barthel,  
12 Meinzer, Djundja & Rockstroh, 2008). Robey (1998) carried out a meta-analysis of the effect  
13 of treatment intensity and concluded that there is a clear relationship between therapy  
14 intensity and the degree of improvement. Raymer et al. (2008) emphasized the need for  
15 systematic research into the optimal aphasia therapy. Standard therapy or different forms of  
16 communicative therapy also seem to benefit from more intense application (Maher et al.,  
17 2006; Barthel et al., 2008). Thus, the effectiveness of a short-term intensive treatment over a  
18 restricted period has been demonstrated in chronic aphasia patients regardless of the type of  
19 treatment (for a review see, Cherney, Patterson, Raymer, Frymark and Schooling, 2008).

20  
21 There have been a large number of studies which focus on the treatment of patients with  
22 nonfluent aphasia (e.g. Fridriksson et al., 2012; Links, Hurkmans & Bastiaanse, 2010; Conley  
23 & Coelho, 2003). However, studies on patients with fluent aphasia are rare. There is no  
24 proven method for the rehabilitation of fluent aphasia (Altschuler, Multari, Hirstein &  
25 Ramachandran, 2006). One of the reasons might be the frequently observed anosognosia in

1 patients with Wernicke aphasia, a problematic factor in relation to a systematic linguistic  
2 treatment. Another factor might be the great variation in the underlying linguistic disorders.  
3 Robson, Sage and Lambon Ralph (2012) propose three hypotheses to account for the  
4 comprehension impairment in fluent aphasia: (1) disruption of acoustic and/or phonological  
5 analysis (e.g. Moses, Nickels & Sheard, 2004); (2) semantic impairment (e.g. Butterworth,  
6 1992); or (3) a combined phonological-semantic impairment, i.e. the dual hypothesis (e.g.  
7 Hillis, Boatman, Hart & Gordon, 1999). Treatment of subjects with fluent aphasia can  
8 therefore focus on semantics, phonology or even syntax (e.g. Boyle, 2004; Edwards &  
9 Tucker, 2006; Sampson & Faroqi-Shah, 2011). The disproportionate representation of  
10 nonfluent aphasia is also characteristic for CIAT studies. In an evidence-based review of the  
11 treatment intensity effects in constraint-induced language therapy, Cherney et al. (2008)  
12 indicated that most of the participants in CIAT studies were nonfluent (60%, 42 of 70) and  
13 therefore it is questionable whether the results can be generalized to patients with fluent  
14 aphasia. Evidence from a cognitive linguistic approach has shown that specific treatment of a  
15 disturbed language level can have a significant impact on verbal communication, i.e. the  
16 ability to bring the message across in speech (Doesborgh et al., 2004). From CIAT literature  
17 evidence has shown that intensive treatment in a chronic aphasia population can augment  
18 conversational skills (Cherney et al., 2008). Therefore we want to explore the relevance of  
19 both approaches in fluent aphasia: CIAT and cognitive linguistic treatment.

20  
21 The objective of this study is to investigate the effectiveness of two intensive therapy  
22 programmes in patients with chronic fluent aphasia after stroke: (1) a cognitive linguistic  
23 therapy, i.e. an individualized drill-based lexical-semantic treatment using the Dutch therapy  
24 programme BOX (Visch-Brink & Bajema, 2001) and (2) CIAT, i.e. a more communication-  
25 based group treatment focusing on verbal communication using constraints (Pulvermüller et

1 al., 2001). It is predicted that a pure semantic treatment with BOX will have a selective  
2 favorable influence on verbal semantic performance and that verbal communication skills will  
3 be enhanced at activity level (Doesborgh et al., 2004), because of an improved verbal  
4 semantic processing in everyday language. It is further predicted that a treatment with CIAT  
5 will not only have a positive effect on patients' verbal communication skills, but will also  
6 create significant improvement at different linguistic levels (i.e. semantics and phonology).  
7 Since CIAT in its nature is an oral communication based treatment focusing on language  
8 production as well as language comprehension, it is reasonable to predict that it would have a  
9 positive effect on multiple levels of verbal communication. Consequently it is expected that  
10 verbal communication, measured by a standardized assessment as well as by a subjective  
11 rating scale, will improve after both treatment methods.

12

13

## 14 **2. METHOD and PROCEDURE**

### 15 **2.1 Participants**

16 The present study is an exploratory study in which participants with fluent aphasia were  
17 randomly assigned to CIAT (Pulvermüller et al., 2001) or BOX (Visch-Brink & Bajema,  
18 2001) (for more details see Appendix).

19 The participants in this study were 9 native speakers of Belgian Dutch (Verhoeven, 2005)  
20 with a mean age of 66.8 years ( $SD \pm 9.2$  years, range 54 to 81 years) and chronic vascular  
21 fluent aphasia (mean duration 56.9 months,  $SD \pm 37.7$  months, range 17 to 138 months).

22 Participants were recruited on the basis of the following inclusion criteria: (1) adult age; (2)  
23 single and first ever stroke in the left hemisphere confirmed by structural brain imaging; (3)  
24 moderately impaired language function and; (4) fluent aphasia with a combined semantic and  
25 phonological deficit. The impairment of language functions was determined on the basis of

1 the Stanine-norms on the Token Test (TT) of the Dutch version of the Aachen Aphasia Test  
2 (AAT: Graetz, de Bleser & Willmes, 1992). The criterion for a semantic deficit was a score  
3 below two standard deviations (SD) on at least one of the following semantic tasks: (1) AAT-  
4 Comprehension (AAT: Graetz et al., 1992); (2) Verbal Semantic Association Test (SAT:  
5 Visch-Brink, Stronks & Denes, 2005); (3) Psycholinguistic Assessment of Language  
6 Processing in Aphasia subtest Synonym Judgment (PALPA: Kay, Coltheart & Lesser, 1992;  
7 Dutch version: Bastiaanse, Bosje & Visch-Brink, 1995); or (4) PALPA Semantic Word  
8 Association of low imageability words. The criterion for a phonological deficit was a score  
9 below two standard deviations (SD) on at least one of the following language tests: (1) AAT-  
10 Repetition; (2) PALPA Non-word Repetition; or (3) PALPA Auditory Lexical Decision.  
11 Explicitly excluded from this study were patients participating in any other treatment  
12 programme, patients with an additional neurological or psychiatric disorder and patients with  
13 severe perceptual, additional speech (e.g. verbal apraxia) or cognitive deficits evidenced by  
14 formal neuropsychological testing.  
15 The demographic and neurological characteristics of the participants are summarized in Table  
16 I.

