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Agrammatism: a rehabilitative programme centered on treatment of verbal inflections

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ABSTRACT. Agrammatism is a clinical syndrome characterised by the omission or substitution of bound morphemes (prefixes, inflectional and derivational suffixes) and function words (articles, prepositions, auxiliary verbs). It is a composite reality with different features involved in differing degrees in each patient. Therefore, treatment should be individually tailored and based on an accurate analysis of the specific pathological manifestations. This study describes a rehabilitative programme used in the treatment of an agrammatic patient. Inflectional morphology training was the core of the programme. For the cognitive rehabilitation of the patient AM we followed the idea that the identification of vulnerable skills should be followed by targeted interventions which constitute the phases of a complete rehabilitation programme. Results showed an improvement of AM's performance in each of the verbal abilities treated (output lexicon, phonological programming and verbal inflections). The global amelioration was also evident in the analysis of samples of spontaneous speech and/or picture descriptions in which both quantitative and qualitative improvement was observed at different steps of the rehabilitative programme and at the 1-year follow-up evaluation (after treatment maintenance). AM's after-treatment amelioration was generalized and prolonged in time. This result even if from the clinical point of view very encouraging, from the experimental point of view constitute a problem, given that the amelioration cannot unambiguously be ascribed to the treatment administered. However, our results, considering that our treatment started one-year after onset of symptoms and that the aphasic picture of AM seemed to be stable in the inter-treatment period (our treatment started six months after a post-acute period of treatment) we consider our results and the rehabilitative paradigm here applied worth of interest.

Key words: agrammatism, cognitive rehabilitation, inflectional morphology.

RIASSUNTO. L'agrammatismo è una sindrome caratterizzata dalla omissione e sostituzione di morfemi legati (prefissi, flessioni e suffissi derivazionali) e di parole funzione (articoli, preposizioni e verbi ausiliari). È una sindrome complessa con differenti caratteristiche nei diversi pazienti; il trattamento dovrebbe pertanto essere individuale, basato su un'analisi approfondita delle specifiche manifestazioni cliniche. Questo studio descrive un programma riabilitativo utilizzato nel trattamento di un paziente agrammatico; il trattamento della morfologia flessionale ha costituito il nucleo centrale del programma. Per la riabilitazione cognitiva del paziente AM ci siamo ispirate al principio che l'approfondita valutazione delle competenze linguistiche avrebbe dovuto essere seguita da fasi di trattamento mirato per le singole abilità compromesse. I risultati ottenuti hanno evidenziato un miglioramento della prestazione di AM in ognuna delle abilità verbali sottoposte a trattamento (lessico di output, programmazione fonologica, morfologia flessionale). Un miglioramento, sia qualitativo che quantitativo, è stato osservato anche nell'analisi di campioni di linguaggio spontaneo e nella descrizione di figure nelle differenti tappe del programma riabilitativo ed al follow-up a distanza di un anno. Il miglioramento della prestazione di AM è risultato essere generalizzato e mantenuto nel tempo. Questi risultati, sebbene molto incoraggianti dal punto di vista clinico, costituiscono un limite dal punto di vista sperimentale, poiché il miglioramento non può essere univocamente attribuito al training somministrato. Tuttavia, considerato che il trattamento è iniziato un anno dopo l'insorgenza dei sintomi e che il quadro linguistico del paziente sembrava essere stabilizzato, riteniamo che i nostri risultati ed il paradigma riabilitativo qui applicato siano meritevoli di interesse.

Parole chiave: agrammatismo, riabilitazione cognitiva, morfologia flessionale.

Introduction

Agrammatism is a clinical syndrome whose distinctive feature is the omission or substitution of bound morphemes (prefixes, inflectional and derivational suffixes) and function words (articles, prepositions, auxiliary verbs). This disturbance gives rise to sentence shortening and sometimes to an extreme simplification of the grammatical structure of sentences.

Since 1913, when Pick (1) made the first attempt to explain agrammatic speech production, there have been many clinical descriptions and theoretic interpretations of the symptomatic manifestations of the syndrome. Early explanations of agrammatism focused their attention on speech production (1, 2, 3). Isserlin (3), for example, advanced the hypothesis that agrammatism was due to articulatory difficulties: speech production, he argued, was an extremely "costly" task for agrammatic patients, and their efforts to economise would give rise to very simple sentences containing only content words (i.e. those conveying the greatest amount of information).

The observation of comprehension deficits alongside production ones was not rare and led to many and contradictory interpretations. Some authors (4, 5, 6) thought that the receptive deficit might be due to a different kind of impairment from that giving rise to the production deficit. Others (7, 8, 9), following the observation that in some patients production and comprehension deficits appeared in association, hypothesised the existence of a central system for grammatical elaboration whose disruption could give rise to deficits in both production and comprehension. The latter theories have often been rejected on the basis of evidence that symptoms which were predicted to co-occur turned out to dissociate across speakers and languages.

