NEUROPSYCHOLOGICAL REHABILITATION, 1998, *8* (2), 123–141

# Therapy of Activities of Daily Living in Patients with Apraxia

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A test of three activities of daily living (ADL) was administered to 35 patients who had aphasia and right-sided hemiplegia after left hemisphere stroke. The number of errors correlated strongly with clinical measures of limb apraxia. Evaluation of the test distinguished between fatal errors, which prevented successful completion of the activity, and reparable errors. Fifteen patients who had made fatal errors on at least two of the three activities were admitted to a therapy study: each week they completed an ADL test. Between tests, one of the three activities was trained whereas maximal support but no therapeutic advice was given when the patients had to perform the other activities in their daily routines. In the following week another activity was trained, and in the third week the remaining activity. The cycle was repeated if there were still fatal errors after a first run. At the end of therapy, 10 of the patients could perform all three activities without fatal errors, and three made only one fatal error. Fatal errors were eliminated exclusively in the weeks when an activity was trained. The absence of any simultaneous improvement in non-trained activities indicates that there was no generalisation of training effects from trained to non-trained activities. We were able to re-examine seven patients more than six months later. The success of ADL training was preserved only in those patients who had practised the activities in their daily routines at home.

The results are discussed in relation to a distinction between knowledge about prototypical use of familiar objects and the ability to infer directly function from structure. We believe that ADL training taught the patients "instructions of use" adapted to the constraints posed by hemiplegia but did not restore their ability to solve mechanical problems by inferring functions from structure.

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The study was conducted when both authors were at the 2nd Neurological Department of the Neurological Hospital Rosenhügel in Vienna and was supported by project 8910M from the Austrian Science Foundation.

## INTRODUCTION

Limb apraxia is a frequent sequel of left hemisphere damage. In contrast to other motor symptoms of hemisphere damage limb apraxia affects the limbs bilaterally. Its manifestations are, in principle, independent of which limb is used for the execution of motor actions. If the left hemisphere lesion has caused paresis of the right limbs, apraxia will manifest itself by faulty motor actions of the non-paretic left limbs (Liepmann, 1908).

Limb apraxia is characterised by a discrepancy between defective motor actions in some situations and the manifestation of normal motor skill in other situations. It has been estimated that routine actions of everyday life constitute one of the situations in which patients with apraxia manifest normal motor skill. For example, De Renzi (1990, p.245) wrote: "The crucial point is that the patient has all the sensory–motor potentialities for proper execution of the movement, and in fact succeeds in many circumstances, but fails when the act must be performed in response to the examiner's request. Thus, although in the most severe cases even daily routines are impaired, it is rather common to see a patient who fails to make the sign of the cross or to demonstrate the use of a toothbrush on command, and nevertheless crosses her/himself on entering a church and brushes her/his teeth in the bathroom… It follows that the interest apraxia has for the neurologist is more because of the light it sheds on the neural organisation of movement planning than because of its practical consequences."

The expectation that activities of daily living (ADL) are spared from apraxia is based on the belief that they constitute overlearned routine actions which run automatically when the appropriate context is provided (de Renzi, 1990). This is not necessarily true. Limb apraxia may be accompanied by right-sided hemiplegia. The need to perform ADL one-handed with only the non-dominant left hand changes them from overlearned routine actions to novel skills and calls for solutions which even normal controls might have difficulty finding without professional support.

Empirical data on the ecological significance of limb apraxia are equivocal. Sundet, Finset, and Reinvang (1988) explored ADL independence in patients who had been discharged from a rehabilitation unit six months before and looked for correlations with neuropsychological measures obtained during their stay at the rehabilitation unit. They found that in left brain-damaged patients apraxia, as assessed by imitation of gestures, correlated significantly with ADL independence and was a stronger predictor of independence than the severity of aphasia. By contrast, Walker and Lincoln (1991) found virtually no correlation at all between apraxia (assessed by a score combining gestures to verbal command and imitation of gestures) and dressing abilities. Possibly, however, a correlation in left brain-damaged patients was obscured by the computation of one common correlation coefficient for left and right brain-

damaged patients. Foundas et al. (1995) observed mealtime behaviour of aphasic patients and found a correlation between action errors and an apraxia score evaluating performance of symbolic gestures to verbal command and imitation. Schwartz et al. (1995) observed and analysed action errors in everyday life activities in a patient with a traumatic left parietal lesion and anomia but did not explicitly comment on the relationship to clinical measures of limb apraxia.

