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Rehabilitation by limb activation training reduces left-sided motor impairment in unilateral neglect patients: A single-blind randomised control trial

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Limb activation treatment for unilateral neglect has been shown to be effective in several single case studies (Robertson, Hogg, & McMillan, 1998a; Robertson, North, & Geggie, 1992). Limb Activation Treatment (LAT) is based on the theoretical model that links different aspects of spatial representation in the brain. Specifically, proprioceptive representations are strongly linked to external visual representations, such as activation of one may have influences on the other. LAT is implemented using an automatic device—the limb activation device (LAD). This device encourages patients with left unilateral neglect to make small movements with the partly paralysed left side of their body. Thirty-nine patients with right brain damage following cerebrovascular accident (CVA) who showed left unilateral neglect, were randomly allocated to perceptual training plus LAT or to perceptual training alone. Both groups received training of 12 sessions of 45 min duration over a 12 week period; 36 of the 39 patients were successfully followed up blind at 3 months, a total of 32 were followed up blind at 6 months and 26 at 18–24 months. Outcome was assessed using a variety of standardised functional outcome and neuropsychological measures. LAT treatment was

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associated with significantly improved left-sided motor function, with effects lasting up to 18–24 months. The limb activation device can be used in the context of existing therapy with no additional therapy time. This study shows that LAT can produce enduring improvements in left-sided motor impairment in CVA patients suffering left unilateral neglect.

INTRODUCTION

Unilateral neglect is a major obstacle to functional rehabilitation and motor recovery following stroke. This disorder is associated with lesions to a wide range of cortical and subcortical areas of the right hemisphere and entails a paucity of responsiveness and attention to events and objects on the left side of space and/or of the body (Robertson & Halligan, 1999; Robertson & Marshall, 1993). Right-hemisphere-based attentional deficits are also linked to reduced use of the left side of the body and may masquerade as apparently primary motor or sensory disorders (Sterzi et al., 1993). Unilateral neglect is also strongly linked to deficits in arousal and sustained attention (Robertson et al., 1997a; Robertson, Mattingley, Rorden, & Driver, 1998b), and deficits in sustained attention (that are closely associated with unilateral neglect) are also predictive of motor recovery following right hemisphere stroke (Robertson, Ridgeway, Greenfield, & Parr, 1997b). At least five studies have found the presence of neglect to predict poor recovery in everyday life functioning (Denes, Semenza, Stoppa, & Lis, 1982; Fullerton, McSherry, & Stout, 1986; Henley, Pettit, Todd-Pokropek, & Tupper, 1985; Kinsella & Ford, 1980; Wade, Skilbeck, & Hewer, 1983). Indeed the Denes et al. study found that the presence of neglect a mean of 53 days post-stroke was the only significant predictor of activities of daily living (ADL) functioning: severity of lesion, dysphasia, intellectual capacity all failed to show a significant relationship with ADL. Furthermore, the presence of neglect has been shown to predict the need for greater amounts of physiotherapy and occupational therapy post-stroke (Kalra, Perez, Gupta, & Wittink, 1997).

In short then, unilateral neglect has ramifications far beyond the attentional and perceptual systems involved in this disorder. This is not surprising because rehabilitation and recovery of function following brain damage is largely a process of learning, and learning depends heavily on such processes (Robertson & Murre, 1999). Learning and the plastic reorganisation of the brain's synaptic connections is extremely difficult, and in many cases impossible, if attention is not paid to the stimuli and responses involved in that learning (Recanzone, Schreiner, & Merzenich, 1993; Robertson & Murre, 1999). Hence it should not be surprising that patients who are inattentive to the left side of their bodies, as well as being more generally inattentive because of deficits in arousal and sustained attention, should show grossly impaired recovery of motor and other functions critical for successful functional recovery. This fact makes the development of a successful treatment of unilateral neglect all the more imperative.