In more recent theories different and sometimes contradictory interpretations of the agrammatic syndrome still continue. Kean (10, 11) advanced a phonological theory of agrammatism arguing that "... by assuming all aspects of the language faculty to be intact, save for the phonological, we can predict that there will be a systematic variation in the likelihood of omission of function words and grammatical morphemes which parallels the variation in the way these elements are treated within the normal language processing system". Berndt and Caramazza (12) in their

theory maintained that agrammatism was due to loss of a central syntactic component of the language system.

Given the complexity and variability of the pathological manifestations of agrammatism, an approach based on *a priori* categories seems inapplicable. Along these lines, Badecker and Caramazza (13, 14) maintained that the aim of a detailed analysis of grammatical deficits in aphasic patients is to formulate hypotheses on the functioning of the cognitive system in normal individuals. Accordingly, Garrett (15, 16) proposed a model of speech production based on the analysis of *lapses* produced by normals during conversations. His model predicted that sentence production was composed of different stages each with an independent representational level. At the message level, semantic information is specified (e.g. who is doing what); at the functional level, semantic information activates lexical representations specified by their semantic and syntactic properties. At the positional level a phonological attribution to the lexical representation of the functional level is given. Garrett also made a distinction between open-class and closed-class words which should be processed in different ways and elaborated at different levels. Open-class words were predicted to be elaborated both at the functional and positional levels while closed-class words would be elaborated only at the positional level where each morpheme is assigned a phonological value on the basis of the information present in the phrasal structure which is generated at this level. Garrett's model, however, does not give an explanation for the pattern of errors shown by the patient FS of Miceli and Caramazza (17). This patient showed difficulties in the production of bound-morphemes not only in sentence production but also in single word repetition tasks. Through the administration of words' repetition tests Miceli and Caramazza observed that the pattern of FS errors was constituted by morphological errors and in particular by inflectional errors (96.7% or errors in words repetition test). The presence of morphological errors in single word processing and the dissociation between inflectional and derivational errors allowed Miceli and Caramazza to support the hypothesis of the existence of an autonomous "Inflectional Processing Component" of the lexicon. This hypothesis has relevant implications for treatment.

The fact that agrammatism is a composite reality with different features involved to different degrees in different patients reinforces the idea that it is not useful to apply standard treatment protocols to agrammatism. On the contrary, treatment of each agrammatic patient should be based on an accurate analysis of the specific pathological manifestations.

The present study is the description of the rehabilitative programme applied to an agrammatic patient. The development of our rehabilitative programme could be conceived as a journey in which each rehabilitative phase led to a further examination which in turn gave rise to a new rehabilitative phase. Inflectional morphology training was the core of the programme and replicated, with slight modifications, the methodology described by Miceli et al. (18).

Materials and Methods

Patient

AM was a 44-year old male, left-handed, with 13 years of education. He had worked since the last 20 years as an employee. On 30th May 2000 he showed the sudden onset of left sensitive motor hemisindrome and global aphasia. A CT scan performed on 1st June 2000 showed an ischaemic lesion in the cortical and subcortical fronto-temporal region of the right hemisphere. Six months later an MRI scan confirmed the stabilised outcome of a vascular injury in the right fronto-temporal-insular region with signs of a gliotic cicatricial reaction.

In the post-acute phase of the ischaemic episode AM underwent language evaluation. He was diagnosed with global aphasia and then submitted to a six month course of logopedic treatment held in a rehabilitative centre. Data we have collected from after-treatment evaluation evidenced an amelioration in comprehension (scores at Token Test from 19/36 correct in July 2000 to 30/36 correct at the end of treatment). Production was still very limited, characterised by non fluent speech (there are no quantitative data available).

AM came to our observation in September 2001, 16 months after the onset of symptoms.

