PAPER

The impact of cognitive impairment on upper body dressing difficulties after stroke: a video analysis of patterns of recovery

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Objective: to study the underlying cognitive deficits influencing a stroke patient's ability to relearn to dress. The aim was to investigate how recovery had occurred and whether the nature of cognitive impairment was the reason for persistent dressing problems.

Methods: the dressing performance of 30 stroke patients was compared at the sub-acute stage and three months later. Standardised cognitive and physical tests were carried out, together with a video analysis of patients putting on a polo shirt.

Results: thirteen patients with preserved power in the upper limb used both arms to put on the shirt. Despite visuospatial impairment or apraxia in some cases, all were successful given sufficient time. Out of 17 patients with arm paresis, 12 were dependent putting on the shirt. Amongst the five who were independent, significantly fewer cases of cognitive impairment were seen on tests for apraxia ($p<0.05$) and visuospatial perception ($p<0.05$). Video analysis confirmed the importance of cognitive problems such as neglect or apraxia. Three patients who failed shirt dressing showed neglect or apraxia at follow up and had persistent arm paresis. Test failures also occurred amongst those who were independent.

Discussion: cognitive impairment affected patients attempting to relearn to dress with one hand, but did not affect patients who used both hands. The three patients who remained impaired on cognitive tests at follow up were unable to adapt or learn any compensatory strategies. The influence of cognition on a person's ability to learn compensatory strategies has implications for the design of rehabilitation therapies.

Dressing is a complex skill, which is important to the successful rehabilitation of stroke patients. Some patients appear to have more difficulty relearning to dress than others. This cannot be explained by physical disability alone as many patients with hemiparesis do learn to dress independently,[1] whereas in some cases dressing problems can persist for many years after a stroke.[2 3] Several studies have reported an association between dressing difficulties and cognitive impairment[4–9]; however, the majority of these have not reported on the impact of cognitive impairment over time on a person's ability to dress. Edmans and Lincoln[2] assessed 150 patients one month after a stroke and found an association between dependence for dressing and impairment in visuospatial tests. Sixty-four percent of those with test deficits were dependent for dressing compared with 5% among those with no test deficit. A two year follow up study[3] showed no significant improvement in dressing ability for patients with persistent perceptual difficulties. In a study investigating the benefits of strategy training for apraxic patients, Goldenberg and Hagman[10] confirmed the impact of apraxia on activities of daily living (ADL) function. These authors carried out a series of clinical tests together with some functional assessments on three ADL tasks. One example was putting on a pullover or T shirt. Out of 35 apraxic patients assessed only nine were able to complete all ADL tasks without making any errors. The other patients made several errors during the tasks or failed the tasks completely. The clinical tests of apraxia significantly correlated with ADL function, thus suggesting the impact apraxia can have on ADL. Van Heugten and colleagues[11] used an element of dressing (putting on a blouse or shirt) to report the impact of apraxia on ADL function. The relationship between apraxia and ADL observation was investigated in 45 patients and the ADL observations were highly associated with apraxia.

The latter half of the century has witnessed considerable debate in the literature as to the underlying deficits that influence a stroke patient's ability to relearn to dress.[12–17]

A limitation of the majority of studies is that they have relied on correlational evidence alone and causal relationships are therefore uncertain. Although such studies indicate that there is a correlation between cognitive impairment and dressing problems, the detail of this relationship remains unclear. Often therapists are unable to identify which cognitive impairment has the greater impact on the patient's ability to relearn to dress and both the therapist and patient struggle on with the patient remaining dependent for dressing.

What sorts of errors arise in dressing and are these dependent on the pattern of cognitive impairment? How is recovery of dressing skill achieved and what types of cognitive impairment are barriers to rehabilitation? Questions such as these cannot be answered simply by looking for correlations between dressing ability and scores on cognitive tests. In recent studies of dexterity after stroke[18 19] the correlational approach was supplemented with a video analysis of the types of errors made during everyday tasks such as using a teaspoon. Frame by frame analysis allowed direct observation of the impact of neglect and apraxia on manual control. Although all the patients were eventually successful in completing the dexterity tests, their clumsiness was only evident from the video analysis. The authors reported that the postural and movement errors seen were most probably due to cognitive deficits affecting perception and control of action. This is the first study not to rely on correlational evidence alone and the video analysis

Abbreviations: ADL, activities of daily living; NSDA, Nottingham stroke dressing assessment was a way of demonstrating how cognitive impairment impacts on activities of daily living.