Occupational therapists working with stroke patients frequently consider apraxia as an obstacle to ADL independence and, consequently, as a case for treatment. There is, however, a striking paucity of studies examining the efficacy of ADL training in these patients. We could locate only one paper, by Bergego, Bradat-Diehl, Taillefer, and Migeot (1994), which reports successful ADL training in a single apractic patient.

An observation that patients with apraxia have ADL difficulties which diminish during ADL training would not be sufficient to prove the efficacy of that training. It might be the case that ADL impairment recovers spontaneously and that the training only accompanies or, at best, accelerates natural recovery. Indeed, significant spontaneous recovery is commonly observed for other manifestations of apraxia. Without therapeutic intervention about one-half of patients who display apraxia on clinical testing one month after stroke are no longer apraxic when re-examined three to five months later (Basso et al., 1987; Kertesz, Ferro, and Shewan, 1984) and only about 20% are still apraxic after one year (Basso et al., 1987).

A further question to be posed about the efficacy of ADL training is whether or not any training effects generalise to situations different from the training situation and to activities different from those trained. Task specificity and context specificity of therapeutic effects are a notorious obstacle to lasting benefit of neuropsychological rehabilitation and may restrict the ecological validity of therapeutic gains.

This paper attempts to answer several questions: Does apraxia affect ADL independence in patients with right-sided hemiplegia? Can ADL independence be restored by ADL-training? Can training effects be distinguished from spontaneous recovery, and is there any spontaneous recovery of ADL capacities at all? Does successful ADL training remain restricted to the activity being trained or does it generalise to other, non-trained, activities? Do the gains of ADL training remain stable when the patients leave the therapeutic institution?

In the first part of the paper we describe our test of activities of daily living; in the second part we present data concerning the impact of apraxia on ADL in patients with aphasia and right-sided hemiplegia; in the third part we report the methods and results of ADL rehabilitation in a subsample of these patients; and in the final discussion we consider the theoretical foundations of ADL training and present a hypothesis which purports to explain both is success and its limitations.

# THE ADL TEST

## Procedure of Testing

Three activities from the domains eating, dressing, and grooming were selected for the test. The three tasks were:

*Spreading margarine on a slice of bread.* A slice of bread, a knife, a packet of margarine, and a one-hand chopping board were placed on a table in front of the patients, and they were asked to open the packet, take out margarine and spread it on the slice of bread.

*Putting on a pullover or a T-shirt.* The patients were asked to take off their pullover or T-shirt. If necessary, they were helped to do so. Then, the pullover or T-shirt was laid out before them, and they were asked to put it on again.

*Brushing teeth.* The patients were placed in front of a sink. On the sink, there was a closed tube of toothpaste and a beaker with a toothbrush in it, beside the sink there was a handkerchief. The patients were asked to brush their teeth.

For patients with false teeth, *creaming hands* was used as an alternative to brushing teeth. A closed pot of hand cream was placed on a table in front of the patients and they were asked to spread cream over both hands.

Patients were tested only if their actions made it unequivocally clear that they had understood the instructions and tried to comply with them. During the test the patients remained in their wheelchairs. No help was given during task execution. The examining occupational therapist interfered and helped the patients through the remainder of the task only if a fatal error (see below) occurred before the end of the task.

## Rating of Tests

Scoring was done during test performance by a trained occupational therapist (SH). For the therapy study all ADL tests was simultaneously scored by a second observer. In addition, several tests were videotaped and scoring was discussed.

For scoring, sheets were prepared which listed all the steps necessary for accomplishment of the task[1]. The rater recorded, for each step, whether and in what sequence it was performed. In addition, she noted errors occurring during performance of a step. She recorded whether the error concerned the selection of objects, the movements done with the object, or the sequence of steps. Errors

[1]Samples of scoring sheets can be obtained from the authors.

were classified as "reparable" or "fatal". An error was considered reparable if the patient succeeded in continuing the task. The error was rated as fatal if the patient was unable to proceed without help, or if as a consequence of the error the task was accomplished without fulfilling its essential purpose. Only one fatal error could be counted per task. Evaluation of fatal errors was thus equivalent to a pass/fail rating of the accomplishment of the task.

For example, if a patient compressed the middle part rather than the end of the tube in order to extract toothpaste, this was classified as a reparable (movement) error. If they held the beaker under the water tap without having opened it and then put the empty beaker back again, this was also primarily classified as a reparable (sequence) error as it left open the opportunity of filling the beaker later on. If, however, the patient never succeeded in filling the beaker and either called for help or did not rinse the mouth after brushing the teeth, the same error was considered fatal. If the patient eventually sucked the toothbrush rather than brushing the teeth and then disposed of the toothbrush, this was considered a fatal (movement) error. If a patient inserted the sound arm into the sleeve of the pullover before pulling the other sleeve up the plegic arm and could not proceed any further without help, this was a fatal (sequential) error.