17  
18 *Insert Table I here please*  
19

20 Six participants were diagnosed with Wernicke's aphasia. The aphasia profile of the other  
21 three was consistent with a diagnosis of transcortical sensory aphasia. In seven patients,  
22 aphasia resulted from a left hemisphere ischemic stroke while two patients had a hemorrhage  
23 (see Table I). In addition to the aphasiogenic lesion in the left temporo-parietal region, CT  
24 scan of the brain in patient B4 revealed a small cystic lesion in the right parietal lobe with  
25 slight attraction of the lateral ventricle. Aphasia symptoms in this patient, however, had

1 emerged simultaneously with the left temporo-parietal infarction only. Careful examination of  
2 the patient's medical history revealed that structural damage in the right parietal region had  
3 not resulted in clinically relevant symptoms and the aphasiogenic nature of this old lesion was  
4 formally ruled out. Although Meinzer et al. (2005) found no relationship between aphasia  
5 severity and the benefit of CIAT treatment, only patients with a moderately impaired  
6 language function were included because (1) CIAT requires similar levels of severity in the  
7 treatment groups and (2) in view of the small number of participants, a homogeneous aphasia  
8 sample was recruited.

9

## 10 **2.2 Treatment programmes**

11 CIAT-treatment is a communication-based group interaction by means of communicative card  
12 games. The picture cards contain objects of high as well as low frequent words, black-and-  
13 white line drawings as well as colored pictures, pictures of objects as well as action cards and  
14 pictures with minimal pairs (such as 'sock' and 'rock') (see below 'Participants treatment'  
15 and Appendix for more details). The intervention procedure was based on Maher et al. (2006),  
16 Meinzer et al. (2005, 2007) and Pulvermüller et al. (2001). In this study, patients were  
17 allowed to produce gestures in order to facilitate verbal output, but their gestures were hidden  
18 from the other participants by a 40-cm high screen between the patient and the other  
19 participants. As a result, gestures could not act as a primary means of communication and  
20 participants were encouraged to use their verbal communicative abilities, i.e. verbal  
21 expressions and phrases (for more details, see Appendix).

22 The semantic therapy is a drill-based lexical-semantic treatment using BOX, which is a Dutch  
23 therapy programme (Visch-Brink & Bajema, 2001). This programme focuses on the  
24 interpretation of written words, sentences and texts (also with an auditory presentation by the  
25 speech and language therapist if required). BOX contains a variety of semantic decision tasks

1 aimed at enhancing semantic processing. There are eight different types of exercises within  
2 each task and the patient is required to deny or confirm the semantic relationship between  
3 (written and auditorily presented) content words, either presented separately or within the  
4 context of a sentence or text (for more details, see Appendix). Word choice, number of  
5 distractors, semantic relatedness and ambiguity were taken into account in creating different  
6 levels of difficulty (Visch-Brink et al., 1997).

7  
8 Participants were randomly assigned to one of the above treatments. One group (three women  
9 and two men) received communication-based treatment (CIAT), while the other group (four  
10 men) received semantic treatment (BOX). The groups did not differ significantly in age  
11 ( $t(7)=-1.4$ ,  $p=0.214$ ), aphasia duration ( $t(7)=0.4$ ,  $p=0.728$ ) or education level ( $t(7)=-0.7$ ,  
12  $p=0.621$ ). The group allocation was computer generated and remained concealed in  
13 sequentially numbered opaque, sealed envelopes until randomization.

14

## 15 **2.3 Intervention**

### 16 **2.3.1 Therapist training**

17 Intervention was administered by seven trained speech and language therapy students (third  
18 year professional bachelor level). During the first two days of the training the students  
19 remained under the supervision of six experienced and professionally trained speech and  
20 language therapists. Students were trained according to the training protocol of laypeople  
21 designed by Meinzer et al. (2007). The speech and language therapists had been given  
22 detailed instructions by means of a two-hour presentation in which the study was presented.  
23 The basic principles of BOX and CIAT were introduced and the materials, procedures and  
24 approaches of both types of intervention were carefully explained. In addition, students were  
25 given a one-hour practical training session. Instruction sessions contained illustrative video

1 materials. The students and therapists were given a detailed manual with explicit guidelines  
2 about CIAT and BOX. The students and therapists kept a detailed daily record of each  
3 intervention, specifying the presence of participants and therapists, the duration of the training  
4 in minutes and the training materials used. These records were used for a daily evaluation and  
5 critical assessment of each session in order to adjust individual or group task difficulty for the  
6 next session.

7

### 8 **2.3.2 Participant treatment**

9 All patients received treatment during two- to three-hour sessions per day on nine or ten  
10 consecutive working days (total mean duration 1175 minutes, SD  $\pm$  64 minutes, pauses not  
11 included). There was no significant difference in the amount of treatment between the CIAT  
12 group (total mean duration 1195 minutes, SD  $\pm$  59 minutes) and the BOX group (total mean  
13 duration 1150 minutes, SD  $\pm$  69 minutes) in terms of the mean duration of intervention in  
14 minutes ( $t(7)=1.1$ ,  $p=0.328$ ). Each session was interrupted by two breaks of 10 to 15 minutes.  
15 For the CIAT treatment the dual card game was used, which has been used in prior studies  
16 (e.g. Maher, 2006). In this game participants are dealt cards from a set of 32 to 42 colored  
17 cards (=16 to 21 pairs of identical cards) per 45 minutes treatment. They take turns either  
18 requesting an identical card from the other participant ( $n=4$  to 6 cards per participant) or  
19 responding to that request (Faroqi-Shah & Virion, 2009; Breier et al., 2009). Constraints were  
20 along three dimensions: (1) difficulty of the material, (2) the rules of the game, as indicated  
21 by verbal instruction and shaping and (3) reinforcement contingencies (Pulvermüller et al.,  
22 2001) (Table II).

23

*Insert Table II here please*

24

1 The patients in the BOX-group worked alternating (1) by themselves on worksheets and (2)  
2 with the therapist according to a therapy schedule (Table II) which allowed one therapist to  
3 supervise two patients. For example, on the first day, patient number one started with 30  
4 minutes of therapy (therapy schedule BOX 1) whereas patient number two began with a 30-  
5 minute individual working session (therapy schedule BOX 2). The next day participants  
6 swapped therapy-schedule. Patients were able to adjust their personal level of difficulty. In  
7 order to apply the shaping principle (see Appendix for more details), therapists monitored  
8 performance and solicited patient feedback to ensure that patients were challenged but not  
9 overly frustrated.