In the present study we extended the use of video analysis to attempt to understand exactly how cognitive impairment may impact on dressing ability after a stroke. By comparing performance at the sub-acute stage and 3 months later, we hoped to learn how recovery had occurred and whether the nature of cognitive impairment was the reason for persistent dressing problems.

PARTICIPANTS AND METHODS

The local ethics committee approved the study and all patients gave informed consent.

Participants

Consecutive admissions to a community hospital stroke unit were screened. Patients were included in the study if they were within six weeks of admission and able to tolerate sitting in a chair for 15 minutes. Exclusion criteria were significant pre-morbid disability (Rankin$<$3),[20] severe depression, or dementia. Patient details are shown in table 1. Of the 11 patients with left paresis, 8 had unilateral right hemisphere infarcts, and 3 had damage to both hemispheres. Among the 19 cases of right paresis, there were 12 with unilateral hemisphere damage, 2 with bilateral damage, 2 with brainstem strokes, and 3 with no brain scan or negative CT.

Procedure

A series of standardised cognitive and physical tests was carried out. These targeted the main cognitive impairments thought to influence dressing ability and allowed the inclusion of aphasic participants. Patients were assessed at recruitment and 3 months later on the following measures:

Nottingham stroke dressing assessment (NSDA)[21]

The patient was positioned in an upright chair or a wheelchair. The clothes normally worn in hospital were scattered in view and within easy reach. For most people these were underwear, shirt or blouse, skirt or trousers, socks and trainers. For each item of clothing a score was given of 2 (independent), 1 (verbal assistance required) or 0 (hands-on assistance required after a 5 minute attempt). As there was a variation in the number of garments between patients, results were expressed as a percentage of the maximum possible score.

Video analysis of shirt dressing

A standard polo shirt in different sizes was used for all patients. The patient was seated in a wheelchair facing the video camera. The therapist held the shirt at the neck and handed it to the patient. No verbal or physical assistance was given. All the patient's actions were video recorded for analysis up to the point at which they had succeeded or had made no further progress for 3 minutes. The procedure for scoring the patient's performance for putting on the polo shirt was similar to the work of Goldenberg and Hagmann.[10] Two raters (CMW & AS) viewed the video recordings and independently recorded each step, which hand was used and if the patient made any errors. An error was considered repairable if the patient succeeded in continuing with the task. The error was rated as non-repairable if the patient was unable to proceed without help. For example, if a patient inserted the sound arm into one sleeve of the shirt before pulling the other sleeve up the hemiplegic arm and could not proceed any further without help, this would be a non-repairable error. If the patient was able to correct what they had done and continue independently, this would be a repairable error. The time taken to complete donning the shirt was also recorded. Times were taken from when the patients first grabbed the shirts to when they finished adjusting the shirts and sat with their hands on their laps. A consensus between the raters was achieved by a final joint viewing of the video.

Table 1 Characteristics of patients

	Left paresis (n = 11)	Right paresis (n = 19)
Age in years		
Mean (SD)	68.0 (9.8)	66.6 (11.4)
Range	48–86	49–83
Sex		
Men:women	6:5	10:9
Days since onset		
Mean (SD)	13.9 (7.5)	17.4 (9.5)
Range	9–34	5–35
Handedness		
Right:left	11:0	17:2
Barthel ADL on admission / 20		
Mean (SD)	9.0 (4.3)	8.7 (4.4)
Range	2–14	3–15

Cognitive and motor assessment

Line cancellation test[22]

This is a test for visual neglect in which the participant has to put a pencil mark through each of 38 oblique lines scattered across an A4 size page.

Subtests from the visual object and space perception battery[23]

Object decision—a multiple choice test of object perception in which the patient has to distinguish between the silhouette of a real object and nonsense shapes. Number location—a multiple choice test of space perception in which the patient has to identify the location of a number on the page.