On discussing discrepancies between the simultaneous ratings of two observers and on re-evaluation of the videotapes, the classification into sequence, object, and movement errors did not yield unequivocal ratings in many instances, although it proved to be helpful as a starting point for planning therapy in individual patients. Therefore, statistical evaluations will distinguish only between reparable and fatal errors.

## Reliability of Rating

During the course of the therapy study (see below) a total of 69 ADL tests from 15 patients were rated simultaneously by two observers. Pearson product-moment correlations between both raters were computed for the number of errors accumulated across all three tasks of the ADL test. (For fatal errors, the maximum possible is three, whereas there is no upper limit to the possible number of reparable errors. The observed range of fatal errors was from zero to three, and that of reparable errors from zero to six). For reparable errors, the correlation coefficient was .83, and the maximum difference between the raters was 3. For fatal errors, the correlation coefficient was .96 and the maximum difference was 1. This difference occurred in four tests and was in all of them caused by discordance as to whether the final action of a task was adequate for the essential purpose or not. For example, a typical source of discrepancy was the judgement of whether the movements of the toothbrush inside the mouth were sufficient for classifying the action as effective toothbrushing.

## Discussion

The procedures for testing and rating were designed to be applicable in a clinical setting which poses limitations on the expense of time and technical equipment. Application of a more fine-grained system of error classification and rating of all tests without time constraints from videotapes might have improved the qualitative analysis of errors (e.g. Mayer et al., 1990). However, as far as quantitative assessment of errors is concerned the reliability is reasonably good for reparable errors and very good for fatal errors.

# RELATIONSHIP OF ADL TO APRAXIA

Patients with right-sided hemiplegia cannot accomplish the three tasks of the ADL test in the same way as normal controls. They have to master them one-handed using the left hand. It might be that any patient with right-sided hemiplegia would be unable to succeed without special training. To find out whether apraxia influences ADL capabilities beyond and above right-sided hemiplegia, we analysed ADL tests and results of clinical apraxia testing in right-sided hemiplegic patients who had not yet received any special training in ADL activities.

## Method of Testing

The following tests were given for the clinical assessment of apraxia.

### *Imitation of meaningless gestures.*

Imitation was tested for three kinds of meaningless gestures: *Imitation of hand position* required the patients to copy different positions of the hand relative to the head while the configuration of the fingers remained the same. For *imitation of finger configuration* the patients were asked to replicate different configurations of the fingers (e.g. a ring finger with thumb and fourth finger; extension of only the first, second, and fifth finger). The position of the whole hand relative to the body was not considered for scoring. *Imitation of combined gestures* required both a defined position of the hand relative to the body and a defined configuration of the fingers (Goldenberg, 1996).

The procedure for testing and scoring was the same for all types of gesture. The examiner sat opposite the patient and demonstrated the gesture “like a mirror” with his right hand. The patients started imitation immediately after the demonstration. For a correct imitation on the first attempt two points were credited. Otherwise, the demonstration was repeated and one point was given for a successful second attempt. Scoring considered only the final position of the hand or fingers and did not take into account hesitation, searching move-

ment, or self-corrections during the course of the movement, nor did it consider minor variations of the angle of the hand or the degree of extension of single fingers.

### *Pantomime of object use*

Performance of meaningful gestures on command was tested for 10 pantomimes of object use (transitive gestures) such as "hammering a nail" or "looking through binoculars". The instruction was given verbally and at the same time the object whose use was to be demonstrated was briefly shown to the patient. A practice item was given first, and if this did not elicit a correct pantomime, the pantomime was demonstrated. Two points were given for each correct gesture and one point for an inaccurate but recognisable performance. Using body parts as objects in otherwise correct pantomimes of object use was credited with a score of one.

### *Use of objects*

The 10 objects whose use had to be demonstrated in the pantomimes of object use were given to the patients and they were asked to use them. Two points were given if the use was correct. One point was credited if the aim of the action was achieved only after hesitation and searching

All patients had clinical examinations to classify the type of aphasia. The German version of the Token Test (Hubert, Poeck, Weniger, and Willmes, 1983) was administered as a measure of the general severity of aphasia.

Assessment of aphasia and apraxia was performed by one of the authors (GG) and the ADL test by the other (SH) within two days. The authors did not communicate their results until they had finished their documentation.