10

11 Five intervention groups (two CIAT and three BOX sessions) were formed. Intervention  
12 sessions were held at four different hospitals of Ziekenhuis Netwerk Antwerp, i.e.  
13 ‘Middelheim’, ‘Jan Palfijn’, ‘Sint-Erasmus’ and CEPOS Duffel: C1, C2 and C3 were treated  
14 at ‘Middelheim’ by two students; C4 and C5 together with another patient with a very mild  
15 aphasia were treated at CEPOS by two other students (the last patient was excluded because  
16 he scored within normal range on the TT at pretest). The CIAT-groups had the same group  
17 members and the same SLT-students throughout the intervention, The BOX participants were  
18 individually treated by another three students at ‘Middelheim’ (B1 and B2), ‘Jan Palfijn’ (B3)  
19 and ‘Sint-Erasmus’ (B4). The student therapists were supervised by one of the authors, a  
20 licensed clinician. Informed consent was obtained from each participant or from a close  
21 relative. The study was approved by the local Ethics Committee of Ziekenhuis Netwerk  
22 Antwerp.

23

## 24 **2.4 Measures**

25

*Insert Tables III here please*

1 Before entering the study all participants were administered the Raven Colored Progressive  
2 Matrices (Raven, 1976) on which they had to obtain a score above the 75th percentile.  
3 Handedness was formally assessed by means of a standard handedness inventory (Oldfield,  
4 1971) (Table III). All participants were formally tested at two different time points during the  
5 study: before the treatment (pre-test) and one week after treatment to check which therapy  
6 condition was the most effective (post-test). The language assessment protocol consisted of:  
7 (1) AAT (Graetz et al., 1992); (2) Boston Naming Test [BNT] (Kaplan et al., 1983; Mariën,  
8 Mampaey, Vervaeke, Saerens & De Deyn, 1998); (3) PALPA (Kay et al., 1992; Dutch version:  
9 Bastiaanse et al., 1995); (4) Semantic Association Test [SAT] (Visch-Brink et al., 2005); (5)  
10 Amsterdam Nijmegen Everyday Language Test [ANELT] (Blomert, Koster & Kean, 1995);  
11 and (6) Communicative Effectiveness Index [CETI] (Lomas et al., 1989) (Table III). Pre- and  
12 post-test assessment consisted of an extensive impairment-focused assessment (1-4) together  
13 with discourse outcome measures (5-6) because the ultimate aim of aphasia treatment is an  
14 improvement of communication rather than a reduction of language impairment (Carragher,  
15 Conroy, Sage & Wilkinson, 2012).

16 The AAT (Graetz et al., 1992) is a standardized comprehensive language battery which  
17 consists of five blocks, i.e. the Token Test, Repetition tasks, Written Language tasks, Naming  
18 tasks and Comprehension tasks. The test has a high test-retest reliability (two-day interval:  
19 retest reliability > .91 for all subtests in chronic aphasia patients (Graetz et al., 1992, p.96)).

20 The AAT was used to obtain a formal description of the individuals' language skills. The  
21 BNT (Kaplan et al, 1983; Mariën et al., 1998) is a naming test consisting of 60 line drawings  
22 representing objects, animals, food and plants. The test was included in the study since  
23 naming is a sensitive outcome measure for linguistic improvement in aphasia (Strauss,  
24 Sherman & Spreen, 2006). Subtests of the PALPA (Bastiaanse et al., 1995) and the SAT  
25 (Visch-Brink et al., 2005) were added to obtain a more detailed picture of participants'

1 phonological and semantic abilities. Four PALPA subtests were included, i.e. Synonym  
2 Judgment, Semantic Word Association of low imageability words, Non-word Repetition and  
3 Auditory Lexical Decision. Two subtests of the SAT were included, i.e. the Visual and Verbal  
4 SAT. The ANELT (Blomert et al., 1995) was administered to identify and rate the severity of  
5 the verbal communicative deficit. In addition, the quality of verbal communication in  
6 everyday life was measured by means of a Dutch translation of the CETI (Lomas et al., 1989),  
7 which is a 16-item visual analog scale scored by patients with aphasia and their relatives.  
8 After the treatment all patients were given a written non-standardized questionnaire regarding  
9 their satisfaction. They had to answer six questions on a seven-point Likert rating scale. The  
10 questions were about (1) the satisfaction of participation, (2) whether or not they would  
11 participate a second time, (3) the feasibility and the pleasantness of intensive treatment and  
12 (4) the preference of an intensive treatment above a nonintensive treatment. The ANELT and  
13 the CETI both measure verbal communication. They differ in that the ANELT is a  
14 standardized test for verbal communication, consisting of ten verbal scenarios to be answered  
15 by the aphasic patient. The verbal responses are rated for informational content on a 0-5 rating  
16 scale. Since in severe aphasia there might be a difference between the judgments of verbal  
17 communicative ability between experts and relatives (De Jong-Hagelstein, Kros, Lingsma,  
18 Dippel, Koudstaal, Visch-Brink, 2012) we also administered the CETI. The CETI is a  
19 subjective rating scale filled in by the patient as well as by their relatives.  
20 Patient scores on the language tests are summarized in tables IV, V and VII.

21

## 22 **2.5 Statistical analysis**

23 Because of the small sample size, a non-parametric statistical analysis (i.e. Mann-Whitney  
24 test or Wilcoxon test) was carried out in addition to the parametric statistical analysis of the  
25 linguistic data. Only the parametric analysis is reported here because there was no difference

1 with the non-parametric tests. Differences in mean scores between groups on the ANELT and  
2 CETI were compared by means of independent-samples two-tailed t-tests. The improvement  
3 on the ANELT, the CETI, and AAT (T-transformed raw scores on 5 subtests), was measured  
4 by means of a paired-samples two-tailed t-test. The effect size (Cohen's d) was derived from  
5 within-group comparisons of the pre- and post-difference mean score from each treatment  
6 (Cohen, 1988). Critical changes in raw scores are discussed on an individual basis for all  
7 measurement outcomes. The AAT and BNT scores and the results on the subtests of the SAT  
8 and the PALPA are reported individually and evaluated based on the change before and after  
9 treatment.