Kimura box test of ideomotor apraxia[24]

This requires the patient to learn a sequence of actions using specified configurations of the non-paretic hand—to press a button with the index finger, grasp a vertical handle with all four fingers, and then press down a horizontal bar with the thumb.

Ten hole peg test of manual dexterity[25]

A board with two parallel rows of 10 holes is placed across the body midline and the task is to move the pegs one by one from the further to the nearer row. The trial is started with the non-paretic hand and then alternated for three trials with each hand.

Ten hole peg test with auditory distraction

In an attempt to measure distractibility, the peg test was repeated for a further six trials with the non-paretic hand. On alternative trials the assessor loudly tapped the baseboard every second throughout the trial.

Motricity index[26]

This was used to assess upper and lower limb paresis.

Barthel index[27]

The Barthel index of self-care was scored by a named nurse using the system by Collin et al.[27]

Rehabilitation intervention

The functional approach was used with patients.[28] Patients were given physical and verbal prompts where necessary to teach them to dress or to learn compensatory strategies. The normal movement approach[28 29] was also taken into consideration when carrying out dressing practice. Dressing practice took place on average twice weekly with the same ward occupational therapist. The treatment the occupational therapist carried out was written in each patient's care plan and the nurses would follow the plan.

RESULTS

Initial dressing ability

At the initial assessment, 20/30 patients were unable to dress independently with their own clothes. The median NSDA score for these 20 patients was 39% independence (range = 5%–95%). Table 2 shows the relationship between the NSDA scores and the shirt-dressing for video analysis. All patients who used both hands when putting on the polo shirt were successful, and all had high scores on the NSDA. Amongst those who used one hand, five were successful and 12 failed. As expected, the use of one arm rather than two was largely determined by the presence of paresis—patients who had good power and range in the paretic arm (Motricity index>65) always used that arm to assist when putting on the shirt.

Comparing those who were or were not able to dress with one hand (Groups 2 & 3 in table 2), there was an association between dressing disability and impairment on cognitive tests. All of those who were independent (Group 2) were within the normal range on tests for visuospatial perception (number location and object decision tests) and ideomotor apraxia (Kimura box), whereas 9/12 who were dependent (Group 3) were impaired on at least one of these tests (χ^2 test, $p<0.01$). Dexterity with the non-paretic hand was also poorer (10 hole peg test, $p<0.05$). Auditory distraction failed to influence peg test performance (median time for the total sample was identical in quiet and distracted conditions) so data were combined across both conditions in the above analysis.

The frequency of errors made on the video analysis

Three groups were defined, based on their performance when putting on the polo shirt. For those patients who were successful putting on the polo shirt at initial assessment, two patients made repairable errors and were within normal limits on cognitive tests. A third patient made two repairable errors and was apraxic on the Kimura box. At follow up only one patient made a repairable error and the patients were within normal limits on all cognitive tests. This group also had the highest scores on the NSDA. For the five patients who were successful putting on the shirt using one hand only, one patient made a repairable error and he was impaired on the test for neglect. At follow up another patient made three repairable errors and was impaired on the test for neglect. There were twelve patients who failed to put the polo shirt on at initial assessment. Two patients made three repairable errors and a further two patients made two repairable errors before making a fatal error. Five patients made one repairable error prior to making fatal errors. Of the three patients who made fatal errors, two of them were impaired on the test for neglect and the third was impaired on all cognitive tests; these patients failed to put on the polo shirt at follow up. The fact that the performance of these patients broke down completely within the first error indicated that they were more severely impaired than the patients in the other groups. At follow up, out of the nine patients who were successful using a one-handed strategy, four patients made one or two repairable errors before completing putting on the polo shirt. These patients also had higher scores on the NSDA.