## Patients

The ADL test and clinical apraxia tests were administered to 35 right-handed patients who had been consecutively admitted to our rehabilitation ward because of a first, unilateral cerebrovascular accident within the territory of the left middle cerebral artery causing right-sided hemiplegia and aphasia. In all patients the paresis of the right upper extremity was so severe as to prevent any functional use. There were nine women and 26 men with a mean age of 56.0 years (SD = 12.0). The mean duration since onset was 6.8 weeks (SD = 4.9). Aphasia was classified as global in 19, Broca in five, Wernicke in two, conduction in two, amnesic in three, and non-classifiable in four. None of the patients had already received training for ADL.

## Results

Nine (25.7 %) patients finished all three tasks without a fatal error, eight (22.9 %) committed one fatal error, 12 (34.3 %) failed two tasks, and six (17.1 %) could not accomplish a single task. Out of the nine patients who had correctly finished all three tasks, five had not committed any reparable error either, while three had made a single, and one had made two reparable errors. The number of reparable errors was positively correlated with the number of fatal errors ($r$ = .35, two-sided $P < .05$). Table 1 shows the results of the Token Test and apraxia testing. Not surprisingly, the aphasic patients scored lower than controls on all tests.

Tables 2 and 3 show the Pearson product-moment correlations between apraxia testing and the Token Test on the one hand, and the number of errors in the ADL tests on the other. There were highly significant correlations between the number of fatal errors and all tests of apraxia and aphasia, whereas for reparable errors only the relationships to pantomime of object use and imitation of combined gestures reached significance.

To distinguish between the contributions of aphasia and apraxia on ADL, partial correlations were computed. Correlations of the five apraxia tests to the number of fatal errors were controlled for covariance with the Token Test. All of them remained significant. By contrast, the relationship between the Token Test and the number of fatal ADL errors lost significance when controlled for the covariance with any apraxia test except imitation of finger configuration.

## Discussion

As normal controls are not hemiplegic, it was not feasible to obtain useful control data for the ADL test. However, nine out of 35 patients with right-sided hemiplegia mastered all three ADL without any prior training. This observation has two implications. On the one hand it indicates that hemiplegia *per se* does not make task solutions impossible, and that there are patients who can find out by themselves how to solve tasks with only the non-dominant left hand. On the other hand, it demonstrates that the majority of patients with right-sided hemiplegia do not succeed in performing basic activities of daily living on their own.

Both the Token Test and clinical tests of apraxia had significant correlations to ADL capabilities, but the relationship of the Token Test was comparatively weak and lost significance when controlled for its covariance with tests of apraxia. It thus appears plausible that failure on ADL was primarily related to the severity of apraxia and not to the severity of aphasia.

TABLE 1
Results of Token-test and Apraxia Testing

| | *35 patients with aphasia and right-sided hemiplegia* | | *Subgroup of 15 patients taken into therapy study* | | *60 controls* | |
|---|---|---|---|---|---|---|
| | *Mean* | *SD* | *Mean* | *SD* | *Mean* | *SD* |
| Token test | 9.4 | 13.8 | 1.7 | 2.7 | – | – |
| Imitation of | | | | | | |
| Hand positions | 13.1 | 6.2 | 8.1 | 5.9 | 19.7 | 0.6 |
| Finger configurations | 14.7 | 4.9 | 11.2 | 5.4 | 19.1 | 1.2 |
| Combined gestures | 9.1 | 6.0 | 2.3 | 4.3 | 17.3 | 2.1 |
| Pantomime of object use | 6.8 | 6.4 | 1.9 | 4.4 | 17.2 | 2.1 |
| Object use* | 15.6 | 4.1 | 12.4 | 4.0 | 19.7 | 0.6 |

The maximum score for all apraxia tests is 20. A description of the control group can be found in Goldenberg (1996).

*Only 23 controls were examined for the test of object use.

TABLE 2
Relationship of Aphasia and Apraxia to ADL

| | *Fatal errors* | *Reparable errors* |
|---|---|---|
| Token test | −0.48** | −0.23 |
| Imitation of | | |
| Hand positions | −0.67*** (−0.58***) | −0.31 |
| Finger configurations | −0.52** (−0.40*) | −0.16 |
| Combined gestures | −0.64*** (−0.53**) | −0.38* |
| Pantomime of object use | −0.64*** (−0.50**) | −0.47** |
| Use of objects | −0.67*** (−0.62***) | −0.25 |

Pearson's $R$ *$P < .05$; **$P < .01$; ***$P < .001$ (one-tailed). Values in parentheses are partial correlations controlling for covariance of Token Test.