10

### 11 3. RESULTS

12 Verbal communication in everyday life as measured by the ANELT (Blomert et al., 1995)  
13 showed a critical change in raw scores for 6 out of 9 (C2, C4, C5, B1, B2 and B3) participants  
14 (see shaded areas in Table IV). There was a significant improvement for both groups  
15 combined (mean improvement=11.8;  $t(8)=6.00$ ,  $p<.001$ ); improvement was smaller in the  
16 CIAT group (mean improvement=6.2;  $t(4)=3.62$ ,  $p=0.022$ ,  $d=1.62$ ) than in the BOX group  
17 (mean improvement=8.2;  $t(3)=4.99$ ,  $p=0.015$ ,  $d=2.50$ ). This difference was not statistically  
18 significant ( $t(7)=-0.85$ ,  $p=0.426$ ). However, it is important to notice that the significant  
19 difference in the prescores ( $t(7)=3.40$ ,  $p=0.011$ ), where patients of the BOX group started  
20 with a significantly lower score on the ANELT than the patients of the CIAT group, could  
21 have influenced improvement.

22

23

*Insert Table IV here please*

24

1 Verbal communication in everyday life was also measured by means of the CETI (Lomas et  
2 al., 1989) showed a critical change in raw score for 4 out of 9 (C4, B1, B2 and B3)  
3 participants (see Table IV). The relatives of the participants indicated that the effectiveness of  
4 the patients' communication had significantly improved after treatment (mean  
5 improvement=11.8,  $t(7)=3.02$ ,  $p=0.019$ ) for both treatment groups combined. No statistically  
6 significant difference in improvement after treatment was found between CIAT and BOX  
7 therapy ( $t(6)=1.01$ ,  $p=0.332$ ). When comparing pre- and postscores for both groups  
8 separately, however, no statistically significant difference was found in the CIAT group ( $n=5$ )  
9 ( $t(4)=1.47$ ,  $p=0.216$ ,  $d=0.66$ ), while in the BOX group ( $n=3$ ) the improvement was significant  
10 ( $t(2)=7.40$ ,  $p=0.019$ ,  $d=4.27$ ). In addition, the pre- and postscores of the BOX group were  
11 higher than the pre- and postscores of the CIAT group on the CETI. Although the difference  
12 between the prescores of both groups did not reach statistical significance ( $t(6)=1.69$ ,  
13  $p=0.142$ ), the difference between the postscores did ( $t(6)=-2.93$ ,  $p=0.026$ ).

14

15 *Insert Table V and VI here please*

16

17 Regarding the impairment-focused assessments, all participants ( $n=9$ ) achieved a critical  
18 change in raw score as defined by the AAT (Graetz et al., 1992) on at least one of the AAT  
19 subtests or subscales (see shaded areas in Table V). Both groups improved on four AAT  
20 language subtests, i.e. comprehension, repetition, naming and written language. Only the  
21 amount of progress differed: although none of the BOX patients showed a critical  
22 improvement in raw score, the improvement in the BOX group was significant ( $t(3)=5.19$ ,  
23  $p=0.014$ ,  $d=2.59$ ) on the comprehension task, but the progress of language production was  
24 not, i.e. repetition ( $t(3)=0.85$ ,  $p=0.457$ ), naming ( $t(3)=1.48$ ,  $p=0.235$ ) and written language  
25 ( $t(3)=1.46$ ,  $p=0.239$ ) (Table VI). For the CIAT group the opposite was observed: the

1 improvement on the comprehension task did not reach significance ( $t(4)=1.43$ ,  $p=0.226$ ), but  
2 these participants scored well on language production, i.e. repetition ( $t(4)=3.00$ ,  $p=0.04$ ,  
3  $d=1.34$ ), naming ( $t(4)=5.10$ ,  $p=0.007$ ,  $d=2.28$ ) and written language ( $t(4)=4.24$ ,  $p=0.013$ ,  
4  $d=1.90$ ) (Table VI). Only one CIAT participant (C5) showed a critical loss of score on the  
5 “Repetition Compounds” task (Table V). The CIAT group did very well on the Token Test  
6 (TT) ( $t(4)=8.95$ ,  $p=0.001$ ,  $d=4.00$ ) and the Boston Naming Test (BNT) (Mariën et al., 1998)  
7 ( $t(4)=6.12$ ,  $p=0.004$ ,  $d=2.74$ ). The improvement of the BOX group did not reach significance  
8 on either test (TT:  $t(3)=2.93$ ,  $p=0.061$ , BNT:  $t(3)=2.42$ ,  $p=0.094$ ). This, however, could be  
9 due to the small sample size ( $n=4$ ). Small sample sizes require a very large effect size in order  
10 to reach significance. In the CIAT group this effect size was large enough to overcome the  
11 small sample size ( $n=5$ ), in the BOX group, however, this was not the case. No differences  
12 were found between the two groups in the prescores on the TT and BNT (TT:  $t(7)=0.90$ ,  
13  $p=0.399$ ; BNT:  $t(7)=0.11$ ,  $p=0.919$ ).

14

15

*Insert Table VII here please*

16

17 In order to evaluate the effectiveness of BOX and CIAT in patients with fluent aphasia,  
18 semantic and phonological measures were analyzed in more detail by means of various  
19 subtests of SAT and PALPA. Table VII summarizes mean progress on these measures after  
20 the two treatments. After BOX treatment, all four participants demonstrated critical gains on  
21 the subtests Semantic Word Association low imageability and three (B1, B2, B4) out of four  
22 on the subtest Auditory Synonym Judgment of the PALPA. However none of the four patients  
23 showed significant improvements on the SAT verbal. By contrast, only two (C3, C4; out of  
24 five) CIAT participants showed a change of two SDs on semantic measures (C3 on SAT  
25 verbal and C4 on PALPA semantic word association).

1 Considering the phonological measures, two (C2, C4) out of five CIAT participants  
2 demonstrated critical changes on both phonological tests (Table VII), i.e. on Auditory Lexical  
3 Decision and on Nonword Repetition. Two (B3, B4) out of four BOX participants showed  
4 critical gains on the Auditory Lexical Decision task (Table VII).

5  
6 All participants expressed their satisfaction with the therapy and indicated that they would  
7 like to participate a second time. Patients unanimously agreed that intensive treatment is  
8 tolerable. All participants preferred a short period of intensive treatment over a prolonged  
9 treatment period. The BOX participants strongly agreed that their communication skills had  
10 improved after treatment, whereas agreement among CIAT participants was smaller.