Table 2 Initial assessment. Comparison of three groups defined by use of one or both hands and success or failure in polo shirt dressing

	Group 1, both hands, successful	Group 2, one hand, successful	Group 3, one hand, failure	Total sample
Number of cases	13	5	12	30
Side of paresis				
Left:right	5:8	1:4	5:7	11:19
NSDA %				
Mean (SD)	97 (5)	58 (31)	29 (19)	63 (35)
Range	84–100	16–100	5–66	5–100
Token test				
Mean (SD)	22 (9)	21 (9)	16 (12)	20 (10)
Range	1–30	7–29	0–30	0–30
N impaired (<27)	6	3	8	17
Motricity index, arm/100				
Mean (SD)	79 (14)	30 (21)	8 (19)	43 (37)
Range	59–100	0–54	0–62	0–100
Dexterity, non-paretic hand, pegs/second				
Mean (SD)	0.65 (0.15)	0.76 (0.22)	0.57 (0.15)	0.64 (0.17)
Range	0.34–0.88	0.62–1.16	0.34–0.86	0.34–1.16
N impaired (<0.61)*	3	0	7	10
Kimura box, errors/5				
Mean (SD)	2 (1)	1 (1)	3 (2)	2 (2)
Range	0–5	0–4	0–5	0–5
N impaired (>4)*	3	0	6	9
Object decision, correct/20				
Mean (SD)	15 (2)	16 (0.7)	11 (3)	14 (3.6)
Range	10–19	15–17	7–19	7–19
N impaired (<14)*	2	0	8	10
Number location, correct/12				
Mean (SD)	9 (2)	10 (1)	6 (4)	8 (3.9)
Range	4–12	8–12	0–12	0–12
N impaired (<7)*	3	0	7	10
Line cancellation, correct/38				
Mean (SD)	35 (7)	31 (12)	34 (8)	34 (8.6)
Range	10–38	10–38	10–38	10–38
N impaired (<37)*	2	2	3	7

*<5th percentile for normal elderly people[1 22–26]

Types of errors made on the video analysis

Those who were successful in one handed dressing used a variety of strategies. The 12 patients who failed did so because of one of four types of error:

- Disorganised strategy—for example dressing the non-paretic arm first (N = 5).
  - All five patients had left parietal or left fronto-temporal damage and four of them were apraxic on the Kimura box test.
- Failing to put the paretic hand through the correct hole (N = 2)
  - Both had right posterior damage and failed on the VOSP tests of visuospatial perception.
- Neglecting to cover the paretic (left) shoulder (N = 2)
  - Both had right posterior damage but neither showed neglect on the visual cancellation test.
- Failing to push the sleeve high enough over the paretic elbow (N = 3)
  - This appeared to be a non-specific problem, with these cases varying in side of damage (two left, one right) and cognitive performance.

Three month follow-up

For the 27 patients with complete follow up data, significant improvements in dressing ability were apparent on the NSDA (see table 3). The number of fully independent patients rose from 10 to 16, and the scores of those who were initially dependent rose from a median of 39% to 60% independence (Wilcoxon paired ranks test, $p<.01$). However 11 were still unable to dress independently with their own clothes (median score = 34%; range = 13–96). For the sample as a whole, there was a significant rank correlation (Spearman's test, $r_s = 0.68$, $p<0.001$) between NSDA total score and time to don the polo shirt for video analysis at follow up.

Of the 12 patients who initially failed on shirt dressing, nine were successful at follow up (see table 3). There was a significant reduction in arm paresis between the assessments (Motricity index arm, mean increase = 17, SD = 19) but success in dressing through a switch from a one handed to a two handed approach occurred for only a single patient. This patient had suffered a left frontal infarct and showed the largest increase in Motricity scores for the arm (63 points—a change from no palpable muscle contraction to full range of movement). In the remaining eight cases, shirt dressing remained one handed and independence was achieved through an improved one handed strategy.

The three cases who continued to fail on the polo shirt test all had significant cognitive impairments (see table 3). Their errors consisted of: disorganised strategy (left parietal infarct plus chronic bilateral small cortical infarcts; impaired on all cognitive tests); failure to identify the correct sleeve hole (right fronto-parietal stroke, neglect on cancellation test); and failure to push sleeve high over paretic elbow (right corona radiata and basal ganglia infarct; complete left neglect on the cancellation test and unable to achieve three correct consecutive responses on the Kimura box text). Impairment on some cognitive tests was also present for four out of nine patients who now succeeded in one handed dressing (see table 3).

