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EFNS TASK FORCE

EFNS Guidelines on cognitive rehabilitation: report of an EFNS Task Force

S. F. Cappa[a], T. Benke[b], S. Clarke[c], B. Rossi[d], B. Stemmer[e] and C. M. van Heugten[f]

Members of the Task Force on Cognitive Rehabilitation, [a]*Department of Psychology and Neuroscience, Vita Salute San Raffaele S. Raffaele University, DIBIT Via Olgettina 58, 20132 Milano, Italy,* [b]*Klinik für Neurologie Innsbruck, Anichstr. 35, A-6020 Innsbruck, Austria,* [c]*Division de Neuropsychologie, CHUV-Nestlé, 1011 Lausanne, Switzerland,* [d]*Section of Neurology, Department of Neuroscience, University of Pisa, Via Roma 67, 56100 Pisa, Italy,* [e]*Kliniken Schmieder, Zum Tafelholz 8, 78476, Allensbach, Germany and* [f]*Netherlands Institute of Primary Health Care NIVEL, Postbus 1568, 3500 BN Utrecht, The Netherlands*

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In 1999, a Task Force was set up under the auspices of the European Federation of Neurological Societies with the aim to evaluate the existing evidence for the clinical effectiveness of cognitive rehabilitation. This review led to the development of a set of guidelines to be used in the management of adult patients with cognitive disorders due to acquired focal neurological damage.

Objectives

The rehabilitation of disorders of cognitive functions (language, spatial perception, attention, memory, calculation and praxis), following acquired neurological damage of different aetiology (in particular, stroke and traumatic brain injury), is an expanding area of neurological rehabilitation, which has been the focus of considerable research interest in recent years. In 1999 a Task Force on Cognitive Rehabilitation was set up under the auspices of the European Federation of Neurological Societies. The aim was to evaluate the existing evidence for the clinical effectiveness of this class of interventions, and provide on this basis recommendations for neurological practice.

Background

For these guidelines, we have limited ourselves to a review of studies dealing with the rehabilitation of non-progressive neuropsychological disorders caused by stroke and traumatic brain damage (TBD). This has resulted in the exclusion of several important areas of 'cognitive rehabilitation', such as the non-pharmacological treatment of dementia and of psychiatric disorder; further, we have not considered the rehabilitation of developmental cognitive disorders, as well as, in general, the rehabilitation of paediatric patients.

Correspondence: Stefano F. Cappa, MD, Università Vita Salute San Raffaele, DIBIT Via Olgettina 58, 20132 Milan, Italy (fax: +39 02 26434892; e-mail: cappa.stefano@hsr.it).

The need to establish recommendations for the practice of cognitive rehabilitation, because of the prevalence and relevance of cognitive rehabilitation for stroke and TBI patients, has been formally recognized by a subcommittee of the Brain Injury-interdisciplinary Special Interest Group of the American Congress of Rehabilitation Medicine. The initial recommendations of the Committee were published in 1992 as the Guidelines for Cognitive Rehabilitation (Harley *et al.*, 1992): such recommendations were based on the so-called 'expert opinion', and did not take into account empirical evidence on the effectiveness of cognitive rehabilitation. More recently, a review of the scientific literature for cognitive rehabilitation in TBI published from January 1988 through August 1998 [including 11 randomized clinical trials (RCTs)] noted that data on the effectiveness of cognitive rehabilitation programmes were limited by the heterogeneity of subjects, interventions and outcomes studied (NIH Consensus Development Panel on Rehabilitation of Persons with Traumatic Brain Injury, 1999). Nevertheless, several studies were identified, including RCTs and case reports that documented the ability of interventions to improve specific neuropsychological processes (predominantly attention, memory and executive skills). It was also noted that comprehensive, interdisciplinary programmes, including individually tailored interventions for cognitive disorders, were commonly used for persons with stroke and TBI.