The only treatment procedure for unilateral neglect to have been submitted to clinical trials with evaluation of long-term effects under controlled conditions consists of scanning training (Antonucci et al., 1995; Paolucci et al., 1996; Pizzamiglio et al., 1998; Robertson, Gray, Pentland, & Waite, 1990). Scanning training is a behavioural strategy that trains patients visually to scan to the neglected left side, and was first developed by Weinberg, Diller and colleagues in New York (Weinberg et al., 1977). Although the effectiveness of this strategy for improving visual neglect was demonstrated, doubts about more broad generalisation to spatial functions were raised by subsequent studies (Gouvier, Bua, Blanton, & Urey, 1987). Later, however, the potential effectiveness of extremely intensive scanning training combined with opto-kinetic stimulation was demonstrated by the group led by Pizzamiglio in Rome (Antonucci et al., 1995; Paolucci et al., 1996; Pizzamiglio et al., 1998). However, the effects of scanning training on functions such as contralesional motor impairment remain to be tested. Given that subtle lateralised attentional problems associated with right hemisphere damage may cause motor, sensory and proprioceptive deficits (Sterzi et al., 1993) it can be predicted that rehabilitation of neglect might result in improvements in motor and other functions on the impaired side, as indeed Paolucci et al. (1996) have demonstrated in the case of scanning training.

Limb activation training (LAT) is a distinctive approach to the rehabilitation of neglect. Its effectiveness has been demonstrated in several controlled single-case-experimental design studies (Robertson et al., 1998a, 1992; Samuel et al., 2000; Wilson, Manly, Coyle, & Robertson, 2000). LAT has also been subjected to a randomised controlled trial (Kalra et al., 1997), although without use of the limb activation device (LAD). In this last study, the neglect patients given LAT and standard inpatient rehabilitation had higher Barthel scores at 12 weeks (14 versus 12.5) and a significant reduction in median length of hospital stay (42 versus 66 days) compared to control patients receiving standard rehabilitation.

LAT was developed from a series of experiments based on evidence for multiple representations of space in the brain, which interact together to produce a coherent spatial reference system against which purposeful motor movements are calibrated and organised (Rizzolatti & Berti, 1990). Figure 1 illustrates these three domains—for personal, near extrapersonal, and far extrapersonal space, respectively. According to this view, it is the parallel activity of these different perceptuomotor neural maps that produces the representation of space, and conversely it is their breakdown that creates distorted representations.

A series of experiments was undertaken: first the effects of left hand finger movements on a visual scanning task were compared with an instruction to scan