DISCUSSION

All patients with preserved power in the upper limb used both arms when donning the shirt. Given sufficient time, all

Table 3 Follow-up assessment. Comparison of three groups defined by use of one or both hands and success or failure in polo shirt dressing

	Group 1, both hands, successful	Group 2, one hand, successful	Group 3, one hand, failure	Total sample
Number of patients	15	9	3	27
Side of paresis				
Left:right	6:9	3:6	2:1	11:16
NSDA%				
Mean (SD)	94 (16)	67 (33)	17 (3)	76 (33)
Range	36–100	22–100	13–21	13–100
Token test				
Mean (SD)	24 (9)	22 (9)	19 (13)	23 (9)
Range	5–30	3–30	3–28	3–30
N impaired (<27)	4	6	2	12
Motricity index, arm/100				
Mean (SD)	81 (21)	32 (27)	15 (26)	57 (35)
Range	35–100	0–75	0–46	0–100
Dexterity, non-paretic hand, pegs/second.				
Mean (SD)	0.77 (0.18)	0.79 (0.05)	0.62 (0.20)	0.76 (0.15)
Range	0.52–1.15	0.75–0.91	0.36–0.86	0.36–1.15
N impaired (<0.61)*	3	0	1	4
Kimura box, errors/5				
Mean (SD)	2 (2)	1 (2)	3 (2)	2 (2)
Range	0–5	0–5	0–5	0–5
N impaired (>4)*	3	2	1	6
Object decision, correct/20				
Mean (SD)	16 (2)	17 (2)	12 (6)	16 (3)
Range	11–19	12–20	5–18	5–20
N impaired (<14)*	2	1	1	4
Number location, correct/12				
Mean (SD)	9 (1)	9 (4)	4 (5)	8 (3)
Range	7–12	0–12	0–10	0–12
N impaired (<7)*	0	2	2	4
Line cancellation, correct/38				
Mean (SD)	36 (3)	31 (9)	24 (7)	33 (7)
Range	26–38	16–38	19–32	16–38
N impaired (<37)*	2	3	3	8

*<5th percentile for normal elderly people[1 22–26]

were successful, despite visuospatial impairment or ideomotor apraxia in some cases. Similarly, in a study of dexterity on one handed everyday tasks such as using a teaspoon[18] it was found that cases with cognitive impairment after unilateral damage were always able to complete the tasks if given sufficient time. Therefore, it seems that routine manual tasks are robust in the face of cognitive deficit. Performance may be slow and detailed video analysis may show clumsiness, but the task is eventually completed successfully. This reflects the adaptive nature of human performance in everyday contexts and that cognitive deficit after unilateral damage is seldom absolute—for example neglect is often overcome where tasks encourage leftward orientation.[30–32]

Dressing errors and cognitive impairment

The pattern of errors observed during dressing was related to the nature of cognitive impairment. Patients with right hemisphere damage had problems in selecting the correct sleeve, self-monitoring their left side or covering the paretic shoulder, suggesting deficits in visuospatial perception or neglect. Patients with left hemisphere damage dressed the non-paretic arm first or showed a disorganised dressing strategy, suggesting impaired action control due to apraxia. These results are consistent with those of Sunderland et al[18] who reported that ideomotor apraxia gave rise to characteristic dexterity errors after left hemisphere damage whereas visuospatial deficits were predictive of the type of dexterity errors seen in right hemisphere damaged participants. However, in the present study, there was poorer agreement between impaired function and test performance. At initial assessment, impaired test performance was statistically associated with dressing failure, but three hemiparetic patients failed on the polo shirt dressing despite normal test performance. At follow up assessment, the three patients who continued to fail at polo shirt dressing showed neglect or apraxia on tests, but test failures also occurred amongst those who dressed successfully. These results support the work of Goldenberg and Hagmann who reported that some apraxic patients were independent with ADL tasks despite evidence of apraxia. These discrepancies found in the present study might arise from limited validity of the tests and task specificity of cognitive impairments—for example, it is known that neglect is a variable and context specific phenomenon.[33–35] A tighter relationship with test performance was seen in the study of one handed dexterity[18] where both tests and dexterity tasks were performed within the same tabletop environment. Dressing occurs within a wider perceptual context including body awareness and perception of clothing, and this might well elicit neglect or apraxia when it is not seen on tabletop tasks. The reverse dissociation (successful dressing but impaired test performance) would be expected if we are correct in our assertion that learning to dress is an adaptive skill. Part of that skill will involve overcoming effects of cognitive impairment, such as development of a strategy to monitor the left side carefully so as to overcome the impaired attentional control which can lead to neglect,[36 37] or to provide specific strategies to overcome apraxia.[10 11]