TABLE 3
Partial Correlations of Token Test to Number of Fatal Errors

| | |
|---|---|
| *Controlling for:* | |
| Imitation of | |
| Hand positions | −0.11 |
| Finger combinations | −0.35* |
| Combined gestures | −0.21 |
| Pantomime of object use | −0.12 |
| Use of objects | −0.29 |

Pearson's $R$ *$P < .05$.

## THERAPY OF ADL

The 15 out of 18 patients who had committed two or three fatal errors on the ADL task were admitted to a therapy study. The aim of the study was to find out whether special training can restore ADL independence in these patients, and whether success of training can be reliably distinguished from spontaneous recovery. A further question was whether success obtained by training of one activity would generalise to other activities. Finally, in a follow-up examination, we sought to find out whether a gain in ADL capacities and independence would be stable when patients had left the therapeutic institution.

### Study Design

Each week a complete ADL test was conducted. Between tests, one of the three activities was trained, whereas maximal support but no therapeutic advice was given for the other activities in the patient's daily routines. In the following week another activity was trained, and in the third week the remaining activity (Fig. 1). The activity trained first was different for each patient. A reduction of errors in the trained activity was considered to reflect the effect of therapy, and a reduction of errors in the other two activities either spontaneous recovery or the effect of generalisation. In patients who had initially committed fatal errors in only two of the three activities, the third activity was trained nevertheless, as all of these patients had made reparable errors in it. It was intended to repeat the cycle until no more fatal errors were observed.

The weekly ADL tests were administered by the patients' occupational therapist and were rated simultaneously by her and a second observer who did not know which of the activities had been trained in the preceding week. In the rare cases of disagreement (see above) the judgement of the second observer was decisive.

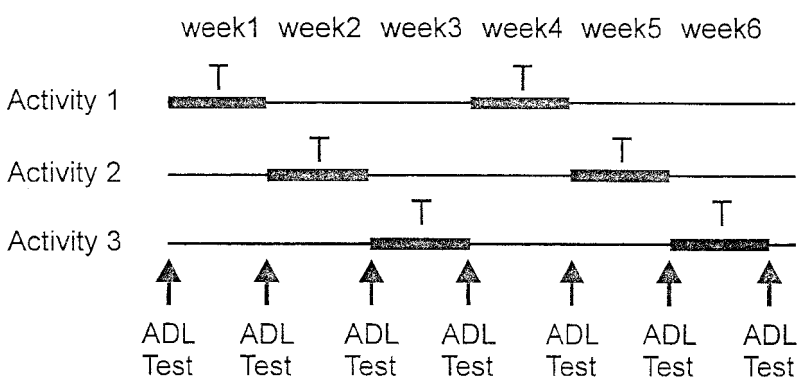


FIG. 1. The experimental design. T denotes training. Each week only one out of the three activities was trained, but the ADL test conducted at the end of each week comprised all three activities.

## Frequency and Method of Therapy

Because of the weekend only five days of therapy were given between the weekly ADL tests. All therapies were performed by the same occupational therapist (SH). Training of the selected activity was done during the daily morning routine on the ward. In addition 20–40 minutes training of the activity was included in the daily sessions of occupational therapy.

Basically, two approaches were combined: errorless completion of the whole activity and training of details.

For achieving errorless completion of the whole activity, support was given at all critical stages and was reduced only when the patients were able to pass these stages on their own. Initially, the therapist would take the patient's hand to lead it through a difficult action. Later, she would sit besides the patient and do the same action simultaneously with the patient. Simultaneity of the demonstration with its imitation and a parallel position of examiner and patient have been shown to alleviate the difficulties which apraxic patients encounter when asked to imitate movements (Jason, 1983). Only as a last stage of support before its ultimate cessation would the therapist demonstrate the required action and the patient copy it afterwards.

Training of details was aimed at directing the patient's attention to the functional significance of single perceptual details and to critical features of the actions associated with them. Steps of the activity which caused difficulties when practising the complete activity were selected for this kind of training. Patients were guided to feel and explore significant details of the objects as, for example, the bristles of a toothbrush, or to make drawings of the objects stressing such details. Actions connected to perceptual details were practised outside the context of the activity. For example, the patient practised searching for and preparing the sleeve-hole without actually inserting the arm into it. Single motor actions contained in the activity were illustrated by similar action in the context of other activities. For example, the action of squeezing toothpaste onto the toothbrush was exemplified by squeezing colours from tubes on paint brushes, or the action of spreading butter on bread with a knife was contrasted by the action of slipping small tokens off the table with a piece of cardboard.