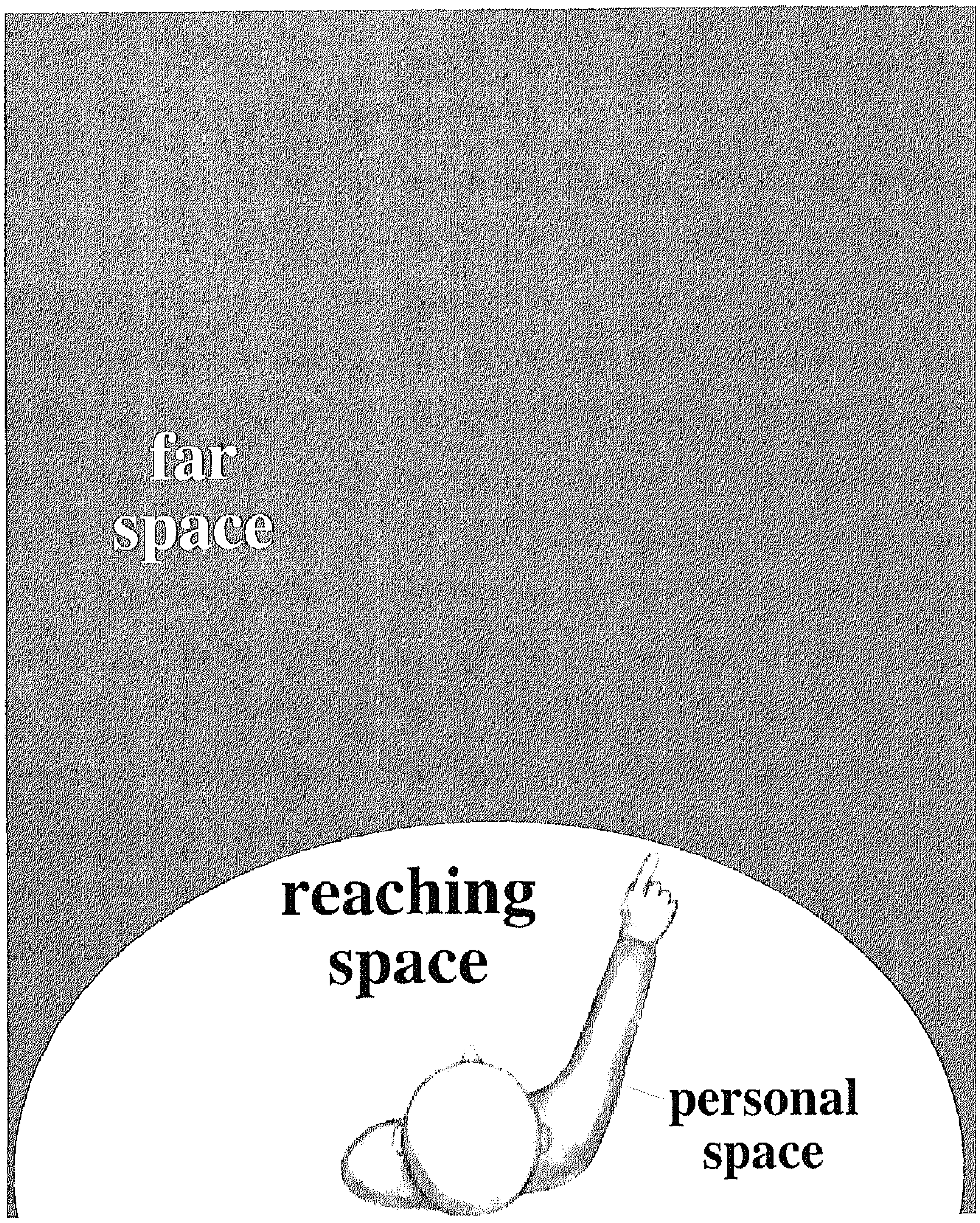

Figure 1. Three semi-independent distinct regions of space—personal space, reaching or near peripersonal space, and far space.

visually to the left side the same number of times that there were finger movements in the finger movement condition (Robertson & North, 1992). This condition allowed the effects of movements to be compared with a visual attention manipulation. Only the finger movements significantly reduced neglect. Second, a comparison was made between "out of sight" finger movements of the left hand, in left and right hemispace, respectively. Only left hemispace "blind" finger movements significantly reduced neglect compared to the standard condition. Third, blind left finger movements in left hemispace were compared with passive visual cueing (reading a changing number), and again it was found that only the finger movements reduced neglect. Finally, right finger movements in left hemispace were compared with left finger movements in left hemispace and only the latter reduced neglect.

These results suggest that this potent effect of moving the hemiplegic side results from making movements of the left limb in left hemispace and is not simply because of cueing attention to the neglected side. Applying this hypothesis to the Robertson and North data, the subject may have been suffering neglect with respect to at least two independent but nevertheless integrated spatial systems—a "personal" space relating in some way to some somatosensory representation of the body, and a peripersonal or "reaching" space within which were manifested such deficits as neglecting the left in letter cancellation. These findings have now been replicated (Ladavas, Berti, Ruozzi, & Barboni, 1997; Mattingley, Robertson, & Driver, 1998).

By inducing the subject to make voluntary movements with the left hand in left hemispace, it is possible that activity in the left half of the somatosensory personal space was activated or enhanced. The integrated nature of the somatosensory and peripersonal spatial sectors, means that this in turn produced enhanced activation of the impaired half of peripersonal space; this is an interpretation that would follow from Rizzolatti's work. But why did left hand movements in right hemispace not similarly activate the left side of peripersonal space? Even though left hemispace may not have been activated, the left side of the body was activated. One possibility is that reciprocal activation of more than one corresponding spatial sector of closely linked neuronal maps in the brain must be activated to overcome the deficit in representing the left side of space. In other words, cueing/recruitment of the hemispatial system was inadequate on its own. So also for the hemicorporeal ("personal") system. Only when both were activated simultaneously did some improvement of spatial perception of the left arise, possibly by reciprocal activation across related neuronal systems.

The above studies led to a series of treatment evaluations (Robertson et al., 1998a, 1992), which involved making minimal movements of left limbs by using a "neglect alert device", which emitted random sounds that the patient had to prevent or terminate by pressing a switch with some movement of a left limb. The results of this training were positive and daily ratings of mobility difficulties arising from the neglect showed improvements in line with the onset of treatment. These ratings improved as the training commenced, and patients also showed improvements on standardised tests.