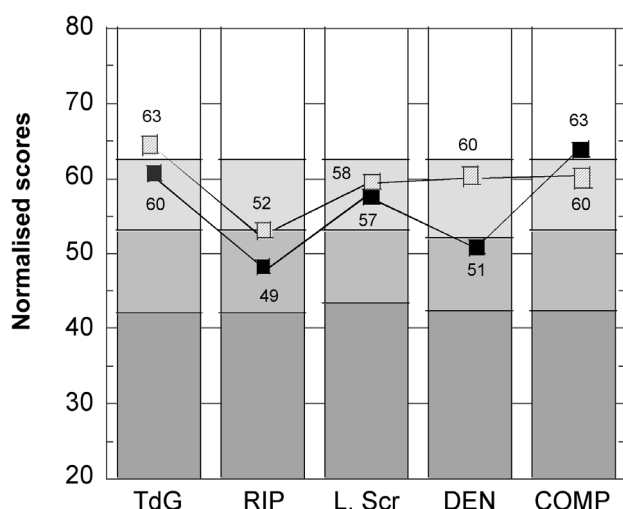
Background neuropsychological assessment

Language evaluation was performed through administration of the AAT (Aachener Aphasia Test, 19) - see Figure 1. AM then underwent tests for memory, attention, non-verbal intelligence, oro-facial, ideomotor and constructive praxis evaluation (see table I). Where not otherwise specified the tests administered were taken from Spinnler-Tognoni Italian standardization and normative data for neuropsychological tests (20).

The Oldfield Inventory for handedness (21) resulted in a score of 15 out of 16 actions developed with left-hand in the pre-morbid period. The only action AM developed with right hand had been writing, in that he has been forced to write with the right hand since entrance in school.

Language examination showed that spontaneous speech was non-fluent and characterised by frequent latencies and blocks. Sentences were cut short and incomplete and hence poor of meaningful content. Qualitative observation showed difficulties at each level of speech production: articulation (with difficulties in the choice of the right point and modality of articulation) and phonological programming, up to lexical access and elaboration of syntactic structures. Contextual comprehension resulted adequate. In the AAT comprehension sub-test (Token test, oral and written comprehension of words and sentences) AM obtained scores indicative of mild or minimal impairment. There was no dissociation between auditory and visual modality. Repetition showed medium impairment and was characterised by articulatory and phonological programming difficulties; repetition of long phrases and sentences revealed also a short term phonologic memory deficit. In the naming sub-test a medium level impairment emerged characterised by latencies, anomias, semantic paraphasias and a few circumlocutions.

Aachener Aphasia Test



Spontaneous speech						
	Com	Art	Aut	Sem	Phon	Synt
1 st examination	1	3	4	3	3	1
2 nd examination	2	3	4	4	4	2

Figure 1. Normalised scores at the AAT (Aachener Aphasia Test) language examination on the first (11/09/01, black squares) and second examination (18/03/02, squares with diagonals)

Table 1. AM's non linguistic neuropsychological assessment

	ORIGINAL SCORE	ADJUSTED SCORE	CUT-OFF SCORE*
<i>Memory</i>			
Verbal span - range 0-10	3	2.25	2.75
Buschke Fuld - range 0-180	85	38	36
Visuo-spatial span (Corsi Blocks) - range 0-10	6	5.5	3.25
Visuo-spatial learning (Corsi Blocks) - range 0.29.16	23.88	24.13	5.75
Rey figure delayed recall - range 0-36	9.5	6.67	6.195
<i>Semantic memory</i>			
Pyramid and Palm tree Test - range 0-30	30		100% correct
<i>Attention</i>			
Digit Cancellation Test - range 0-60	47	36.25	31
<i>Intelligence</i>			
Raven's Progressive Matrices (PM 47, set A B C D) - range 0-48	40	38.25	14.75
Elithorn's Perceptual Maze Test - range 0-16	16	16	7.5
Verbal Judg. and abstract thinking - range 0-60	51	44.25	32
Arithmetical Judgements - range 0-10	10	10	6.5
<i>Apraxia</i>			
Rey complex figure, copy - range 0-36	30	29	28.27
<i>Ideomotor apraxia - range 0-72</i>			
Right hand, non dominant	70	68	52
Mouth and face apraxia - range 0-20	19	19	18

* Scores equal to or below cut-off are considered pathological.

Picture description was characterised by a disorganised syntactic structure in which function word omissions besides difficulties of lexical access were evident.

Non-linguistic neuropsychological assessment showed a score below cut-off in the short term verbal memory test while just above cut-off for supra-span verbal learning. As foreseeable, anomias and blocks severely interfered with word production in the verbal memory tests.

Visuo-spatial short-term memory and learning, as well as delayed recall of the Rey complex figure (22) were well within the normality range.

Semantic memory tested through the pictorial version of the Pyramid and Palm Trees Test (23) resulted unimpaired.

The score of the digit cancellation test (DCT, 24) fell within the normality range.

AM's performance in non-verbal intelligence tests was well within the normality range (Raven Progressive Matrices and Elithorn's Perceptual Maze Test). Verbal and arithmetical judgements were also above cut-off.

There were no signs of oro-facial, ideomotor (25) or constructive apraxia. Ideomotor apraxia was testable only on the right due to left hemiparesis.