11

#### 12 **4. DISCUSSION**

13 Although only preliminary conclusions can be drawn from the relatively small sample size,  
14 this study demonstrates that chronic patients with a diagnosis of a moderate fluent aphasia  
15 after a left vascular lesion may significantly benefit from an intensive CIAT or BOX  
16 treatment in the chronic stage of recovery. Nine participants with a diagnosis of Wernicke  
17 aphasia or transcortical sensory aphasia with an underlying semantic and phonological deficit  
18 received intensive semantic treatment (BOX) or constraint-induced communicative treatment  
19 (CIAT). The two types of intervention differed in the theoretical perspective of the therapy  
20 (i.e. impairment-focused versus focus on CI-principles), the content (i.e. focus on semantics  
21 versus focus on verbal communication) and the nature of the interaction (i.e. one-to-one or  
22 group therapy). The therapy regime (duration, frequency and intensity) was identical in both  
23 groups and both groups received an intensive treatment of 30 hours over nine to ten  
24 weekdays. Meinzer et al. (2005), Maher et al. (2006), Barthel et al. (2008) and Berthier and  
25 Pulvermüller (2011) have demonstrated that treatment intensity has a positive effect on the

1 language and communication skills in a heterogeneous group of patients with chronic vascular  
2 aphasia. The findings of the present study are in line with these results and support the general  
3 behavioural effectiveness of a short-term intensive treatment approach in the chronic stage of  
4 aphasia.

5  
6 In a homogeneous group, i.e. a chronic moderate fluent aphasia population, verbal  
7 communication (ANELT) showed a significant improvement for both groups, but  
8 improvement was smaller in the CIAT group than in the BOX group; nevertheless, the CIAT  
9 group scored better on language production (AAT-Repetition, AAT-Naming and BNT) than  
10 the BOX group. The more limited improvement on verbal communication (ANELT and  
11 CETI) might be in contradiction with the findings of Kirmiss and Lind (2011) who found  
12 more improvement in everyday communication after CIAT because turn taking and  
13 interactional behaviors are trained more intensively compared to purely carrying out written  
14 instructions after semantic treatment. It is important to notice that two factors could have  
15 influenced the improvement: (1) the significant difference in the prescores on the ANELT  
16 (e.g. scores of BOX group < scores of CIAT group); and (2) the way verbal effectiveness is  
17 measured. First, the smaller potential for improvement in the CIAT group possibly results in a  
18 lesser mean improvement, making a comparison between the two groups difficult. Second,  
19 the ANELT is a qualitative measure, looking at the verbal response as a whole, whereas a  
20 linguistic analysis, a quantitative detailed description of parameters such as the type token  
21 ratio and mean length of utterance of the ANELT responses might have been more sensitive  
22 to detect changes in verbal effectiveness over time (Doesborgh et al., 2004; Grande et al.,  
23 2008; Ruiter, Kolk, Rietveld, Dijkstra & Lotgering, 2011). With the CETI, however, no  
24 statistically significant improvement was found for the CIAT group. In contrast, the BOX  
25 group did improve significantly on the CETI even though the prescores of the BOX group on

1 the CETI were higher than those of the CIAT group, resulting in significant higher postscores  
2 in the BOX group than in the CIAT group.

3  
4 Regarding the impairment-focused assessments, all participants (n=9) improved on at least  
5 one of the AAT subtests or subscales, i.e. comprehension, repetition, naming and written  
6 language (AAT). Only the amount of progress differed: the improvement in the BOX group  
7 was significant on the comprehension task, but the change in language production was not.  
8 For the CIAT group the opposite was true: no significant improvement on comprehension,  
9 while a significant improvement on language production was noted. A significant  
10 improvement was noted for the CIAT group, both on the TT (an aphasia severity scale) as on  
11 the BNT (a confrontation naming test), but not for the BOX group. This, however, could be  
12 due to the small sample size. Small sample sizes require a very large effect size in order to  
13 reach significance. More in-depth linguistic analysis (PALPA and SAT) showed that intensive  
14 task-oriented cognitive linguistic treatment of a specifically impaired linguistic level (BOX,  
15 i.e. a purely semantic treatment) in a chronic fluent aphasia population led to a significant  
16 improvement on two semantic measures (Semantic Word Association low imageability and  
17 Auditory Synonym Judgment) for almost all BOX participants (B1, B2 and B4, see Table  
18 VII). By contrast, only two (out of five) CIAT participants critically improved on semantics  
19 (C3 and C4). For phonology, two out of five CIAT (C2 and C4) participants showed  
20 significant improvement on both phonological tests, whereas in the BOX group improvement  
21 was seen on only one phonological subtest (Auditory Lexical Decision) in two out of four  
22 participants (B3 and B4). These linguistic results are in line with the results of Barthel et al.  
23 (2008), who emphasized that treatment effects were best achieved by specific and intensive  
24 treatment. The results are also in agreement with the findings of previous cognitive linguistic  
25 studies (Visch-Brink et al., 1997; Doesborgh et al., 2004) which reported a significant

1 influence on semantics but not on phonology after pure semantic treatment. The results also  
2 meet neurobiological principles of use-dependent learning whereas intensity as well as  
3 specificity of treatment affects improvement (Maher et al., 2006). Intensity has been reported  
4 in the literature to be an important factor in the outcomes of aphasia rehabilitation (e.g.  
5 Bhogal et al., 2003). However, intensity alone cannot explain the positive differences between  
6 the two groups' performance, because intensity was controlled. These results demonstrate that  
7 intensity of treatment as well as specificity of treatment could influence therapy outcome. In  
8 the BOX group lexical semantic skills, i.e. the underlying linguistic skill of comprehension,  
9 were trained. In the CIAT group, however, treatment focused on forced use of spoken  
10 language so that phonology, i.e. the underlying linguistic skill of language production, was  
11 trained. Kleim and Jones (2008) reported that treatment driven by a specific brain function  
12 can lead to an enhancement of that function.

13 In general, it was demonstrated that both types of therapy (CIAT and BOX) have a positive  
14 effect on verbal communication in chronic fluent aphasia. However, three out of nine (C1, C3  
15 and B4) patients failed to improve on verbal communication (ANELT-results). These three  
16 patients did improve significantly on impairment-focused language tasks, i.e. naming (AAT-  
17 naming and BNT). This might be due to the fact that a naming test is less complicated than a  
18 communicative test in terms of the load on the language system and other cognitive functions.  
19 A naming test requires a straightforward word-level response, whereas a communicative test  
20 requires a coherent discourse-level response. A naming test might be less challenging for the  
21 cognitive system (the visual stimulus is the starting point of the clearly defined response),  
22 whereas a communicative test is influenced by auditory working memory (the patient has to  
23 memorize the instruction as well as the scenario) and by executive functioning (the patient has  
24 to consistently structure his answer and has to delineate his response).