## Patients

Three women and 12 men participated in the therapy study. Their mean age was 55.7 years (range 36–72), and the mean time from cerebrovascular accident to entry in the study was 6.1 weeks (range 4–12). Aphasia was classified as global in 10, Broca in one, Wernicke in three, and amnesic in one patient. All patients had severe apraxia on clinical assessment (see above).

## Results

Figure 2 shows the error scores of all patients at the start and end of their therapy. In 10 patients therapy was terminated when they did not commit any more fatal errors. In three patients therapy had to be interrupted after three weeks (one patient) or five weeks (two patients) when they still committed fatal errors. The reasons for the interruption were transfer to another institution in one patient and medical complications in the other two. In two further patients therapy was discontinued after three and four weeks respectively because of an obvious lack of any success of therapy. The mean duration of therapy was 3.5 weeks (range 2 to 5) for the ten patients who did not make any fatal errors at the end of the study, and 4.0 weeks (range 3 to 5) for the five patients who still made fatal errors. Across the whole group of 15 patients the number of fatal errors decreased significantly (Wilcoxon test: $Z = -3.2$, $P < .01$). By contrast, there was no significant change in the number of reparable errors (Wilcoxon test: $Z = -0.15$, $P > .5$).

Table 4 shows the influence of therapy on the reduction of fatal errors. It was statistically highly significant ($\chi^2 = 31.6$, $P < .000005$). The majority of weeks without therapy was not associated with any change of fatal errors. The few instances of spontaneous elimination of a fatal error were nearly equalled by instances of the occurrence of a new fatal error, and the probability of elimination of a fatal error did not significantly differ from the probability of occurrence of a new error (Binomial test, $P = .45$).

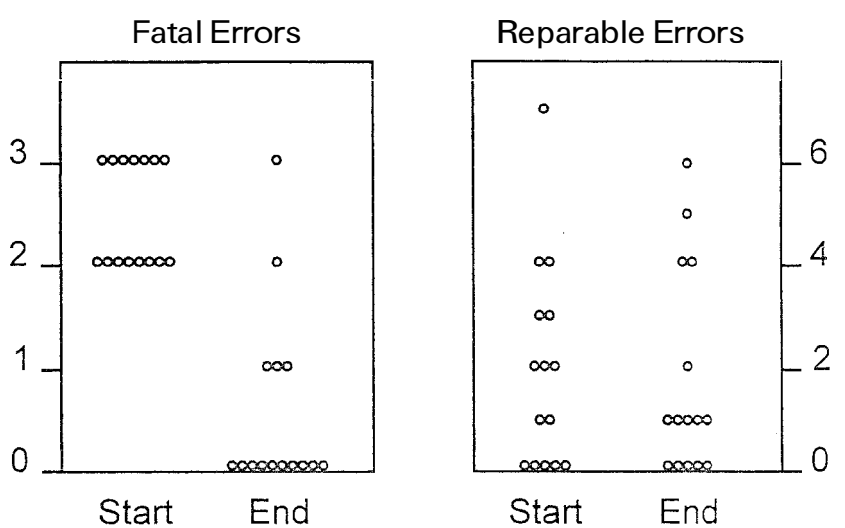


FIG. 2. Distribution of errors scores for the 15 patients at the start and end of therapy. The time from start to end varied individually (see text).

TABLE 4
Influence of Therapy on Fatal Errors

| | *110 weeks of activities without therapy* | *55 weeks of activities with therapy* |
|---|---|---|
| Elimination of fatal error | 10 | 26 |
| No change | 94 | 28 |
| Occurrence of fatal error | 6 | 1 |

$\chi^2 = 31.6$, $df = 2$, $P < .000005$. The 15 patients were treated for a total of 55 weeks. Each week therapy was given for one activity while the other two activities were without therapy. Thus, each actual week yielded three weeks of measurement, one for each activity (see Fig.1). The values give the number of weeks in which the respective change of error scores was observed.

By contrast, nearly half of the weeks with therapy led to the elimination of a fatal error, and there was only one single instance of a new fatal error occurring in a week of therapy. The probability of elimination of a fatal error was significantly higher than the probability of occurrence of a new error (Binomial test, $P < .00005$).

## Follow-up

It was possible to examine seven patients at follow-up 6–30 months after termination of therapy. All of them lived at home with their families. The ADL test was repeated and the patients' relatives were interviewed about the patients' independence in daily routines.