In conclusion, the neuropsychological evaluation showed the presence of Broca's aphasia and short term verbal memory deficit.

Rehabilitative phases and further assessments

AM's rehabilitative programme was developed over a period of two years in which different assessment sessions were followed by periods of rehabilitative treatment focused on a particular aspect of language production.

First phase of treatment

AM underwent a 3-month treatment (40 sessions - three sessions a week, about sixty minutes each) centred on articulation and phonological and orthographic output lexicon. Exercises of repetition, reading, writing and naming (with possible phonological facilitation) with the same 100 high-frequency stimuli (objects, food, clothes and occupations) were proposed. Verbal fluency exercises for both semantic (objects, food, clothes and occupations) and phonological categories (fluency by letters of the Italian alphabet) were also included.

Results

A post-treatment control through a second administration of the AAT (see Figure 1) showed a significant improvement ($\chi^2 > 9.24$, $\alpha = 0.01$) in naming sub-tests (from medium-mild to mild-minimal impairment).

AM's improvement at the AAT led us to consider the possibility of further language evaluation through administration of the BADA (Batteria per l'Analisi dei Deficit Afasici, 26).

Further language examination

The administration of the BADA battery (April 2002 - see Table II) confirmed the presence of deficits, though of differing degree, at various levels of the linguistic system (phonological, lexical-semantic and grammatical). The dissociation between production and comprehension abilities, evident in the AAT examination, was confirmed.

Concerning the ability to elaborate grammatical structures, grammatical judgements impairment was evident mainly in the visual modality (errors = 29.1%). Phrases and sentences repetition was characterised by frequent phonemic errors, omissions and substitution of elements constituting the stimulus (short term memory deficit); quantitatively errors amounted to 55%.

Spontaneous speech and oral and written pictures description showed frequent anomalous delays, blocks, phonological errors, paraphasias and errors with free and bound morphemes, particularly with verbal inflections. These last were mainly errors in the concordance subject-verb (e.g., "la mattina mi alzo e ... fa la colazione" - in the morning I wake up and ... has breakfast, "due cani corre" - two dogs runs). Speech was relatively rich in content but disorganised and characterised by abnormally simple syntactical structures. Oral and written controlled description showed less difficulties in syntactical organisation. AM was able to produce passive verbal forms on demand.

The administration of the BADA battery was particularly helpful to show the presence of grammatical production difficulties, besides other linguistic deficits. Morphological errors both in sentence production (spontaneous speech and picture description) and in the elaboration of isolated words (repetition, writing, reading, nouns and verbs written denomination) were evident. This last aspect

Table I. Battery for the analysis of aphasic deficits BADA (n° of errors/n° of stimuli, percentage of errors)

PHONOLOGY	DISCRIMINATION	AUDITORY	7/60	11.6%
		AUD/VISUAL	2/60	3.3%
		REPETITION	3/36	8.3%
		READING	8/45	17.7%
	TRANSCODING	WRITING	7/25	28%
		COPY	1/6	16.6%
LEXICON	LEXICAL DECISION	AUDITORY	2/80	2.5%
		VISUAL	10/80	12.5%
		REPETITION	6/45	13.3%
		READING	21/92	22.8%
	TRANSCODING	WRITING	11/46	23.9%
		COPY	1/10	10%
	WORD-OBJECT MATCHING	AUDITORY	0/40	0%
		VISUAL	1/40	2.5%
	WORD-ACTION MATCHING	AUDITORY	1/20	5%
		VISUAL	1/20	5%
	OBJECT NAMING	ORAL	14/30	46.6%
		WRITTEN	10/22	45.4%
ACTION NAMING	ORAL	11/28	39.2%	
	WRITTEN	11/22	50%	
NAMING ON DESCRIPTION	ORAL	8/16	50%	
GRAMMAR	DECISION	AUDITORY	9/48	18.7%
		VISUAL	7/24	29.1%
	TRANSCODING	REPETITION	11/20	55%
		READING	1/6	16.6%
	COMPREHENSION	AUDITORY	2/60	3.3%
		VISUAL	1/45	2.2%

prompted us to submit AM to an inflectional morphology training centred on the treatment of verb inflections, following the methodology proposed by Miceli et al. (18).

With the aim of reducing the influence of phonological deficits on morphological production we thought it better to apply a phonological training before the morphological one.

Second phase of treatment

Phonological training (25 sessions - three sessions a week for two months, sixty minutes each) was realized through the administration of tasks of repetition, reading and writing of 400 non-words of increasing difficulty. Stimuli were bi-syllabic non-words with simple (CVCV) and complex (CCVCV, CVCCV, CVCCCV) structure and three-syllabic non-words with simple (CVCVCV) structure. Each stimulus could be repeated on AM demand. In writing sub-test a judgment on the correctness of production of each stimulus was requested from AM.