The purpose of the present study was to conduct a randomised controlled group trial of LAT, using a semi-automatic device with a new, more effective set of characteristics from the one used in the previous single case studies. To ensure comparibility of experimental and control groups, all subjects received a standard perceptual training protocol, thus excluding the possibility of non-specific placebo variables such as novelty causing observed changes. This perceptual training protocol involved elements of training patients to scan to the neglected side and provided best approximation to current clinical practice. It is therefore possible to evaluate the *additional* effects of LAT over best current clinical practice—the aim of this study.

It was therefore hypothesised that LAT would produce (1) lasting reductions in unilateral neglect, and (2) would produce lasting improvements in contralesional motor function.

METHOD

Subjects

One hundred and fifty five patients from South London who suffered a right hemisphere CVA, were screened for unilateral visuospatial neglect. Subjects met the following criteria:

1. Diagnosis of right hemisphere stroke according to WHO criteria (Abo et al., 1980).
2. No history of major psychiatric problems or organic disorder (other than stroke) likely to influence cerebral function.
3. No other co-existing disease or disability preventing testing.
4. Willingness to provide informed consent to participate in the study.
5. Presence of unilateral left visual neglect as defined by a score of 51 or less on the Star Cancellation Test of the Behavioural Inattention Test (BIT; Wilson, Cockburn, & Halligan, 1988) or a score of 7 or less on the Line Bisection Test of the BIT, with at least two of the three lines in this test bisected to the right of centre.
6. Sensory, physical and cognitive capacities at a level sufficient to carry out all the assessment procedures described later.
7. Age under 80.
8. No other disability or disease likely to prevent or contaminate assessment or follow-up.
9. Right handed.
10. Age 20–75.
11. Score of 7 or above on the Hodkinson Mental Test for dementia (Hoddinson, 1973).

A total of 55 people with unilateral neglect met these criteria. Three of these were pilot patients and were discarded, leaving 52. Twelve of these patients dropped out before the start of treatment because of medical complications and social and geographical limitations, leaving 40 patients for randomisation.

These 40 patients were randomly allocated to an experimental treatment group (limb activation + perceptual training, LAT + PT), or to a control group (perceptual training only, PT). Each group received the same number of visits, approximating to 45 min, once a week for 12 weeks.

Of the 40 patients, 19 were randomly allocated to the LAT + PT group and 21 to the PT group. A further four subjects (two from each group) dropped out during the course of treatment. The remaining 36 patients were followed up at 3 months, and 32 of these were followed up at 6 months. Of the four who dropped out at 6 month follow-up, two had a further CVA, one died, and one refused to participate. A further 26 patients were followed up at 18–24 months, 11 in the LAT + PT group, and 15 in the PT group. Table 1 outlines the demographic and neurological characteristics of the two groups. Table 2 outlines the neuropsychological and functional status of the groups.

Procedure

Patients were recruited from hospital and community rehabilitation teams serving a large population in south west London. They were assessed on a range of measures (see below) at intake, post-training, and at 3 months and 6 months after the end of training. A further follow-up 18–24 months after training repeated a shortened version of the original battery of tests. Most patients were treated in their own homes. A small number received training in a nursing home. Therapy received from health or social services was not influenced by

TABLE 1
Clinical and demographic data on the two groups

	Experimental group LAT + PT		*Control group PT only*		
Sex (M:F)	13:6		16:5		n.s.
Age M (SD)	69.3	(9.0)	67.0	(9.4)	n.s.
Time post-stroke (days) M (SD)	152.8	(142.4)	152.1	(117.9)	n.s.
Lesion type (Infarct:haemorrhage) (NB 1 subject not classified)	18:1		16:4		n.s.
First:Recurrent stroke	15:4		19:2		n.s.
Destination on discharge from hospital (Home: Rehabilitation Unit: Nursing Home)	9:8:2		11:9:1		
Hours of therapy					
Pretraining to post-training M (SD)	14.8	(21.8)	19.05	(22.4)	n.s.
Post-training to 3 months assessment M (SD)	4.6	(7.3)	16.8	(20.9)	$t = 2.4$, $p < .02$
3 month to 6 month assessment M (SD)	7.9	(25.8)	7.5	(13.0)	n.s.