Table 5 compares the results of the follow-up to the number of fatal errors at the end of therapy. Inspection of the table suggests a straightforward relationship between the stability of therapeutic success and the regularity with which the patients had practised independent performance of the activities in their daily routines at home. The success of therapy was preserved in those patients who had done the activities at home, and lost in those who had not.

TABLE 5
Results of Follow-up

| *Fatal errors at end therapy* | *Activities practised at home?* | *Fatal errors at follow-up* |
|---|---|---|
| 0 | yes | 0 |
| 0 | yes | 0 |
| 0 | yes | 0 |
| 0 | partly | 1 |
| 0 | partly | 1 |
| 0 | no | 2 |
| 2 | no | 2 |

It was not easy to discern in the individual cases whether the reasons for not performing trained activities at home were due to the patients or their relatives or to an interaction between them. It appeared from the interviews that the following reasons contributed in different degrees to the abandonment of ADL independence: Patients had a preference for being helped and refused to make the effort to do ADL by themselves. Relatives underestimated the patients' abilities and felt obliged to help them as much as possible in all ADL. When relatives observed the patients' slowness and apparent clumsiness in doing the activities they interfered and took over in order to have the activities done "properly".

## Discussion

Whereas therapy led to a significant improvement of trained ADL capabilities, there was virtually no improvement when the same capabilities were left to spontaneous recovery.

The absence of any indication of spontaneous recovery contrasts with the evolution of other manifestations of apraxia. Longitudinal studies of performance of gestures on verbal command (Kertesz et al., 1984) and of imitation of gestures (Basso et al., 1987; Kertesz et al., 1984) showed considerable spontaneous improvement during the first six months following stroke. In these studies spontaneous recovery was documented at re-examinations after three months. This is about three times the mean duration of our study. However, in our study there was virtually no reduction of fatal errors at all during the weeks without therapy which makes it unlikely that spontaneous recovery would have shown up with longer intervals. At the follow-up examination, the number of fatal errors had increased in some patients, and had not decreased in the one patient who still made fatal errors on discharge. It thus seems that there is no spontaneous recovery of ADL capacities, and that the patients would never have acquired ADL independence without therapeutic intervention.

A corollary of the absence of any spontaneous recovery is that there was no generalisation of therapeutic gains from trained to non-trained activities. The effect of therapy remained specific to the activity being trained. We will return to possible explanations for this specificity in the final discussion.

Stability of the success of therapy was guaranteed only if patients continued to practise the trained activities at home. Most of the patients had stayed on the ward for some time after completion of the study and were encouraged and supported to perform the activities by themselves in their daily routine. Nevertheless, this amount of practice did not appear to be sufficient for securing the stability of independence. From our interviews with the patients' relatives we gained the impression that the cause for abandoning independence in ADL was

sometimes found in the interaction between patients and relatives rather than in the patients' own incapacities or refusal. The apparent instability of therapeutic success in ADL thus points to the necessity for extending therapeutic intervention and care to the relationships between the patients and their relatives and to the relatives' attitudes towards the patients' independence.

## GENERAL DISCUSSION

The main results of the study can briefly be summed up as follows: Limb apraxia has an adverse influence on ADL independence in patients with right-sided hemiplegia. There is no spontaneous recovery of ADL capacities in apraxic patients, but specific training can restore independence for trained activities. The success of training does not generalise to non-trained activities. It remains stable only if the activities are practised in daily routines after leaving the institution where training took place.

In the final part of the paper a hypothesis is put forward which could account for the absence of generalisation of therapeutic gains from one activity to another. The hypothesis starts from a consideration of the cognitive basis of object use and mechanical skill.

It has been reasoned that knowledge about appropriate use of tools and objects can be retrieved in two ways (Morlaas, 1928; Roy & Square, 1985; Vaina & Jaulent, 1991). On the one hand, recognition of a tool can permit access to an "instruction of use" stored as a part of semantic memory. This instruction specifies the prototypical action associated with this tool as, for example, screwing for a screwdriver, pinching and pulling for pincers, and hammering for a hammer. This way of recognising the appropriate use is available only for familiar tools and objects and supports only their prototypical use. On the other hand, possible ways of using objects can be directly inferred from a comparison of their structural properties with the requirements posed by actions. This inference can be applied to both familiar and novel objects, and it permits detection of other ways of using familiar objects than those for which they were specifically designed. For example, it allows the realisation that pincers are better adapted for hammering than a screwdriver. The capability to make such inferences subserves mechanical problem-solving in situations where contextual constraints prohibit the routine way of performing actions.