Search strategy

The Task Force systematically searched the Medline database using the key words and searched textbooks and existing guidelines. Articles were included if they contained data which could be rated according to the grades of recommendation for management, classified in terms of level of evidence according to the guidance statement for neurological management guidelines of the European Federation of Neurological Societies (Hughes *et al.*, 2001). Evidence level (EL) for health care interventions was classified as Ia (meta-analysis of RCTs), Ib (at least one RCT), IIa (well-designed controlled study), IIb (well-designed quasi-experimental study), III (well-designed non-experimental comparative, correlation or case studies), and IV (expert committee reports or opinions). Classification grades for management recommendations were: grade A [recommendations based on Ia and Ib evidence (RCTs)], grade B [evidence II or III (not randomized)] and grade C (expert committee reports or opinions and/or clinical experience of respected authorities; EL = IV).

Results

Rehabilitation of aphasia

The rehabilitation of speech and language disorders following brain damage is the area of intervention for acquired cognitive deficits with the longest tradition, dating back to the 19th century (Howard and Hatfield, 1987). A variety of approaches have been applied to the rehabilitation of aphasia, from stimulation approaches to the recent attempts to establish theory-driven treatment programmes based on the principles of cognitive neuropsychology (Basso *et al.*, 2000). The need to establish the effectiveness of aphasia rehabilitation has stimulated a number of investigations, dating back to the period after the Second World War, which have been based on a variety of methodologies.

A meta-analysis of studies dealing with the effectiveness of language rehabilitation, limited to aphasia as a result of stroke, has been recently made available by the Cochrane collaboration. The review covers articles about speech and language rehabilitation after stroke up to January 1999 (Greener *et al.*, 2000). The conclusion of the review is that 'speech and language therapy treatment for people with aphasia after a stroke has not been shown either to be clearly effective or clearly ineffective within an RCT. Decisions about the management of patients must therefore be based on other forms of evidence. Further research is required to find out if effectiveness of speech and language therapy for aphasic patients is effective. If researchers choose to do a trial, this must be large enough to have adequate statistical power, and be clearly reported.' This conclusion is based on a limited number of RCTs (12), all of which were considered of poor quality.

Another recent review by Cicerone *et al.* (2000), already mentioned above, reached a different conclusion. On the basis of 3 Class I studies and 4 Class II studies, the conclusion is that 'cognitive-linguistic therapies' can be considered as Practice Standard for aphasia after stroke; similar, positive conclusions for TBI were based on less consistent evidence.

The reasons for this discrepancy can be found in the different criteria used in the two reviews. Several studies included by Cicerone *et al.* (2000) were not considered in the Cochrane review for the following reasons. In comparison with an untreated control group, one study by Hagen (1973) was excluded because of the lack of true randomization (the patients were sequentially assigned to treatment or no treatment). Another study (Katz and Wertz, 1997) was probably excluded because it dealt only with computer-assisted reading rehabilitation. Two small RCTs (class I) (Helffenstein and Wechsler, 1982; Thomas-Stonell *et al.*, 1994), which reported positive treatment effects, were excluded from the Cochrane review because they were devoted to communication disorders after TBI.

By definition, all class II evidence is not included in the Cochrane review. This resulted in the exclusion of the three large studies of Basso *et al.* (1979), Shewan and Kertesz (1985) and Poeck *et al.* (1989), all indicating significant benefits of treatment. Similarly, single case studies (class IIb) are not considered in the Cochrane reviews. This is particularly relevant because most of the recent treatment studies based on the cognitive neuropsychological approach, make use of the single case methodology. A recent review paper by Robey *et al.* (1999) reports a critical discussion of this approach, concluding for the presence of generally large treatment effects in aphasic patients.

An update of the reviews mentioned above must consider the results of a small class I study of group communication treatment, compared with 'deferred treatment', which was shown to be effective on both linguistic and communication measures (Elman and Bernstein-Ellis, 1999); and of another small class I study comparing 'massed' to conventional treatment, which showed a significant superiority of the former type of intervention (Pulvermueller *et al.*, 2000). A small, class II study by Carlomagno *et al.* (2001) supports the usefulness of writing rehabilitation in patients in the post-acute stage.