More frequent errors along treatment were lexicalization moreover AM often required to be repeated a stimulus even more than once.

Results

The post-training control through a second administration of words and non-words transcoding sub-tests of the BADA battery showed a reduction of errors in both non-words and words transcoding sub-tests (see Table III). In particular concerning non-words, AM did not make any error in sub-tests of repetition and delayed copy. In reading and writing, errors were reduced respectively by 11% and 12%.

When the stimuli were words the improvement was more evident. Errors were 4% in word repetition, 6.5% in reading, 13% in writing and there were no errors in delayed copy.

Table III. Scores at non-words and words transcoding sub-test of the BADA pre and post phonological treatment (n. of errors/n. of stimuli, percentage of errors)

	Pre-phonological treatment	Post- phonological treatment
Non-words transcoding		
Repetition	3/36 (8.3%)	0/36
Reading	8/45 (17.7%)	3/45 (6.6%)
Writing	7/25 (28%)	4/25 (16%)
Copy	1/6 (16.7%)	0/6
Words transcoding		
Repetition	6/45 (13.3%)	2/45 (4.4%)
Reading	21/92 (22.8%)	6/92 (6.5%)
Writing	11/46 (23.9%)	6/46 (13%)
Copy	1/10 (10%)	0/10

Qualitatively errors with non words mainly consisted of articulatory difficulties (reading) or difficulties in digraph management and in discrimination of pairs of similar sounds (writing). With words a significant reduction of phonological errors was evident. There were no differences in the number of morphological errors and stress assignment errors in reading (when AM made stress assignment errors he almost always showed to have not had access to the meaning of the word). Also in spontaneous oral and written production there were significant improvements in the production of phonologically complex words (e.g. "semaforo" previously written as "sefamara" was after treatment correctly written).

Third phase of treatment: inflectional morphology training

Inflectional morphology training was conducted in two courses of two months each (three sessions a week - about 60 minutes each). Training was preceded and followed by evaluation sessions. A follow-up evaluation 1 year after the end of treatment was also conducted.

Inflections evaluation (T0)

To judge inflectional morphology performance AM was required to repeat 1150 verbal forms. These verbal forms were extracted from the paradigm of 50 regular and

irregular verbs of the three conjugations and represented a wide range of use according to a frequency vocabulary (27). The 50 verbs were subdivided into 25 pairs. Verbs of the same pair belonged to the same conjugation and were comparable for length and use frequency.

In order to create two parallel lists of 1150 verbal voices for evaluation purposes, each form of the paradigm was assigned a number (e.g. 1st person singular of the present indicative = 1, 2nd person = 2, and so on to the infinitive form = 46). From the 25 pairs, even forms of the first verb of the pair and odd forms of the second verb of the pair were assigned to the same list (List A). The parallel list was constructed in mirror fashion with odd forms of the first verb of the pair and even forms of the second (List B).

In the evaluation sessions the stimuli were presented one at a time to AM and only on his request could they be repeated for a maximum of two times.

In the first evaluation (see Table IV) AM made 271 errors out of 1150 stimuli (23.5%). A qualitative classification of errors showed the presence of 122/1150 inflectional errors with correct reproduction of the verb stem and substitution of the inflection; 109/1150 phonological and articulatory errors with production of non-words phonologically related to the stimulus characterised by the presence of omissions, substitutions and/or addition of phonemes to the original stimulus; 21/1150 mixed errors in which responses included both an inflectional and one or more phonological errors; 19/1150 were "other" errors consisting of fragments of correct response and omissions.

Inflectional morphology training

Training Set 1

The stimuli used for the treatment were selected as follows: two groups of verbal inflections were identified and assigned respectively to Set 1 and Set 2. Inflections selected belonged to regular and irregular verbs at high and low use frequency, comparable both for length (number of phonemes) and for segmental (syllabic, e.g. CVC) and supra-segmental structure (stress position). Each set consisted of 200 stimuli composed of 8 verbal inflections. Each was administered to AM 25 times (one for each of the 25 verbs selected).

Training consisted in exercises of repetition, reading aloud and writing to dictation of the different verbal forms. In addition comprehension of verbal voices was investigated, asking AM to state if a verbal form was singular or plural and if the action was taking place in the past, present or future.

After the first period of treatment (three sessions a week - about 60 minutes each - for 2 months - using the items of Set 1) a control evaluation was conducted through the administration of List B (see above) stimuli. This experimental paradigm allowed to administer the same verbal stems before and after treatment, even if the verbal voice resulted different in the two evaluation sessions.