Adaptive recovery

Amongst patients with arm paresis, over two thirds were initially unable to put on the polo shirt but by three months, most of these were able to do so. In most cases, dressing remained one handed and only one patient achieved independence through recovered function in the paretic arm. So the major route to recovery was through learning a procedure to compensate for persistent arm paresis. The role of adaptive learning in functional recovery has been a frequent source of speculation[38 39] but there has been little hard evidence to back this up. Nakayama et al[39] concluded that compensatory strategies were important in upper limb recovery, but only on the basis that functional ability improved over several months without large gains on motor tests. In contrast the video analysis used in this study provided direct evidence of compensatory learning. The clinical implications are that for dressing (and perhaps other functional skills) rehabilitation effort for the upper limb should focus on teaching compensatory strategies if there is no useful motor control in the paretic limb at the sub-acute stage.

Wider implications for dressing

This study focused on one very specific aspect of upper body dressing (pulling on a polo shirt). This allowed us to collect detailed information to compare across patients, but raises the question of whether our findings can be generalised to other aspects of dressing. The correlations with the NSDA at initial and follow up assessment points, suggests that the polo shirt assessment is a valid indicator of dressing ability. As might be expected, Walker et al[6] found that severity of hemiparesis was the strongest correlate of dressing ability, especially for lower body items where gross body movement and balance are crucial. This study is in agreement with their suggestion that cognitive factors are important especially for upper body dressing. Increased understanding of this relationship will be important in devising approaches to rehabilitation therapy which can assist the patient to learn adaptive skills to gain a degree of independence in dressing despite persistent hemiplegia.

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REFERENCES

1 **Walker M**, Drummond A, Lincoln N. Evaluation of dressing practice for stroke patients after discharge from hospital: a crossover design study. *Clin Rehabil* 1996;**10**:23–31.
2 **Edmans J**, Lincoln NB. The relationship between perceptual deficits after stroke and independence in activities of daily living. *British Journal of Occupational Therapy* 1990;**53**(4):139–42.
3 **Edmans J**, Towle D, Lincoln N. The recovery of perceptual problems after stroke and the impact on daily life. *Clin Rehabil* 1991;**5**:301–9.
4 **Tasi I**, Howe T, Lien I. Visuospatial deficits in stroke patients and their relationships to dressing performance. *J Formos Med Assoc* 1983;**882**:353–9.
5 **Titus MND**, Gall NG, Yerxa EJ, *et al.* Correlation of perceptual performance and activities of daily living in stroke patients. *Am J Occup Ther* 1991;**45**(5):410–8.
6 **Walker MF**, Lincoln NB. Factors influencing dressing performance after stroke. *J Neurol Neurosurg Psychiatry* 1991;**54**(8):699–701.
7 **Williams N**. Correlation between copying ability and dressing activities in hemiplegia. *Am J Phys Med* 1967;**464**:1332–41.
8 **Bernspang B**, Asplund K, Eriksson S, *et al.* Motor and perceptual impairments in acute stroke patients: effects on self care ability. *Stroke* 1987;**18**:1081–6.
9 **Bjorney E**, Reinvang IR. Acquiring and maintaining self-care skills after stroke. The predictive value of apraxia. *Scand J Rehabil Med* 1985;**17**:75–80.
10 **Goldenberg G**, Hagmann S. Therapy of activities of daily living in patients with apraxia. *Neuropsychological Rehabilitation* 1998;**8**(2):123–41.
11 **Van Heughten CM**, Dekker J, van Dijk A, *et al.* Outcome of strategy training in stroke patients with apraxia: a phase II study. *Clin Rehabil* 1998;**12**:294–303.
12 **Brain W**. Visual disorientation with special reference to lesions of the right cerebral hemisphere. *Brain* 1941;**64**:244–72.
13 **McFie J**, Zangwill O. Visual-constructive disabilities associated with lesions of the left cerebral hemisphere. *Brain* 1960;**83**:243–60.
14 **Piercy M**, Hecaen H, De Ajuriaguerra J. Constructional apraxia associated with unilateral cerebral lesions—left and right sided cases compared. *Brain* 1960;**83**:225–42.
15 **Benton A**. The visual retention test as a constructional praxis task. *Confin neurol* 1962;**22**:141–55.