Recommendation

The conclusions of the Cochrane review of aphasia rehabilitation after stroke (la evidence) are not compatible with Grade A recommendation for aphasia therapy. There is however considerable evidence, both from Ib studies not included for different reasons in the

Cochrane review, and from Class II and III studies supporting the effectiveness of the procedure, allowing a Grade B recommendation for aphasia therapy after stroke. There is a need for further investigations in the field. In particular, the evidence of effectiveness of pragmatic-conversational therapy after TBI is based on a limited number of studies on small samples, and appears in need of confirmation.

Rehabilitation of ULN

The presence of hemineglect beyond the acute stage is associated with poor outcome in terms of independence (Denes *et al*., 1982; Stone *et al*., 1992) and considerable effort is therefore devoted to its rehabilitation. We review here published studies of neglect rehabilitation, and refer also to recently published reviews (Robertson and Hawkins, 1999; Robertson, 1999; Diamond, 2001), including the recent Cochrane review (Bowen *et al*., 2002). The latter analysed 15 studies and found evidence that cognitive rehabilitation resulted in significant and persisting improvements in performance on impairment level assessments. There was, however, insufficient evidence to confirm or exclude an effect of cognitive rehabilitation at the level of disability or on destination following discharge from hospital. Different types of approaches are currently used for neglect rehabilitation; we review here evidence for these different approaches.

Combined training of visual scanning, reading, copying and figure description yielded statistically significant improvement of neglect symptoms in one level Ib (Antonucci *et al*., 1995) and two level IIa studies (Pizzamiglio *et al*., 1992; Vallar *et al*., 1997). Visual scanning training alone was shown to improve significantly neglect in one level Ib study (Weinberg *et al*., 1977). Spatiomotor or visuo-spatiomotor cueing improved neglect significantly in one level Ib (Kalra *et al*., 1997) and two level IIa studies (Lin *et al*., 1996; Frassinetti *et al*., 2001). Visual cueing with kinetic stimuli was found to bring significant, albeit transient, improvement in three level IIa studies (Butter *et al*., 1990; Pizzamiglio *et al*., 1990; Butter and Kirsch, 1995). Video feedback was shown to improve significantly performance on trained tasks in one level IIa study (Tham and Tegnér, 1997). Training of sustained attention, increasing of alertness or cueing of spatial attention were shown to improve significantly neglect in level IIa studies (Hommel *et al*., 1990; Ladavas *et al*., 1994; Robertson *et al*., 1995; Kerkhoff, 1998).

Several studies investigated effects of influencing multisensory representations. All of these studies demonstrated transient effects, lasting little longer than the end of the appropriate stimulation. Vestibular stimulation by cold water infusion into the left outer ear canal showed significant effects on different aspects of the unilateral neglect in five level IIa studies (Rode and Perenin, 1994; Rode *et al*., 1998). Galvanic vestibular stimulation improved significantly neglect symptoms in one level IIa study (Rorsman *et al*., 1999). Transcutaneous electrical stimulation of the left neck muscles showed significant effects in three level IIa studies (Vallar *et al*., 1995; Guariglia *et al*., 1998; Perennou *et al*., 2001). Changes in trunk orientation had significantly positive effects in one level Ib study (Wiart *et al*., 1997).

The use of prism goggles deviating by 10° to the right, introduced relatively recently, was shown to improve significantly, in a transient fashion, neglect symptoms in one level Ib study (Rossetti *et al*., 1998). A recent level IIa study applied the prism goggle treatment for a 2-week period and obtained statistically significant improvement in the long term (Frassinetti *et al*., 2002). Specific training of visual imagery proved useful in a level IIa study (Niermeir, 1998). Forced use of left visual hemifield or left eye showed a relative benefit in neglect in one level Ib (Beis *et al*., 1999) and two level IIa studies (Butter and Kirsch, 1992; Walker *et al*., 1996).

