Long-Term Stability of Improved Language Functions in Chronic Aphasia After Constraint-Induced Aphasia Therapy

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Background and Purpose—In response to the established notion that improvement of language functions in chronic aphasia only can be achieved through long-term treatment, we examined the efficacy of a short-term, intensive language training, constraint-induced aphasia therapy (CIAT). This program is founded on the learning principles of prevention of compensatory communication (constraint), massed practice, and shaping (induced).

Methods—Twenty-seven patients with chronic aphasia received 30 hours of training over 10 days. Twelve patients were trained with the CIAT program. For 15 patients the training included a module of written language and an additional training in everyday communication, which involved the assistance of family members (CIATplus). Outcome measures included standardized neurolinguistic testing and ratings of the quality and the amount of daily communication.

Results—Language functions improved significantly after training for both groups and remained stable over a 6-month follow-up period. Single case analyses revealed statistically significant improvements in 85% of the patients. Patients and relatives of both groups rated the quality and amount of communication as improved after therapy. This increase was more pronounced for patients of the group CIATplus in the follow-up.

Conclusions—Results confirm that a short-term intense language training, based on learning principles, can lead to substantial and lasting improvements in language functions in chronic aphasia. The use of family and friends in the training provides an additional valuable element. This effective intervention can be successfully used in the rehabilitation of chronic aphasia patients. Additionally, its short-term design makes it economically attractive for service providers. **(*Stroke*. 2005;36:000-000.)**

Key Words: aphasia ■ outcome ■ rehabilitation ■ speech

Aphasia, a severe impairment of language production and comprehension, is a frequent consequence of left-hemispheric stroke. In the first weeks after the insult, ≈38% of the patients experience aphasia.[1] Although spontaneous recovery within the first 6 months can be substantial, only minimal further improvement is reported thereafter.[2] Approximately 40% to 60% of the patients move from the acute stage to the chronic stage as the condition persists 6 to 12 months after the stroke.[3] Whereas early intervention during the acute phase has a positive outcome,[2] it has been generally assumed that no additional improvements are to be expected from interventions in the chronic stage. This view has recently been challenged by studies demonstrating improvements of language functions in chronic patients[4–6] in whom successful training was intense (several days/week) and long-lasting (over several months),[7] a treatment modality that unfortunately is limited because of affordability.

A compact, short-term, and intensive language training based on learning principles was recently introduced by Pulvermüller et al in a randomized controlled trial.[8] Constraint-induced aphasia therapy (CIAT) uses the principles of *massed practice* (30 hours of training within 2 weeks), *shaping* (language tasks of increasing level of difficulty embedded in communicative language games realized within a group setting including 2 to 3 patients), and *constraint of compensatory (nonverbal) communication strategies*.[9] CIAT was shown to result in improved performance on a standardized language test in 10 aphasics, whereas this was not the case for conventional therapy with the same amount of treatment extended over 3 to 5 weeks. In addition, patients and clinicians blind to the condition groups, who evaluated the everyday communication of patients being treated with CIAT, reported higher levels of improvement compared with the conventional treatment group.

The present study's goal was to replicate the improvement of language functions for a larger sample and to assess its long-term stability across a 6-month follow-up period. Moreover, the study was designed to evaluate an extension of the original CIAT—the CIATplus—with an additional group of patients by including written materials and photographs of everyday situations and a training module including a patient's relative in daily individual communication exercises.

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Clinical and Sociodemographic Parameters