Results at T1 (see Tables IV and V)

Results of the evaluation conducted after Set 1 treatment showed a significant reduction of total errors made

by AM, from 271/1150 before treatment to 95/1150 after treatment ($\chi^2_{100,650}$; $p < 0,001$). Analysis of errors after treatment showed the presence of 37/1150 inflectional errors (pre-/post-treatment difference reached significance: $\chi^2_{48,815}$; $p < 0,001$), 40/1150 phonological and articulatory errors, 13/1150 omissions or fragments, 3/1150 mixed errors (both inflectional and phonologic components) and 2/1150 substitutions of verbal stem with a phonologically similar stem and correct inflections.

The analysis of inflectional errors showed that errors with inflections submitted to treatment in Set 1 were reduced from 18/1150 before treatment to 4/1150 after treatment.

Inflectional errors of verbs included in Set 2 after Set 1 treatment were reduced from 11/1150 to 2/1150.

Training Set 2

The second phase of inflectional treatment was conducted in the same manner as the first. The only difference was in the selection of items (this time, Set 2) for training.

The control evaluation was conducted through the administration of the list of 1150 verbal forms submitted at the beginning of the study (List A). Considering that the previous administration of stimuli of List A was conducted 4 months before, it seemed reasonable to exclude a learning effect.

Results at T2 (see Tables IV and V)

Total inflectional errors at T2 were still significantly reduced with respect to T0 evaluation ($\chi^2_{38,283}$; $p < 0,001$). They showed a non significant increase with respect to T1 evaluation ($\chi^2_{0,809}$; $p = 0,368$). Errors with inflections treated in Set 1 were 3/1150 and errors with inflections of Set 2 were 2/1150. The remaining inflectional errors (40) regarded particularly difficult and rarely used verbal voices (particularly so in patients affected by non fluent aphasia). For this reason those verbal voices had not been included in the treatment Sets. Inflections treated in Set1 were reduced by one and inflections treated in Set 2 did not show quantitative nor qualitative modifications with respect to the post-treatment evaluation at T1. AM in fact made a total number of 92/1150 errors; 45 of these were inflectional errors, 30 phonological and articulatory errors, 4 mixed errors and 13 fragments and omissions.

Follow-up at 1-year

Results at T3 (see Tables IV and V)

Total number of errors at follow-up evaluation was 70/1150; 26 of these were inflectional errors, 37 phonological and articulatory errors and 7 were omissions.

There were no errors in inflections treated in Set 1 and just one inflectional error for an inflection treated in Set 2.

Results at follow-up evaluation showed a further reduction both of inflectional errors in general and of inflections treated in Sets 1 and 2. The number of errors, both total errors and inflectional errors, were still significantly reduced respect to T0 ($\chi^2 =_{139,101}$; $p < 0,001$). They did not show a significant difference with respect to T1 and to T2.

The comparison between the number of errors for inflections of Set 1 and those of Set 2 did not show a significant difference at any step of evaluation (T0, T1, T2, T3).

Discussion

Results of the present study show an improvement of AM's performance in each of the verbal abilities subjected to treatment (output lexicon, phonological programming and verbal inflections). The global amelioration is also evident in the analysis of samples of spontaneous speech and/or picture descriptions (see Appendix) in which both quantitative and qualitative improvement was observed at different steps of the rehabilitative programme and at the 1-year follow-up evaluation (after treatment maintenance).

Table V. Inflectional errors analysis: inflectional errors at T0, T1, T2 and T3 subdivided into Set1 and Set 2

	Total inflectional errors	Set1	Set2
T ₀ pre-training	122	18/122 (14.7%)	11/122 (9%)
T ₁ post-training Set1	37	4/37 (10.8%)	2/37 (5.4%)
T ₂ post-training Set2	45	3/45 (6.6%)	2/45 (4.4%)
T3 follow-up at 1 year	26	0/26	1/26 (3.8%)

Table IV. Errors of AM in the repetition of List A and B verbal inflections at T0 (pre-treatment), T1 (post-Set 1 treatment), T2 (post-Set2 treatment) and T3 (follow-up evaluation)

	Total errors#	Inflection#	Phon & artic	Mixed	Fragm & omiss	Root substit.
T ₀ pre-training	271/1150 (23.5%)	122/1150 (10.6%)	109/1150 (9.4%)	21/1150 (1.8%)	19/1150 (1.6%)	
T ₁ post-training Set 1	95/1150 (8.2%)	37/1150 (3.2%)	40/1150 (3.4%)	3/1150 (0.2%)	13/1150 (1.1%)	2/1150 (0.1%)
T ₂ post-training Set 2	92/1150 (8%)	45/1150 (3.9%)	30/1150 (2.6%)	4/1150 (0.3%)	13/1150 (1.1%)	
T3 Follow-up at 1 year	70/1150 (6%)	26/1150 (2.2%)	37/1150 (3.2%)		7/1150 (0.6%)	

Total and inflectional errors at T1, T2, T3 were each significantly reduced compared to T0 ($p < 0,001$). Both for total and inflectional errors there were non-significant differences among T1, T2, T3 (in all possible combinations).