16 **Hecaen H**, Assal G. A comparison of constructive deficits following right and left hemisphere lesions. *Neuropsychologia* 1970;**8**:289–303.
17 **Gainotti G**, Tiacci C. Patterns of drawing disability in right and left hemispheric patients. *Neuropsychologia* 1970;**8**:370–84.
18 **Sunderland A**, Bowers MP, Sluman SM, *et al*. Impaired dexterity of the ipsilateral hand after stroke and the relationship to cognitive deficit. *Stroke* 1999;**30**(5):949–55.
19 **Sunderland A**. Recovery of ipsilateral dexterity after stroke. *Stroke* 2000;**31**(2):430–3.
20 **Rankin J**. Cerebral vascular accidents in patients over the age of 60. 2; prognosis. *Scott Med J* 1957;**2**:200–15.
21 **Walker MF**. Dressing after stroke. *Division of stroke medicine*. Nottingham: University of Nottingham, 1991:77.
22 **Wilson BA**, Cockburn J, Halligan P. *Behavioural inattention test*. Bury St Edmunds: Thames Valley Test Company, 1987.
23 **Warrington EK**, James M. *The visual object and space perception battery*. Bury St Edmunds: Thames Valley Test Company, 1991.
24 **Kimura A**, Archibald Y. Motor functions of the left hemisphere. *Brain* 1974;**97**:337–50.
25 **Annett M**. Five tests of hand skill. *Cortex* 1992;**28**:583–600.
26 **Wade DT**. *Measurement in neurological rehabilitation*. Oxford: Oxford University Press, 1992.
27 **Collin C**, Wade D, Davis S, *et al*. The Barthel ADL index: a reliability study. *Int Disabil Stud*, 1988;**10**;61–3.
28 **Zoltan B**. *Vision, perception, and cognition. A manual for the evaluation and treatment of the neurologically impaired adult*. 3rd ed. Thorofare, NJ: SLACK Inc, 1996.
29 **Pollock AS**, Durward B, Row P, *et al*. The effect of independent practice of motor tasks by stroke patients: a pilot randomized controlled trial. *Clin Rehabil* 2002;**165**:473–80.
30 **Robertson I**, North N, Greggie C. Spatiomotor cueing in unilateral; left neglect: three case studies of its therapeutic effects. *J Neurol Neurosurg Psychiatry* 1992;**55**:799–805.
31 **Robertson IH**. Phasic alerting of neglect patients overcomes their spatial deficit in visual awareness. *Nature* 1998;**395**:169–72.
32 **Robertson IH**, Hogg K, McMillan TM. Rehabilitation of unilateral neglect: improving function by contralesional limb activation. *Neuropsychological Rehabilitation* 1998;**8**(1):19–29.
33 **Bowen A**, Mckenna K, Tallis R. Reasons for variability in the reported rate of occurrence of unilateral spatial neglect after stroke. *Stroke* 1999;**30**(6):1196–202.
34 **Young AW**. Progress and neglect. *Neuropsychological Rehabilitation* 1994;**4**:225–9.
35 **Kinsella G**, Ford B. Acute recovery patterns in stroke patients. *Med J Aust* 1980;**2**:663–6.
36 **Robertson IH**, Mattingley JB, Rorden C, *et al*. Phasic alerting of neglect patients overcomes their spatial deficit in visual awareness. *Nature* 1998;**395**(6698):169–72.
37 **Ladavas E**, Menghini G, Umilta C. A rehabilitation study of hemispatial neglect. *Cognitive Neuropsychology* 1994;**11**(1):75–95.
38 **McDowell F**, Louis S. Improvement in motor performance in paretic and paralyzed extremities following nonembolic cerebral infarction. *Stroke* 1971;**2**:395–9.
39 **Nakayama H**, Jargensen H, Raaschou H, *et al*. Compensation in recovery of upper extremity function after stroke: the Copenhagen stroke study. *Arch Phys Med Rehabil* 1994:75.