Group	Age, y	Sex	Cause	Duration of Aphasia, mo	Classification	Severity
CIAT	35	F	Hemorrhagic	33	Not classified	Mild
CIAT	53	F	Hemorrhagic	32	Broca	Mild
CIAT	64	M	Ischemic	24	Broca	Mild
CIAT	51	M	Ischemic	13	Wernicke	Moderate
CIAT	60	M	Ischemic	60	Not classified	Severe
CIAT	41	M	Ischemic	70	Wernicke	Moderate
CIAT	69	M	Ischemic	33	Wernicke	Mild
CIAT	70	F	Hemorrhagic	38	Wernicke	Moderate
CIAT	61	M	Hemorrhagic	81	Amnesic	Mild
CIAT*	49	F	Ischemic	71	Broca	Moderate
CIAT	18	M	Hemorrhagic	14	Broca	Moderate
CIAT	39	M	Ischemic	56	Amnesic	Mild
	Ø50.1			Ø46.2		
CIATplus	51	M	Hemorrhagic	29	Broca	Moderate
CIATplus	47	F	Hemorrhagic	54	Not classified	Moderate
CIATplus	67	F	Ischemic	42	Amnesic	Mild
CIATplus	49	M	Ischemic	92	Broca	Moderate
CIATplus	41	M	Hemorrhagic	46	Not classified	Mild
CIATplus	66	M	Ischemic	26	Not classified	Moderate
CIATplus	67	M	Hemorrhagic	116	Wernicke	Moderate
CIATplus	38	M	Hemorrhagic	53	Wernicke	Moderate
CIATplus	36	M	Ischemic	12	Broca	Mild
CIATplus	53	F	Ischemic	50	Broca	Moderate
CIATplus	47	F	Ischemic	87	Broca	Moderate
CIATplus*	56	F	Hemorrhagic	28	Global	Severe
CIATplus	47	M	Ischemic	29	Broca	Moderate
CIATplus	36	F	Ischemic	32	Wernicke	Moderate
CIATplus*	80	F	Ischemic	23	Wernicke	Mild
	Ø 52.1			Ø 47.9		

*No follow-up.
F indicates female; M, male.

Materials and Methods

Sample

Twenty-seven patients (11 females, mean age 51.5±13.8 years) with chronic aphasia (mean duration 45.6±26.5 months) were recruited for the study (Table). Aphasia resulted from left-hemispheric ischemic stroke in 16 patients and from hemorrhage in 11 patients. Diagnoses were made according to the guidelines of the Aachen Aphasia Test (AAT).[10] Aphasic syndromes were determined as Broca (N=10), Wernicke (N=8), amnesic (N=3), and global aphasia (N=1). Five cases could not be assigned to the standard syndromes. Aphasia was classified as moderate (N=15), mild (N=10), or severe (N=2). Patients were recruited from local rehabilitation centers (Kliniken Schmieder, Jugendwerk Gailingen, Universitätsspital Zürich), aphasia/stroke support groups, or neurologists and speech therapists. Patients with severe global aphasia or residual symptoms and severe perceptual or cognitive deficits were excluded from this study.

Patients were assigned in groups of 2 or 3 to the treatment groups; the first 12 patients were allocated to the CIAT and the next 15 patients to the CIATplus condition. Groups did not differ in clinical or demographic variables before training and were comparable with respect to further treatment between the discharge from the program and the follow-up (CIAT: Ø1.5 hours/week; CIATplus: Ø1.7; $F < 1$).

Training Procedure

All patients received 30 hours of training over a 2-week period (3 hours/day). Communicative language games included pairs of cards with object drawings (each set contained 15 pairs) that were distributed among the "players" (2 to 3 patients and 2 therapists per group). Screens between players prevented them from seeing each other's cards and movements to enforce communication by spoken language and to "constrain" communication by gestures. Players were instructed to ask for matching cards by using verbal expressions and phrases with increasing levels of difficulty.

In the CIATplus treatment program, the set of cards used for the communication game included written language (eg, rhyming words, categories) and photographs of everyday situations that were not included in the standard intervention. Moreover, this condition involved additional exercises to be performed at home in the afternoon and included daily communication practiced with a family member. The patients' relatives were asked to encourage the patient to engage in verbal communication as often as possible. The exercises for the training at home were individually defined with the therapist on each day (eg, a seriously handicapped patient might be asked to go to the bakery and ask for a bread, a less handicapped patient might be asked to go to the tourist office to get information about a local tourist attraction and to report to the other participants the next morning). Patients and relatives

kept record of communicative activity executed outside of the clinical setting using a diary. The exercises' difficulty level was gradually increased across the training. Patients of the original CIAT received no specific instructions for practice at home but were told that it was favorable to speak as much as possible in everyday situations.