TABLE 2
Neuropsychological data on the two groups

	Experimental group LAT + PT		*Control group PT only*		
	M	*(SD)*	*M*	*(SD)*	
Barthel Index	13.3	(5.7)	11.4	(6.5)	n.s.
Motricity Index (left arm + leg)	52.4	(31.1)	44.5	(34.1)	n.s.
Tactile Sensory Detections (left)	8.8	(2.4)	7.6	(3.5)	n.s.
Frenchay Arm Test	2.2	(2.4)	1.5	(2.0)	n.s.
Behavioural Inattention Test score (Conventional tests)	107.8	(29.9)	108.7	(32.0)	n.s.
As above (Behavioural tests)	25.1	(12.0)	28.7	(13.1)	n.s.
Verbal Memory—immediate recall	17.3	(7.5)	25.2	(9.3)	$t = -2.9$; $p < .006$
Test of Everyday Attention—Elevator Counting	11.1	(4.4)	11.0	(3.5)	n.s.
Stimuli detected in lower left visual field	4.3	(1.6)	4.0	(1.9)	n.s.
Stimuli detected in upper left visual field	4.4	(1.4)	4.3	(1.6)	n.s.
Depression (Hospital Anxiety and Depression Scale)	7.3	(3.6)	8.3	(3.9)	n.s.

the trial. The amount of therapy time received was therefore monitored (see Table 1).

Assessment measures

Assessment measures given at intake only, for background and comparison purposes. Memory was assessed using the prose recall subtest of the Adult Memory and Information Processing Battery (Coughlan & Hollows, 1985). Visual fields confrontation assessment was carried out using standard confrontation testing, including catch trials and extinction trials where bilateral stimuli were presented. Ten left and 10 right single stimuli were presented. Detection of unilateral and bilateral touch to the hands was assessed using an identical format. Measures of emotional function were made using the Hospital Anxiety and Depression Scale (Zigmond & Snaith, 1983). Attention was measured using an extended version of the Elevator Counting Test of the Test of Everyday Attention (Robertson, Ward, Ridgeway, & Nimmo-Smith, 1994). The Health Locus of Control Scale (Partridge & Johnston, 1989), a measure of perceived control over recovery after stroke, was also given at 6 month follow-up. At 18–24 month follow-up the Motricity Index, CB Scale, Barthel Index and the Balloons Test of unilateral neglect (Edgworth, Robertson, &

MacMillan, 1998) were given. The last test was included to determine whether the absence of group differences on neglect measures at 6 month follow-up were because of practice effects on the standard neglect measures.

Outcome measures given at all four follow-up assessments up to 18–24 months post-intake. Three measures were given at intake and all four follow-up periods, to detect whether the rehabilitation had any effects. These were: (1) Barthel Scale of functional independence (Mahoney & Barthel, 1965). (Because of ceiling effects on the Barthel, the Nottingham Extended ADL scale was given at final follow-up; Nouri & Lincoln, 1987.) (2) The CB rating scale of unilateral neglect (Azouvi et al., 1996). (3) The Motricity Index of limb function (weighted scores are given to each movement and these are added to give a score for each arm or leg and for each side of the body, Collen & Wade, 1990). (See Table 3.)

Outcome measures given at first three follow-up assessments (up to 6 months) only. Unilateral neglect was assessed using the Behavioural Inattention Test (BIT; Wilson et al., 1988) and the Comb and Razor Test of personal neglect (Beschin & Robertson, 1997). Patients were also given an adapted version of the Landmark Test (Milner, Brechmann, & Pagliarini, 1992). In this test subjects are asked to judge which end of a 200 mm horizontal line a smaller line transecting at 90° (the "landmark") is closest to. The number of left landmarks reported as right and the number of right landmarks reported as left (in addition to their actual deviation in mm) provides a measure of lateralised perceptual bias. (See Table 4.)

Experimental and control procedures

Patients in both groups received the same perceptual training procedure and the same research therapist contact time. The only procedural difference between groups was that during the course of perceptual training, the LAT + PT group had the LAD attached to them, and were given specific instructions about limb activation in the context of this device. The PT group had a "dummy" (i.e., inactive) LAD attached to the left side of their body to control for simple cueing effects of having a stimulus attached to the left side. Further details of the procedure are outlined below.