AM clinical manifestations in verbal production and their evolution along treatment seemed us to fit in the model of inflectional morphology organization within the lexical-semantic system, as suggested by Miceli and Caspasso in their work of 1991 (18) which we have here replicated.

However, being present an impairment at various levels of the linguistic system, inflectional morphology was not the only deficit presented by AM. For this reason we have tried to apply a training in which the deepened analysis of linguistic skills has been followed by specific interventions which constituted the modules of a complete rehabilitation programme.

Even though our rehabilitative programme had a modular design, our data on inflectional treatment, which was the core of the rehabilitative programme, fail to show a specific effect of inflections treated and seem rather to show a generalised effect of the treatment applied.

The first finding that contradicts a specific effect of inflectional training is the presence of a significant reduction of phonological errors after the treatment of Set 1 inflections. This amelioration of phonological abilities after a treatment devoted to inflections could be at first view surprising. However it should be noted that the task of inflectional training was a repetition task. Moreover inflectional training required repetition of long and complex words which undoubtedly had also an effect to train phonology.

Concerning verbal inflections, which were the core of our rehabilitative programme, the global reduction of inflectional errors in both Sets 1 and 2 (which had not yet undergone treatment) after the first part of inflectional training seems to argue against the presence of a specific effect of inflectional training and was not expected. Our explanation is that the generalised effect of inflectional training, which regards the whole inflectional paradigm, was for AM wide enough to embrace the possible presence of a specific effect. This seems to be far more true considering that inflections included in Sets 1 and 2 were deliberately chosen in order to be particularly simple and frequent (so as to reflect needs of daily living) and were similar in the two Sets in terms of both their syllabic structure and stress assignment position. It is possible that the introduction in both Sets of more difficult and more differentiated inflections would have facilitated the manifestation of a specific effect.

After Set 2 treatment we observed an increase of the total number of inflectional errors; however inflections treated in Set 1 and in Set 2 remained almost stable (just one unit decrease in Set 1 inflections). This finding seems again explainable in terms of a generalised effect which encompasses the possible presence of a specific effect. In other terms as the amelioration of inflections treated in Set 1 seems to produce an effect also on inflections of Set 2 (which are not yet treated but are similar in many respects to Set 1 inflections) the same effect of the inflections treated in Set 2 seems to be produced on inflections treated in Set 1 (which were not submitted to treatment in the time period between T1 and T2 evaluation). The absence of an amelioration of inflections treated in Set 2 seems to be at-

tributable to a kind of saturation of the system after the first period of treatment (at T1) which did not allow a further improvement in the inflections treated.

The increase of total inflectional errors at T2 occurred in inflections which had never been submitted to treatment.

The follow-up evaluation showed a further reduction of inflectional errors which was not expected. Our hypothesis is that the long, in-depth work done on inflections during the rehabilitative programme allowed AM to activate or reorganise some mechanisms involved in verbal inflections production. Moreover we suggest that the treatment had as a secondary effect the advantage of encouraging AM to try to use and inflect verbs as often as possible. This might have produced a circular benefit in the form of continued improvement over the follow-up period. This effect seems to have been present not only for verbal inflections but also for total errors.

It is obvious that AM will not recover normal functioning. After the cerebral lesion in fact it seems that the power of the system remains limited so that in the recovery process there is the need to dedicate residual potentialities and attention to specific gains. In our case it seems natural that verbal inflections, which were submitted to longer and deeper attention during the rehabilitative programme, showed a greater long-term benefit.

In conclusion, the rehabilitative programme here applied was effective in ameliorating AM communicative behaviour more than one year after aphasia onset. This result, undoubtedly relevant on the clinical point of view, failed to be supported by statistical evidence of a specific effect of the treatment applied. We argue that the generalised and prolonged effect of our treatment paradigm is due to the activation or reorganisation of some mechanisms involved in verbal inflections production.

The clinical relevance of the outcome of this study seems at least to support the need to submit to further investigation the rehabilitative paradigm here applied, i.e. an individualised approach to the treatment of agrammatism, in which an in-depth examination of communicative behaviour led to the implementation of different modules of treatment which were administered by the speech therapist according a schedule based on the patient's individual pattern of impairment and recovery.