Language functions were evaluated by a standardized language test (AAT),[10] which included 5 subtests: Token Test, repetition, written language, picture naming, and comprehension. Language functions were assessed before the training, immediately after the 2-week training, and again at a 6-month follow-up visit. Three subjects (CIAT, N=1; CIATplus, N=2) were not available for testing at follow-up because of illness, noncompliance, or having moved. General improvement is estimated as a weighted average of all AAT subtests (profile score), whereas individual improvement is evaluated for subtests and subscales.

Two questionnaires assessed quality and quantity of everyday communication. In the Communicative Effectiveness Index (CETI),[11,12] relatives of the patients evaluate the quality of everyday communication on a 16-item analogue scale. In the Communicative Activity Log (CAL),[8] patients and relatives separately rated the amount of everyday communication (CALpat1/rel1) for 11 items (eg, How often would the patients communicate with a relative?) and the quality of comprehension (CALpat2/rel2) for 10 items, each on a 6-point scale (0=never and 6=as often as before the stroke). The study was approved by the local ethics committee, and informed consent was obtained from all patients.

Data Analyses

Individual improvement of language functions (AAT subtests and AAT subscales) were evaluated according to the manual of the AAT.[10] T-transformed scores of AAT profile scores and subtest scores were compared between groups and across measurements (before, after, and follow-up) in repeated-measure ANOVAs. The Greenhouse–Geisser (G-G) correction was applied when necessary.

Changes across time in each group were further evaluated by means of paired *t* tests (before, after, and before follow-up: 1-tailed; after follow-up: 2-tailed). For the comparison of assessments before follow-up and after follow-up, only patients who completed the follow-up were included. CETI and CAL ratings were evaluated by repeated-measure ANOVAs and paired *t* tests. Differences between intervention groups in categorical variables were evaluated by χ^2 tests. Associations between individual improvement in the AAT profile and demographical parameters (time since stroke/age) and between language functions and measures of functional communication (CALpat1/rel1, CETI versus AAT profile; CALpat2/rel2 versus AAT comprehension) were substantiated by Pearson correlation. Improvement of language functions of patients with mild and moderate/severe aphasia were compared using analysis of variance to assess the impact of severity (raw scores of the AAT subtests were used because calculations based on *t* scores might overestimate the change in less severe aphasia).

Results

Neuropsychological Test Performance

Independent of the training group, significant improvement was confirmed for the AAT profile immediately after training (main effect time: F[1,25]=79.1, $P<0.0001$) and across all subtests (all subtests F[1,25]>16.4, $P<0.001$). For each group, this was substantiated by significant improvements on the AAT profile score (CIAT: t[11]=6.2, $P<0.0001$; CIATplus: t[14]=6.3, $P<0.0001$) and all subtests (CIAT: t[11]=2.2 to 5.5, $P<0.03$ to 0.0001; CIATplus: t[14]=2.5 to 5.5, $P<0.03$ to 0.0001). Groups did not differ on any test scores before or after training (all F<1). In both groups, improvements remained stable across the follow-up period (for the comparison before to follow-up time: AAT profile F[2,44]=33.5, $P<0.0001$; all subtests F[2,44]>9.2, $P<0.001$). For each group this was confirmed by paired *t* tests. All results remained significantly improved compared with baseline (AAT profile CIAT t[10]=4.7, $P<0.001$, CIATplus t[12]=4.4, $P<0.001$; all subtests: CIAT t[10]=2.7 to 5.2, $P<0.03$ to 0.001, CIATplus t[12]=2.4 to 3.7, $P<0.03$ to 0.01). There were no differences concerning language test results between intervention groups (Interaction time × group: all F<1; Figure 1).