Perceptual training procedure

The perceptual training procedure followed the exercises prescribed in *Lessons for the Right Brain*, a perceptual training workbook designed for occupational therapists (Anderson & Crowe-Miller, 1985). This training consists of a number of workbooks that the patients worked through with the help of the research therapist. It included training in perceptually organising reading and

TABLE 3

Outcome data for assessments given up to 18–24 months

	Intake		*Post-training*		*3 months post-training*		*6 months post-training*		*18–24 months post-training*	
	M	*(SD)*	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*
Barthel Index										
Experimental	13.3	(5.7)	13.1	(5.5)	14.6	(4.6)	13.6	(14.5)	25.1[1]	(21.3)
Control	11.4	(5.5)	12.6	(5.1)	12.5	(4.7)	12.3	(5.1)	24.3[1]	(15.2)
CB Rating Scale of Neglect (Informant)										
Experimental	10.5	(8.5)	9.4	(9.1)	9.9	(8.4)	11.9	(8.6)	7.6	(6.2)
Control	14.9	(9.6)	12.6	(8.8)	11.9	(8.3)	13.8	(10.5)	9.5	(6.8)
Motricity Index (total, left side)										
Experimental	53.0	(30.3)	62.0	(31.5)	66.1	(30.6)	67.3	(32.6)	67.3	(33.3)
Control	44.5	(34.1)	48.4	(36.9)	51.0	(35.3)	49.6	(35.6)	44.9	(33.4)

[1] At final follow-up ceiling effects dictated Barthel be replaced by the Nottingham Extended ADL scale (see text)

TABLE 4

Outcome data for assessments given up to 6 months

	Intake		*Post-training*		*3 months post-training*		*6 months post-training*	
	M	*(SD)*	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*
BIT Behavioural Tests								
Experimental	25.0	(12.0)	30.2	(11.9)	30.1	(11.5)	30.1	(13.2)
Control	28.7	(13.1)	31.2	(11.9)	32.8	(11.9)	33.5	(12.6)
Landmark Test (Correct)								
Experimental	2.9	(2.4)	4.0	(1.7)	3.3	(1.4)	4.2	(1.6)
Control	2.3	(2.9)	3.4	(2.0)	4.0	(2.1)	3.7	(1.8)
Comb and Razor Test								
Experimental	0.23	(0.15)	0.27	(0.15)	0.22	(0.14)	0.25	(0.16)
Control	0.23	(0.11)	0.25	(0.13)	0.22	(0.14)	0.24	(0.11)

writing, large print crosswords, two separate jigsaws, dominoes and playing cards. The training procedure did not explicitly train patients to scan to the left, but successful completion of these tasks meant that they had to be reminded to look to the left in order to solve the puzzles and carry out the various exercises. In short, not only were patients being trained to solve visuoperceptual puzzles, they were also being given considerable training in scanning to the left.

In the PT group, a "dummy" LAD was attached to the left arm and patients were told "this is to remind you to attend to your left side". No further mention was made of the LAD and it was removed at the end of each treatment session.

Limb activation training

The perceptual training procedure was applied identically in the LAT + PT group, with the exception that a "live" LAD was attached to the left side of the body. The LAD consists of a wristwatch-type attachment that can be attached to the left wrist (used in 10 LAT + PT and 10 PT patients) or the left leg or the left shoulder (9 LAT + PT and 11 PT patients). Two mercury tilt switches inside the device trigger an auditory tone in the small plastic control box attached to the patient's belt. The device is programmed to emit a tone if a movement is not made within a set period of time. When a movement is made, the mercury tilt switches reset the timer and prevent it from going off until the set period of time has elapsed once more. If the patient does not move, the device goes off, and the limb must be moved to terminate the auditory tone.

In this study, the period of time before a tone was emitted could be set between 2 and 120 s. Initially, a period of 30 s was chosen. If patients did not move within the 30 s, the research therapist reminded them to end the tone by movement. After several trials, they were asked to try to movement before the tone went off. As training proceeded, the time for which the tone was deactivated by a move was gradually decreased, and the number of left-sided movements required in each session therefore increased. The precise time intervals used and the rate of change varied from patient to patient, and depended also on which part of the body was used.