25

1 Besides the small sample size and the chosen outcome measures, some other limitations to the  
2 study should be taken into account: (1) previous treatment experience by the participants; (2)  
3 relevance of materials; (3) clinician's experience and (4) group versus single-patient setting.  
4 First, it is not known which therapy regimen (content or quantity) the participants have  
5 received before participating in this study. It is known that none of the nine participants had  
6 prior exposure to an intensive therapy program. As Holland, Greenhouse, Fromm and  
7 Swindell (1989) noted, previous treatment might be an influential factor on treatment  
8 outcome since the treatment might facilitate or speed up neural recovery processes. Second,  
9 Murray and Clark (2006) found that the degree of relevance of materials to the participant  
10 contributes to generalization. This factor was not examined in this study. Third, the CIAT and  
11 BOX treatment was given by seven different students, although these students received the  
12 same training and coaching, their experience, personality and way of shaping might have  
13 influenced the participants' outcome. The fact that students instead of professionals  
14 supervised the interventions should have no impact since several studies (Davis, Enderby &  
15 Bainton, 1982; Lesser, Bryan, Anderson & Hilton, 1986; Marshall et al., 1989; Meikle et al.,  
16 1979; Shewan & Kertesz, 1984; Wertz et al., 1986; Worrall & Yiu, 2000) found no  
17 differences in language improvement of patients with aphasia, when treatment was applied by  
18 trained laypersons or by professional therapists (Meinzer et al., 2007). Fourth, therapy in a  
19 single-patient setting is more intensive than in a group setting, where practice time is divided  
20 among the group members (Berthier & Pulvermüller, 2010). In this study CIAT-participants  
21 received as much individualized cueing as necessary for a successful expression (no detailed  
22 records were kept to count the exact minutes), whereas BOX-participants alternated between  
23 working 30 minutes by themselves and 30 minutes with the therapist. This might have caused  
24 a more intensive experience for the BOX group.

25

1 The question remains whether a specific treatment (BOX or CIAT) delivered under different  
2 conditions (i.e. varying the intensity schedule, quantity of treatment, aphasia population/  
3 linguistic impairments, involving relatives) would still yield positive outcomes. Some  
4 suggestions for further study can be summarized as follows: (1) How can the delivery of  
5 therapy be restructured to enhance the learning effect (e.g. is an intensive treatment schedule  
6 beneficial in the subacute phase); (2) Which type of aphasia responds best to intensive  
7 treatment (e.g. is an intensive phonological treatment in an individual with conduction aphasia  
8 more useful than CIAT-therapy (Szaflarski et al., 2008; Goral & Kempler, 2009)); (3) Which  
9 linguistic process should be intensively trained (e.g. will an intensive, phonologically based  
10 therapy in fluent aphasia also significantly improve verbal communication); and (4) What are  
11 the most appropriate outcome measures to assess treatment gains (e.g. is more attention to  
12 conversation screening and analysis as useful as in-depth assessment of the impact on verbal  
13 communication (DiFrancesco et al., 2012))?  
14 We can conclude based on this explorative study that (1) intensive treatment has a significant  
15 effect on language and communication skills; (2) an intensive semantic treatment (BOX)  
16 results in selective treatment effects and a more pronounced improvement of verbal  
17 communication when compared to CIAT.

18

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1 **Appendix**

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3 **Detailed description of the constraints used in CIAT-training**

4 *Material constraints*

5 All words represented by pictures of objects and actions (n=450) were classified for lexical frequency (high, middle and low frequency words)  
6 according to the database CELEX (Centre for Lexical Information; Bayen, Piepenbrock, & Van Rijn, 1993). Because of the moderate severity of  
7 language impairment in both CIAT groups, the participants almost exclusively practiced with low frequency picture cards (n=287). In the first  
8 sessions, only simple black-and-white line drawings of objects (n=249) were used. These drawings were taken from an Internet database  
9 (Szekely et al., 2004). Later on, colored pictures of objects from different semantic categories or themes, action cards, sentences cards (n=173)  
10 (internet database 'Imagine Symbols', 2004) and pictures with minimal pairs (n=28) were introduced. Thus, the therapist triggered a more  
11 advanced communication by means of (1) decreasing word frequency, (2) introducing coloured pictures from the same semantic category or  
12 theme, (3) using action or sentence cards and (4) requesting the exact pronunciation by using cards of phonetically minimal pairs.

13

14 *Shaping and rules constraints*

15 In the first session, participants were allowed to use any relevant verbal expression to obtain a particular card. The therapist provided as much  
16 cueing as necessary for a successful expression. Cueing strategies that were used consisted of: semantic cueing, phonological cueing, selecting,  
17 repeating or a reminder/visual cueing. These verbal expressions and cueing strategies were gradually constrained by (1) the introduction of  
18 explicit rules and (2) shaping and modelling (i.e. encourage increasing complexity of verbal responses). The rule of constraining allows the

1 players (1) to use the names of the co-players, (2) to use politeness rules and (3) to use more complex verbal expressions. To encourage the self  
2 cueing capacities of the patients in a communication setting and to introduce the use of more complex verbal expressions, the “questioner” was  
3 sometimes asked to give only a description of the object. The “receiver” was expected to name the object. Following the shaping principle, the  
4 cueing strategies were gradually reduced. Finally, the participants were encouraged to communicate without any help.

5

#### 6 *Reinforcement contingencies*

7 Because we composed groups based on a similar degree of linguistic impairment, the rules and shaping principles could be performed on a group  
8 basis. Everyone could practice with the same rules and constraints.

9

#### 10 **Detailed description of the exercises used in BOX-training**

11

12 There are eight different types of exercises: I Semantic Categories; II Syntagmatic and Paradigmatic Relationship; III Semantic Graduation; IV  
13 Adjectives and Exclamations; V Part-Whole Relationship; VI Anomalous Sentences; VII Semantic Definition; VIII Semantic Context.

14 Most of the exercises contain three levels of difficulty:

- 15 - Word choice: imageability, frequency, word length, and abstractness were considered.
- 16 - Number of distractors: in general the level of difficulty increases by adding more distractors.
- 17 - Semantic relatedness: there are mostly unrelated distractors at the easy level, and only related distractors at the most difficult level.
- 18 - Ambiguity: incorporated in the difficult level are ambiguous words; this task is to survey both word meanings at the same time.