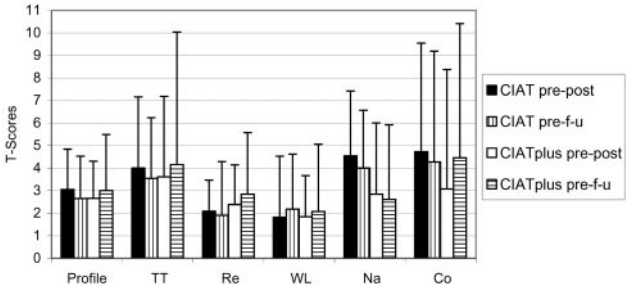

Figure 1. Improvement of language functions for post-test and follow-up assessments. Gains on the profile score/subtests of the Aachen Aphasia Test (mean and SD) for pretest and post-test and prefollow-up assessments (TT indicates Token Test; Re, Repeating; WL, Written Language; Na, Naming; Co, Comprehension). All measures were improved after therapy and remained above baseline at the follow-up for both groups. No interaction time×group was found at any time.

Improvements were confirmed on an individual basis. After training, 17 of the 27 patients across groups showed significant improvement on at least one AAT subtest (CIAT N=8/12, CIATplus N=9/15), 6 patients improved on at least one subscale (CIAT N=2/12, CIATplus N=4/15). A total of 85% of the patients improved after therapy. Individual improvements proved to be stable from the post-test to the follow-up. Compared with the baseline in the follow-up period, patients of the group CIAT improved on 10 subtests (post-test N=12) and 10 subscales (post-test N=10). Patients of the group CIATplus improved on 19 subtests (post-test N=14) and 9 subscales (post-test N=11).

Individual improvement after therapy was uncorrelated with age or time since stroke ($r=0.04/-0.07$). The average performance in all subtests of the AAT (all F <2.5, $P>0.1$) and the number of improved subtests/subscales (χ^2 [2,23]>0.3, $P>0.8$) were comparable for patients with mild and moderate/severe aphasia.

Rating of Everyday Communication

Communicative effectiveness, as assessed by the CETI, was considered by relatives as improved after training (time: F[1,25]=21.3, $P<0.0001$; CIAT: t[11]=3.0, $P<0.01$; CIATplus t[14]=3.7, $P<0.01$; time × group F<1). Improvement remained above baseline ratings in the follow-up for both groups (time: F[2,44]=19.1, $P<0.0001$; CIAT t[10]=3,0, $P<0.02$; CIATplus t[12]=4.8, $P<0.001$). Compared with post-assessment in the follow-up, only relatives of patients trained by CIATplus reported a further improvement in the quality of everyday communication (t[12]=2.6, $P<0.03$), which explained an interaction effect of group×time (after follow-up: F[1,22]=4.6 $P<0.05$; Figure 2).

Improvement of communication was also supported by the CAL. Patients and relatives of both groups reported an increase in the *amount* of everyday communication after training (time CALpat1: F[1,24)=23.3, $P<0.0001$; CIAT t[10)=2.5, $P<0.02$, CIATplus t[14]=4.5, $P<0.001$; CALrel1: F[1,24]=32.5, $P<0.0001$; CIAT t[10]=4.0, $P<0.01$, CIATplus t[14]=5.4,

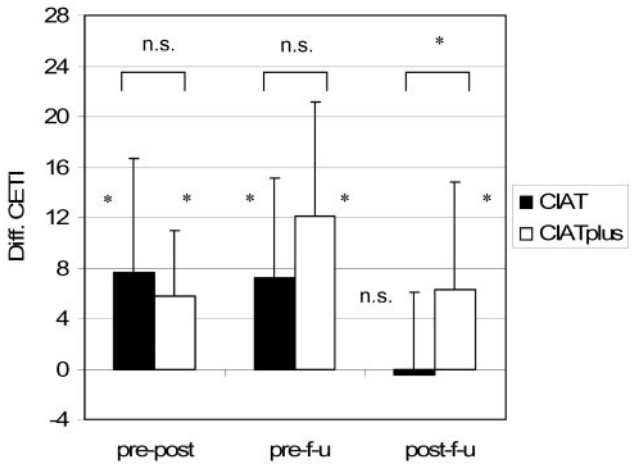

Figure 2. Improvement of communicative effectiveness for post-test and follow-up assessments. Comparison of Communicative Effectiveness Index (CETI) ratings of the patients' relatives for both intervention groups comparing pretest, post-test, prefollow-up, and post–follow-up assessment of the quality of daily communication. Significant improvement was reported after therapy in both groups, and there was further improvement in the follow-up only for the CIATplus group.