Of the 17 patients who completed training, 10 had sufficient movement of the left arm to allow the device to be attached to the left arm, while the remaining seven patients had the device attached to their left shoulder or left leg.

RESULTS

Assessment measures given at intake only, for background and comparison purposes. There were no significant differences between groups on pretraining measures except for immediate prose recall on the AMIPB, $t(38 = -2.9$; $p < .006$; LAT + PT mean score 17.3 (SD 7.5); PT mean score 25.2 (SD 9.3). These mean scores were similar to those found for this age group from the test norms (Coughlan & Hollows, 1985). This measure did not correlate significantly with the outcome measures, so this difference was not considered further in the analysis. The length of inpatient neurorehabilitation provided by the health service prior to this study did not differ between groups. Health service rehabilitation (hours) given after the study began (and which was independent of it), did not differ significantly between groups pre to post-treatment or between 3 and 6 months. However, more hours of therapy were given to the PT control group between post and 3 month follow-up treatment, $t(33) = 2.22$, $p < .02$.

Outcome measures given at all four follow-up assessments up to 18–24 months post-intake. A two-factor ANCOVA, the appropriate design for this type of study (Pedhazur & Schmelkin, 1991), was performed on each of the three outcome measures, with one between-subjects factor (treatment group; 2 levels—experimental, control) and one within-subjects factor (time; 5 levels—intake plus follow-up times 1–4). The covariate in each case was the performance at intake on the variable in question. Of the three measures, only one showed a statistically significant time by treatment condition effect, namely the Motricity Index, $F = 4.55$; $p = .009$. Neither the Barthel nor the CB scale showed a statistically significant time by treatment condition interaction.

Figure 2 summarises the changes over time for the two groups for the Motricity Index (Arm).