1 **Some examples of exercises** (Visch-Brink et al., 1997)

LEVEL 1	LEVEL 2	LEVEL 3
<p><b>I Semantic Categories</b></p> <p>Postcard</p> <p><i>Cigar</i></p> <p>Bill</p>	<p>Comma</p> <p><i>Number</i></p> <p>Question mark</p> <p>Semi-colon</p> <p>parentheses</p>	<p>Greatness</p> <p>Superiority</p> <p>Importance</p> <p>Power</p> <p><i>Motivation</i></p> <p>Authority</p>
<p><b>II Syntagmatic and Paradigmatic Relationship</b></p> <p>CRIPS: <i>popcorn</i> or towel</p> <p>Let's have something to go with our drinks</p>	<p>THEATRE: <i>musical</i> or home movie</p> <p>It appears that the show is sold out.</p>	<p>INTERPRETER: actor, <i>translator</i> or courier</p> <p>The Russian ambassador is coming to Holland.</p>
<p><b>III Semantic Gradation</b></p> <p><i>SPRING</i> or AUTUM</p> <p><i>Blossom</i>      <i>cleaning</i></p> <p>Mushroom      chestnut</p> <p><i>First cuckoo</i>      September</p>		
<p><b>IV Adjectives and Exclamations</b></p>		

<p><b>The boy from next door is playing in the mud.</b></p> <ul style="list-style-type: none"> <li>- <i>The boy from next door is dirty.</i></li> <li>- The boy from next door is clean.</li> </ul>	<p><b>That piano makes a terrible noise.</b></p> <ul style="list-style-type: none"> <li>- The piano is white.</li> <li>- The piano is new.</li> <li>- <i>The piano is out of tune.</i></li> </ul>	<p><b>I've got my driver's licence!</b></p> <ul style="list-style-type: none"> <li>- Oh dear.</li> <li>- <i>Congratulations!</i></li> <li>- Is that so?</li> </ul>
<p><b>V Part whole relationship</b></p> <p>The towels are in <b>the linen-cupboard.</b></p> <p><i>Dishcloth</i></p> <p>Lawn mower</p> <p><i>handkerchief</i></p>	<p>That painting has a nice <b>list.</b></p> <p><i>Portrait</i></p> <p><i>Watercolour</i></p> <p>film</p>	<p>A cat's <b>tail.</b></p> <p><i>Frock</i></p> <p>Dress</p> <p>Coat</p>

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**Table I** Demographic and neurological data

	Treatment Group	Age (years)	Sex	Handedness	Education (years)	Duration of Aphasia (months)	Etiology	Lesion site	Classification of aphasia	Severity of aphasia pretest	
Case	C1	CIAT	73	F	R	8	17	I	L	TC sensory	Moderate
	C2	CIAT	65	F	R	12	70	I	L	Wernicke	Moderate
	C3	CIAT	69	F	R	15	25	H	L	TC sensory	Moderate
	C4	CIAT	55	M	L	15	138	I	L	Wernicke	Moderate
	C5	CIAT	54	M	R	17	56	I	L	Wernicke	Moderate
	Mean (SD)		63 (8)			12 (6)	61 (48)				
	B1	BOX	60	M	R	13	61	H	L	Wernicke	Moderate
	B2	BOX	76	M	R	12	26	I	L	Wernicke	Moderate
	B3	BOX	81	M	R	15	82	I	L	TC sensory	Moderate
	B4	BOX	68	M	R	12	37	I	L	Wernicke	Moderate
	Mean (SD)		71(9)			13 (1)	52 (25)				

*Note.* C=CIAT, B=BOX; SD=Standard Deviation); F=female, M=male, R=right, L=left, I=ischemic, H=hemorrhagic), TC=transcortical.

**Table II** Therapy schedule in minutes BOX 1, BOX 2 and CIAT

Therapy schedule BOX 1	Therapy schedule BOX 2	Therapy schedule CIAT
A: 30 Therapy session	A: 30 Individual work session	45 Therapy Session
B: 15 Individual work session	B: 15 Therapy session	
<b>Pause</b>	<b>Pause</b>	<b>Pause</b>
A 30 Individual work session	A 30 Therapy session	45 Therapy Session
B 15 Therapy session	B 15 Individual work session	
<b>Pause</b>	<b>Pause</b>	<b>Pause</b>
A 30 Therapy session	A 30 Individual work session	45 Therapy Session
B 15 Individual work session	B 15 Therapy session	
75 Therapy session	60 Therapy session	135 Therapy session
60 Individual work session	75 Individual work session	

*Note.* A=first part of 45 min (30 min), B=last part of 45 min (15min).

**Table III** Test procedure

To establish functional lateralization of the brain	- Handedness Inventory
To measure visuo-perceptual problem solving	- Raven Colored Progressive Matrices
To establish an overall cognitive linguistic profile	- Aachen Aphasia Test - Boston Naming Test
To measure semantic outcomes	- PALPA Synonym Judgment test - PALPA Semantic Word Association of low imageability words - Visual Semantic Association Test - Verbal Semantic Association Test
To measure phonological outcomes	- PALPA Non-word Repetition - PALPA Auditory Lexical Decision
To measure verbal communication and social validation	- Amsterdam, Nijmegen Everyday Language Test - Communicative Effectiveness Index
To evaluate satisfaction	- Written, non-standardized subjective rating scale

**Table IV Individual case data:** ANELT and CETI pre- and post therapy, and improvement

		ANELT Max 50			CETI Max 100		
		pre	post	I	pre	post	I
CIAT	C1	41	45	4	54.7	61.0	6.3
	C2	35	46	11	46.1	52.4	6.3
	C3	38	39	1	43.4	43.4	0.0
	C4	32	40	8	25.0	56.2	31.2
	C5	40	47	7	40.0	39.2	-0.8
	Mean	37.2	43.4	6.2	41.9	50.5	8.6
	(SD)	(3.7)	(3.6)	(3.8)	(10.9)	(9.0)	(13.1)
BOX	B1	29	37	8	44.1	61.5	17.4
	B2	33	42	9	56.7	69.6	12.9
	B3	30	42	12	64.2	85.0	20.8
	B4	26	30	4	(89.4)	/	/
	Mean	29.5	37.8	8.3	55	72.0	17.0
	(SD)	(2.9)	(5.7)	(3.3)	(10.2)	(12.0)	(4.0)

*Note.* SD=Standard Deviation, I=Improvement; C=CIAT, B=BOX; Shaded areas indicate on an individual basis a critical change in raw score as defined by the ANELT ( $\geq 7$  points) or by the CETI ( $\geq 10$  points).