$P<0.0001$). Although patients' ratings were comparable between groups ($F<1$), relatives of patients trained with CIATplus noticed a more pronounced increase of everyday communication than relatives of patients trained with the original CIAT ($F[1,24]=9.5$, $P<0.01$).

Even though *comprehension* was appraised as significantly improved from pretraining to post-training only by patients of the group CIATplus, this did not yield a significant time × group interaction (time CALpat2: $F[1,24]=11.3$, $P<0.01$, CIAT $t[10]=1.7$, $P>0.05$, CIATplus $t[14]=3.1$, $P<0.01$; Interaction $F[1,24]=1$, $P>0.3$). In contrast, relatives in both groups rated comprehension as improved (time CALrel2: $F[1,24[=7.5$, $P<0.02$; CIAT $t[10]=2.2$, $P<0.03$, CIATplus $t[14]=2.5$, $P<0.02$), although there was a tendency for more improvement in comprehension after CIATplus training (CALrel2: $F[1,24]=2.2$, $P>0.1$).

Patients in the CIAT group did not report an increased *quantity of everyday communication* at the time of the 6-month follow-up, as compared with baseline. Patients of the CIATplus group did rate the *quantity of communication* as above baseline; however, no significant differences were found between intervention groups (time CALpat1: $F[2,44]=11.4$, $P<0.0001$, CIAT $t[10]=1.6$, $P>0.1$, CIATplus $t[12]=4.4$, $P<0.001$, Interaction $F<1$). Patients' relatives reported a significant increase in the amount of communication compared with baseline values for both groups (time CALrel1: $F[2,44]=18.8$, $P<0.0001$; CIAT $t[10]=3.3$, $P<0.01$, CIATplus $t[12]=5.0$, $P<0.001$), with a trend toward a more pronounced increase in the amount of communication with the CIATplus group (G-G–corrected $F[3.7,1.3]=9.8$, $P<0.06$).

Again, even though only patients in the group CIATplus reported an increase in *comprehension* when comparing follow-up ratings with the baseline, no differences were found between groups (time CALpat2: $F[2,44]=7.0$, $P<0.01$; CIAT: $t[10]=1.1$, $P>0.3$, $t[12]=3.8$, $P<0.01$; interaction $F[2,44]=2.3$, $P>0.1$). Relatives of the group CIATplus rated the improvement in quality of comprehension as above baseline, whereas this was not the case in the CIAT group (CALrel2 $t[10]=1.0$, $P>0.3$; CIATplus CALrel2 $t[14]=3.6$, $P<0.01$), which explained a significant interaction time × group ($F[2,44]=3.44$, $P<0.05$). There were no correlations between changes in the AAT and measures of functional communication (all $r<.3$).

Discussion

The present study replicated the results of a pilot study[8] in which language functions were shown to improve within a very short period of time even in the chronic stage of aphasia after CIAT. Most interestingly, the improvements were equally found among patients irrespective of age, severity, and duration of aphasia. Therefore, there is a potential for further progress in a wide range of patients after CIAT. Furthermore, improvements were not transient and results were stable at a 6-month follow-up visit. Patients and relatives of both groups reported an increase in the amount of communication and comprehension in everyday communication immediately after therapy and this increase was more pronounced and lasting in those patients who received additional training in daily communication in the follow-up. This parallels the larger improvement of communicative effectiveness in this group after 6 months.