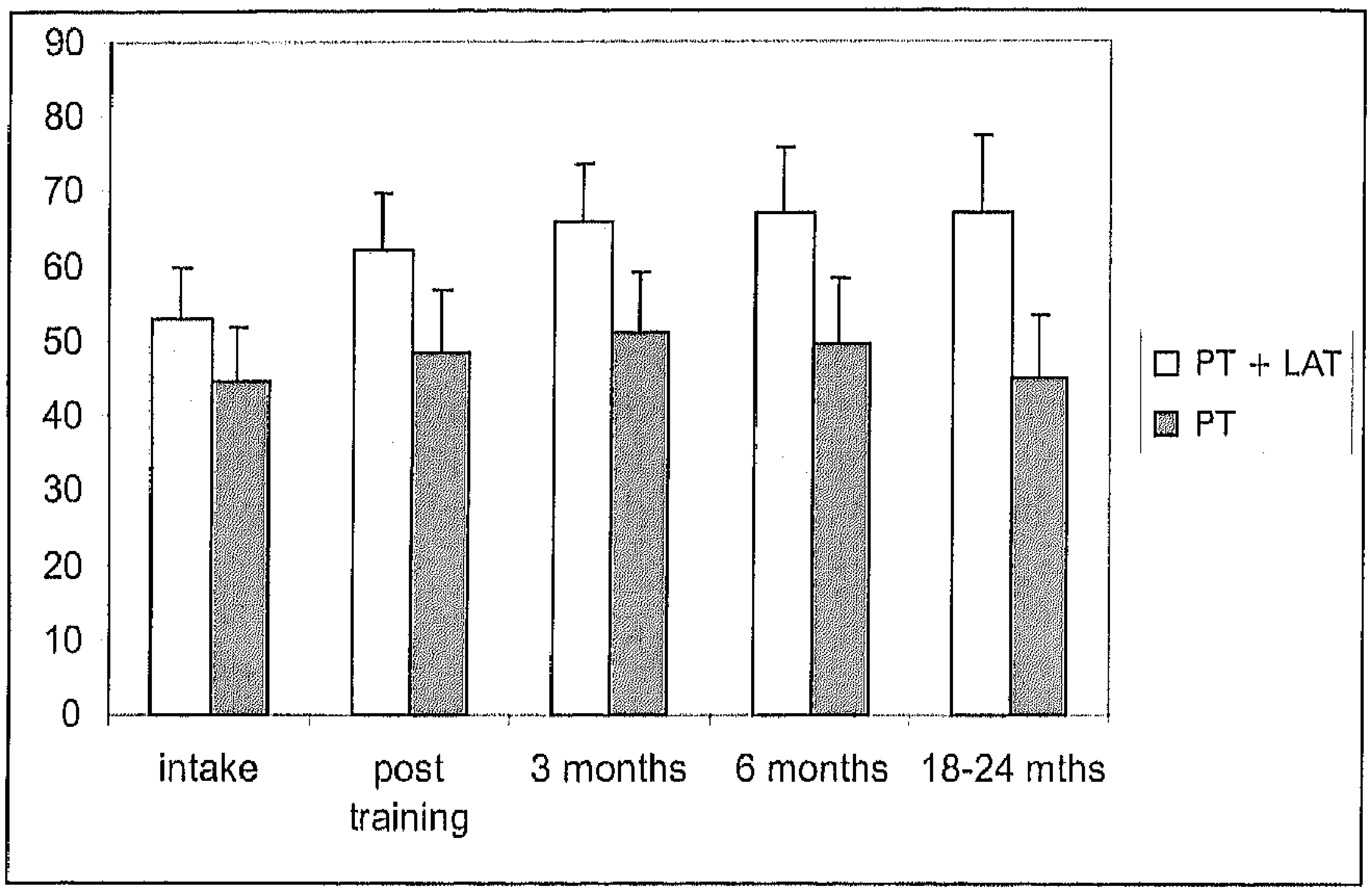

Figure 2. Motricity index arm scores over 24 months for LAT + PT and PT groups, respectively.

Outcome measures given at first three follow-up assessments (up to 6 months) only. Again using two-factor ANCOVA, the time by condition interactions for the three measures of unilateral neglect (BIT, Landmark, Comb and Razor) given at all assessment points up to 6 months post-training were examined. None of these time by condition interactions reached statistical significance.

DISCUSSION AND CONCLUSIONS

All patients in this trial received a very full perceptual training, which included considerable cueing to attend to the left side, as well as necessary feedback when they missed stimuli on the left side. Scanning training like this has been shown to reduce neglect (Antonucci et al., 1995) and is of a kind often administered in neurorehabilitation. The main purpose of the present study was to find out if LAT results in improvements that are greater than those produced by standard training for perceptual problems associated with unilateral neglect. The results show that only motor function of the left arm and leg showed a significant treatment effect, with these gains persisting over 18–24 month follow-up.

LAT training added no extra time whatsoever to existing therapy, and it imposes no additional costs on existing treatments for stroke, other than the cost of the apparatus. Clinically, the results of this randomised control trial suggest that LAT is an effective treatment for unilateral neglect post-stroke, at least as far as improving left-sided motor function is concerned. As discussed in the introduction, it is now clear that attention deficits following right hemisphere stroke often masquerade as primary sensory or motor deficits, and unilateral visuospatial neglect has been shown particularly to predict recovery of motor function after stroke. Hence, given that traditionally oriented perceptual scanning training was given to all subjects in the current study, it is not surprising that differences between groups were manifest beyond the visuoperceptual domain.

The size of the effects observed at 18–24 months is large, suggesting that improvements may continue after the end of treatment. This is entirely predictable from the theoretical model on which LAT is based. Specifically, neglect of the left side of the body results in an under use of the left side of the body, and this under use in turn decreases the general activation in perceptuomotor attentional circuits in the damaged hemisphere. When limb activation is increased by LAT, this results in greater activation and consequently, greater attention to the left side of the body. This increased attention to the left in turn increases the probability of the left side of the body being moved or used, and so on in a positive feedback loop that would predict continuing benefit of LAT after the treatment has ended. Taken together with the fact that LAT takes no longer than existing therapy, then the benefits are considerable, particularly since only 8 hours of therapy were given over 12 weeks. We predict that if LAT were used more intensively in a clinical setting (e.g., for 1–2 hours per day rather than for a short period each week) over a period of 3 months, then even greater improvement in functional status following right hemisphere stroke would be expected. There is potential to reduce disability and, with this, to reduce the level of social services care required. Furthermore, a rehabilitation assistant under the direction of a qualified therapist could in principle administer this treatment. Given this, LAT might reduce current costs of rehabilitation and care, an important consideration for all novel treatments given continuing funding difficulties in health care.

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