**Table V** Individual case data: Aachen Aphasia Test (Token Test, Comprehension, Repetition, Naming, Written Language) and Boston Naming Test (BNT) raw scores pre- and post- therapy

	CIAT-group					Mean (SD)	BOX-group					Mean (SD)										
	C1		C2		C3		C4		C5	B1			B2		B3	B4						
	pre	post	pre	post	pre		post	pre	post	pre	post		pre	post	pre	post	pre	post				
Token Test (max 50)	29	20	28	18	38	28	39	24	32	17	33.2 (5.1)	21.4 (4.6)	29	20	24	13	39	34	27	26	29.8 (6.5)	23.3 (8.9)
Comprehension (max 120)	81	92	79	87	88	86	87	96	104	100	87.8 (9.8)	92.2 (5.9)	103	110	100	113	66	83	104	113	93.3 (18.2)	104.8 (14.6)
Repetition (max 150)	144	148	119	124	132	136	116	130	105	108	121.2(16.4)	129.2 (14.8)	117	120	136	143	145	143	95	94	123.3(22.2)	125.0(23.3)
Compounds (max 30)	29	29	22	22	18	23	20	26	17	10	21.2 (4.8)	22.0 (7.2)	18	16	26	29	29	29	9	12	20.5 (9.0)	21.5 (8.8)
Sentences (max 30)	27	29	14	16	24	23	12	18	9	12	17.2 (7.8)	19.6 (6.6)	13	16	25	25	28	26	9	11	18.8 (9.2)	19.5 (7.2)
Naming (max 120)	93	96	96	102	66	75	90	99	99	111	88.8 (13.2)	96.6 (13.3)	86	105	96	87	48	57	77	104	76.8 (20.7)	88.3 (22.4)
Color (max 30)	27	27	28	28	16	25	28	27	30	30	25.8 (5.6)	27.4 (1.8)	30	30	23	18	14	15	30	30	24.3 (7.6)	23.3 (7.9)
Compounds (max 30)	25	22	20	22	12	12	23	24	19	28	19.8 (5.0)	21.6 (5.9)	17	26	25	22	10	12	16	28	17.0 (6.2)	22.0 (7.1)
Sentences (max 30)	16	21	21	23	18	18	13	25	20	23	17.6 (3.2)	22.0 (2.6)	14	20	24	20	7	13	10	16	13.8 (7.4)	17.3 (3.4)
Written Language (max 90)	84	87	82	84	67	72	81	82	66	70	76.0 (8.7)	79.0 (7.5)	82	85	76	73	79	85	65	74	75.5 (7.4)	79.3 (6.6)
To dictation (max 30)	26	27	28	27	23	29	26	25	11	17	22.8 (6.8)	25.0 (4.7)	27	27	23	20	26	27	15	21	22.8 (5.4)	23.8 (3.8)
BNT (max 60)	30	45	33	39	7	17	37	44	44	54	30.2 (14.0)	39.8 (13.8)	37	46	46	45	0	19	33	49	29.0 (20.1)	39.8 (13.9)

*Note.* Shaded areas indicate on an individual basis (1) a critical change in raw score as defined by the AAT (Token Test=8, Comprehension=22, Repetition=15 (compounds=7, sentences=7), Naming=17 (colors=10, compounds:10, sentences=7), Written Language=12 (writing to dictation=8)) or (2) a change in score of  $\geq 2SD$  from the gender, age and education adjusted mean normal performance on the BNT. Token Test is an error score.

**Table VI** t- and p-values of the comparison (paired t-test) between the pre- and postscores on the subtests of the Aachen Aphasia Test (Comprehension, Token Test, , Repetition, Naming, Written Language) and on the Boston Naming Test of the CIAT- and the BOX-group

	CIAT-group		BOX-group	
	t(4)-value	p-value	t(3)-value	p-value
Comprehension	1.43	0,226	5.19	0.014
Token Test	8.95	0.001	2.93	0.061
Repetition	3.00	0.040	0.85	0.457
Naming	5.10	0.007	1.48	0.235
Written Language	4.24	0.013	1.46	0.239
Boston Naming Test	6.12	0.004	2.42	0.094

*Note.* Shaded areas indicate a significant difference in pre- and postscores according to the paired t-test ( $p \leq 0.05$ ).

**Table VII** Individual case data: Raw scores and mean scores pre- and post therapy on semantic and phonological measures (n=9)

		Semantic Measures						Phonological Measures			
		Verbal Semantic Word Association (SAT) Max 30		Semantic Word Association Low Imageability (PALPA) Max 15		Auditory Synonym Judgment (PALPA) Max 60		Nonword Repetition (PALPA) Max 30		Auditory Lexical Decision (PALPA) Max 160	
		pre	post	pre	post	pre	post	pre	post	pre	post
Case	C1	24	22	6	7	47	49	28	27	149	148
	C2	21	24	14	13	51	51	18	21	131	140
	C3	18	28	6	7	54	52	27	29	156	156
	C4	22	25	8	10	52	53	18	27	129	152
	C5	30	27	13	12	57	57	21	22	157	160
	Mean	23.0	25.2	9.4	9.8	52.2	52.4	22.4	23.4	144.4	151.2
	(SD)	(4.5)	(2.4)	(3.8)	(2.8)	(3.7)	(3.0)	(4.8)	(6.9)	(13.5)	(7.7)
	B1	27	28	12	14	52	59	28	26	159	154
	B2	23	27	8	10	49	55	24	25	141	140
	B3	13	12	3	6	46	46	26	28	139	144
	B4	27	30	12	14	54	58	3	4	124	136
	Mean	22.5	24.2	8.7	11	50.2	54.5	20.2	20.7	140.75	143.5
	(SD)	(6.6)	(8.3)	(4.3)	(3.9)	(3.5)	(5.9)	(11.6)	(11.2)	(14.3)	(7.7)

*Note.* Shaded areas indicate on an individual basis a critical change in raw score on the Semantic Association Test ( $\geq 6$  points), and a change in score of  $\geq 2SD$  from the mean on the Semantic word association for low imaginability words ( $\geq 2$  points) on the Auditory synonym judgment ( $\geq 3$  points), the Repetition of nonwords ( $\geq 3$  points) and the Auditory lexical decision ( $\geq 5$  points).