Because of hemiplegia the patients could not perform the three activities of daily living in their usual manner. Right-sided hemiplegia challenged the planning of actions in two ways. First, actions which are normally performed unimanually by the dominant right hand now had to be done by the left hand. This transfer did not seriously interfere with the validity of the instruction of use prescribing the actions. They only adaption necessary was to specify the left rather than the right hand as the executor of the actions. Second, actions which are normally performed bimanually had to be performed unimanually

by the left hand only. This restriction invalidated the instruction of use and transformed the actions into mechanical problems. Their solution called for a perceptual analysis of the object's structural properties and a comparison of these properties to the requirements of the intended actions. For example, patients could not hold the toothbrush in one hand while squeezing toothpaste out of the tube with the other hand. They had to find a way to position the brush without using a hand to hold it. An analysis of the structure of the sink was necessary to find a flat place where the brush would lie with sufficient stability. Alternatively, they might have used their mouth in a non-prototypical way for holding the handle of the brush between their teeth rather than in their hand[2].

The ADL contained actions which were to be performed in a usual way although not with the usual hand, as well as actions which called for mechanical problem-solving. Errors could thus result from either a loss of knowledge about prototypical object use or from a loss of the ability to solve mechanical problems.

Although it appeared that the non-routine parts of the three ADL were those which posed the most severe difficulties to apraxic patients, they also committed errors with actions which had to be performed as usual. For example, a typical error in toothbrushing was to immobilise the toothbrush inside the mouth rather than to make brushing movements. The brushing movement is a part of the routine action which patients only had to transfer from the dominant to the non-dominant hand. It would thus appear that at least in the majority of patients who had problems with ADL, retrieval of prototypical use was affected as well as mechanical problem-solving. Our data do not allow us to distinguish reliably their respective contributions to ADL impairment.

The assumption that apraxia interfered with knowledge about prototypical object use as well as with the capacity to solve mechanical problems leads to the question as to how ADL training influenced either of these impairments. We believe that the training taught the patients instructions of use adapted to the constraints posed by hemiplegia but did not all restore mechanical problem-solving. The main reason for this belief is the absence of any generalisation from trained to non-trained activities. If the patients had regained some capacity to solve mechanical problems by inferring function from structure they should have been able to apply this capacity to non-trained ADL and to find ways of mastering them without receiving specific instructions.

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[2] A referee remarked that it is difficult to see how severely hemiparetic patients can perform such a bilateral movement as creaming hands. The main problem in this task is the creaming of the non-paretic hand. A solution to this problem is to place the plegic hand on the table, to spread a heap of cream on its back and to rub the back and the palm of the non-paretic hand over the cream.

Our clinical experience in a day-care rehabilitation setting endorses the conclusion that the capacity for mechanical problem-solving is irrevocably damaged in patients with apraxia. Patients who had apraxia in the acute stage of stroke but who now pass clinical tests of apraxia normally and in whom training has been successful in restoring ADL independence are still awkward and "clumsy" when confronted with doing handicraft and the manipulation of technical equipment and machinery. Because of aphasia and right-sided hemiplegia vocational rehabilitation is rarely considered for these patients, but their inability to master mechanical problems may rob them of previously favourite pastimes and hobbies. The loss of competence for managing household affair or fixing repairs may cause a loss of family respect and self-esteem. The long-term residual effects of apraxia may thus add to the deprivations and restrictions caused by aphasia and motor disability and further diminish the quality of life of the afflicted patients. Paraphrasing the quotation which opened the paper (de Renzi, 1990, p.245), we conclude that apraxia does have practical consequences for patients above and beyond the light it sheds on the neural organisation of movement planning.

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## Appendix: Influence of Therapy on Fatal Errors for each Activity

### Spreading margarine on a slice of bread

| | 40 weeks of activities without therapy | 15 weeks of activities with therapy |
|---|---|---|
| Elimination of fatal error | 5 | 7 |
| No change | 33 | 7 |
| Occurrence of fatal error | 2 | 1 |

### Putting on a pullover or T-shirt

| | 33 weeks of activities without therapy | 22 weeks of activities with therapy |
|---|---|---|
| Elimination of fatal error | 3 | 9 |
| No change | 29 | 13 |
| Occurrence of fatal error | 1 | 0 |

### Brushing teeth or creaming hands

| | 37 weeks of activities without therapy | 18 weeks of activities with therapy |
|---|---|---|
| Elimination of fatal error | 2 | 10 |
| No change | 32 | 8 |
| Occurrence of fatal error | 3 | 0 |