Even though the present study was not designed to clarify which aspect of the CIAT procedure (constraint, shaping, intensity, or their combination) contributes most to the improvement of language functions, intensity seems to be a crucial factor for the successful rehabilitation of chronic aphasia (or, as we believe, in neurorehabilitation in general). This is further supported by the fact that no additional improvement of language functions could be substantiated in either group during the follow-up assessment, even though the patients received ambulatory speech and language therapy after a nonintensive schedule with approximately the same amount of therapy as provided during the 2 weeks of CIAT (1.6 hours/week on average). As has been shown in the case of motor rehabilitation,[13,14] evidence for concomitant plastic changes in brain functions in chronic aphasia after intensive treatment has been provided.[15] Equal improvements in language functions and correspondent changes in brain functions were found in treatment groups that received CIAT or conventional aphasia therapy with a massed schedule. Any well-substantiated intervention in the chronic stage of aphasia may profit from an intensive treatment schedule.

There is now evidence that plastic reorganizational changes in the brain are highly dependent on the use of a certain function.[16] Any enhancement of desirable activity, especially when it is relevant to a given individual, should be related to a favorable outcome. Changes in communicative activity are not only limited to therapy provided by professionals; rather, there is a potential for the involvement of relatives who are often most influential in training and motivating patients. Learning (or relearning) lost language functions in aphasia should be promoted repeatedly in real-life situations, especially in the chronic stage, during which patients are prone to not using verbal communication, a condition that can persist for years.

Given that the health care system is not capable of providing more intensive treatment, 2 alternative ways of intensifying the training may be to involve patients' relatives or support net-

works even more, or to move to the use of computer-based training programs.[17]

Bhogal et al[7] concluded that nonprofessional intervention can be an effective adjunct to professional treatment, and that the recruitment of volunteers and family members might be a way of providing a more intensive therapeutic environment. The effectiveness of a computerized treatment has been demonstrated in patients with chronic aphasia by Katz et al[6] and for children with specific language impairments.[18] In the latter study, subjects were trained for 20 days (100 minutes/day) using a shaping procedure. The training principles of the therapy included a "heavy schedule" on successive days and "high motivational drive," similar to principles that seem to be valid for stroke patients.

The current practice in neurorehabilitation of spreading treatment sessions over a long time period should be questioned, especially in the chronic stage of stroke-related disorders. Given the fact that an intense schedule has been shown to be more effective,[7,8] a blocked treatment schedule, rather than an extended one, might be more effective. It is rather a question of organization than of capacity to provide patients with effective (intensive) therapy.

Another issue within the health care system is that of spiraling costs. The involvement of patients' relatives or support networks may prove to be cost saving in the long run. In the present study, involvement of the patients' relatives did not lead to increased cost because most were involved in intensive direct care of the patient and therefore were present (often patients with aphasia have comorbid hemiplegia and are dependant on their caregivers). The intention of the study was not to train the patients' relatives to act as therapists but to allow patients to engage in everyday communication as much as possible. In this way, the impact of the patients' relatives might even be greater than that of the therapist, given the amount of time the patients spend with their caregivers and thus the amount of time their daily communication skills were monitored and influenced.

Simply advising patients to speak as much as possible is not sufficient to maintain an increase in communicative activity over time. In the present study, only patients who were encouraged by their relatives to be more active verbally for 2 weeks exhibited more communicative activity than before treatment started when reexamined after 6 months. It was only in this CIATplus group that an increase in the rated effectiveness of everyday communication was found. Future studies might benefit from the addition of therapist-administered measures of functional communication to exclude the possibility that these variables are confounded with expectations regarding the efficacy of treatment. This aspect might have had an influence on the present study.

There were no differences in the language tests at any given time between the intervention groups. Still, there is good reason to believe that there is a difference between what is measured by means of the AAT and everyday communication. Pedersen et al[19] recently noted that the CETI might be sensitive to improvements in everyday communication, independent of what is assessed by standardized language tests. What might be gained by the increased amount of communication and comprehension in daily communication might manifest itself gradually over a longer period of time, namely increased confidence and further activity, which potentially provide the basis for further behavioral and brain reorganization.

Summary

It is concluded that CIAT is effective in improving language functions in chronic aphasia within a relatively short period of time with improvements that remain stable over time. Both the amount and the quality of everyday communication are improved. This might provide a basis for long-term improvement of communication. Treatment outcomes may be further enhanced by active inclusion of relatives or caregivers.

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