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APPENDIX

1° Language examination AAT (September 2001) -

Spontaneous speech, 2 minutes

Stavo fatendo i ...ieh.....stavo to-to.....bici.....è stato eh...tavo...po-lando bici.....e poi boh nonso cesso so-sta ma.....stavo stre-strettoquei non... e non più niente.

Eh.....co-computerta-ta-ta.....

2° Language examination AAT (March 2002) -

Spontaneous speech, 3 minutes

Lavoro sei ore eh..due pagate dall'imps eh sisi somma.....bene..... ho com-comperato.....boh?.....no niente. Im-piegato.....dopo ragioneria e basta; impi-e-gato una..in una fab-brica

.....fanno dei rotoloni in finta pelle eh...uno è 50 per 50 metri poi boh.....

Io mi occupo del..... del delmi occupo del.....ilmi oppo del.....banche cioè con.....non mi viene.

T0 evaluation

Complex picture description of the BDAE (28/10/02) 3 minutes

La nonna.....eh...la mamma sta lavando, sta lavando, sta...sta...sta....lavando.....vicino al lavabo che.....acqua...acqua.....solo ci-tramacima..... dunque lail il in cucina ci sono.....ci sono Anna..... e due.....Marco.....due.....

Dunque la la Anna sta a terra, mentre.....sopra il..... si..... che..... Marto sta per cadere, mentre i biscotti...raccoglie e.....dare a Anna.

Spontaneous speech (28/10/02) 3 minutes

Devo andare allo spa...allo spa allo ..all'ospedale si, perché ho...eh... ho...si, me viene un po' da ridereeh.....ca ...sangue allo mattina.....moi.....il mo.....no.....allora faccio, andiamo sono andato e fatto comocopoia e devo ora st.....ehtutto di un giorno.....pertè.....a Moa Bresa.....è Leno.....li.....mi hanno, mi legano,legano.....

T2 evaluation

Complex picture description of the BDAE (12/5/03) 3 minutes

Questa figuradunque.....è la mamma, si pensa, che stailla mamma con i due bambini un maschio e una femmina, ilsta cadendo il bambino e piendre i biscotti.....ma i.....la.....e la mamma sta lavando i piattini, i piatti davanti al lavandino che acqua fori...fuoriesci.... E non sa boh, non boh...niente non li importa. Poi la cucina che lei di fronte èharitre,fitetra....finestra dove si vede il...il casa.

Spontaneous speech (12/5/03) 1 minute and 30 seconds

Anna fa arrabbiare.....mangia, mangia....vacca cane, è che lei mangia poi du-du-du, non si mitte mai ferma, ma mai e poi a nove e trenta si....paf.....e fino alle sette e trenta non muove. Se siamo noi, io e la mamma non sembra di averla, lei cista con noi mamma e papà e quando arriva unamico, un.....boh...chiunque lei alè!

T3 evaluation

Complex picture description of the BDAE (May 2004) 3 minutes and 30 seconds

Dunque, in questa ...in questa foto..voto...votografia si....allora, in questa casa, in cucina...in.....la mogli, la donna chesta asciugando i piatti eil il.lavandino è pieno d'acqua che sta uscendo, poi nel.....e...guarda alla finestra molto grossa aperta e vede o sente il profumo. Poi c'è un bimbo su un.....seggolino che si s-s-che si ribalta con i biscotti che prende in...in...nonella..... scansaia mentre ne offre alcuni alla bimba che sta coi piedi per terra.

Spontaneous speech (May 2004) 4 minutes

Sono andato a portare l'orologio è per quello che sono venuto prima.....era pieno d'acqua.....tanto domani è già pronto e poi ce n'ho naltro a casa.

Anna ha fatto tre settimane dimamma mia.. è stata benone, adesso va.... Dunque ha fatto lunedì e ieri, cioè oggi, da-dalla nonna a Remedello, dopo ma.....poi è lei.....va un po' dai nonni, un po' da questi, un po' da quelli...

Alla una, alle due faccio, vado a fare u bel sonno: un'ora, due, tre dipende; poi mi alzo e guardo la televisione cosa fanno.....il ciclismo.....

Io sono amante di la formula uno. Partito Mikael quarto, poi però ha fatto due fermi per la ben-zina, mentre l'altri ne han fatti tre: Schumacher è stato fuori a girare, gli altri sono entrati a cambiare, a fare benzina. C'è stato l'incidente a l'italiano della Ro... della Renault, Trulli che ha fatto una.....uscita, che è andato contro il muro e s'è ribaltato e poi s'è fermato per..... è per.....ha fatto, si è fatto vedere e fortuna niente, niente a duecentocinquanta!

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