Computer training yielded mixed results. One level Ib (Robertson *et al*., 1990) and one level IIa study (Bergego *et al*., 1997) reported absence of significantly positive effects, whilst a recent level IIa study showed statistically significant improvement in wheel chair mobility (Webster *et al*., 2001).

Recommendation

Several methods of neglect rehabilitation were investigated in level Ib or IIa studies. The present evidence confers grade A recommendation to the combined training of visual scanning, reading, copying and figure description; to visual scanning training; to spatio-motor and visuo-spatio-motor training; to trunk orientation; and to forced use of left eye. The use of prism goggles obtained the same level of evidence for transient effect and level IIa evidence for long-term effect if used over longer periods (grade B recommendation). Grade B recommendation exists for visual cueing with kinetic stimuli; video feedback; training of sustained attention and alertness; and training of visual imagery. The same level of recommendation is valid for transient effects caused by caloric or galvanic vestibular stimulations as well as transcutaneous electrical stimulation of neck muscles. The use of computers in neglect rehabilitation remains controversial.

Rehabilitation of attention disorders

Attention deficits follow many types of brain damage, including stroke, TBI and brain tumour (Bruhn and

Parsons, 1971; Van Zomeren and Van DenBurg, 1985). A pioneer study by Ben-Yishay *et al.* (1978) explored the treatment of deficits in focusing and sustaining attention with 40 brain-injured adults. There was not only improvement on the attention training tasks, but also generalization to other psychometric measures of attention which were maintained at 6-month follow-up. Using a multiple-baseline design, with patients at 4–6 years after head injury, Wood (1986) found that contingent token reinforcement was effective in increasing patients' ability to sustain attention on a task. Several studies (Ponsford and Kinsella, 1988; Niemann *et al.*, 1990; Novack *et al.*, 1996) have explicitly incorporated and/or evaluated therapeutic interventions such as feedback, reinforcement and strategy teaching into the attention rehabilitation programmes.

The Cochrane review by Lincoln *et al.* (2000), having searched for controlled trials of attention training in stroke, identified the study of Schottke (1997) showing the efficacy of the attention training in improving sustained attention.

Thirteen studies were reviewed by Cicerone *et al.* (2000), including three class I prospective RCTs (Niemann *et al.*, 1990; Gray *et al.*, 1992; Novack *et al.*, 1996), four class II controlled studies (Sohlberg & Mateer, 1987, Strache, 1987; Ponsford and Kinsella, 1988; Sturm and Wilmes, 1991); and six Class III studies (Wood, 1986; Ethier *et al.*, 1989; Gray and Robertson, 1989; Gansler and McCaffrey, 1991; Wilson and Robertson, 1992; Sturm *et al.*, 1997). Most controlled studies compared attention training with an alternative treatment, without including a no-treatment condition; a very important distinction is between studies conducted in the acute and postacute stage. Cicerone *et al.* (2000) concluded that evidence from two class I (Niemann *et al.*, 1990; Gray *et al.*, 1992) studies with a total of 57 subjects and two class II studies (Sohlberg & Mateer, 1987; Strache 1987) with a total of 49 subjects supports the effectiveness of attention training beyond the effects of non-specific cognitive stimulation for subjects with TBI or stroke during the post-acute phase of recovery and rehabilitation. Cicerone *et al.* (2000) recommended such a form of intervention as a practice guideline for these persons. Interventions should include not only training with different stimulus modalities and complexity, but also therapist activities such as monitoring subjects' performance, providing feedback and teaching strategies. Attention training appears to be more effective when directed at improving the subject's performance on more complex, functional tasks. However, the effects of treatment may be relatively small or task-specific, and an additional need exists to examine the impact of attention treatment on activities of daily living (ADL) or functional outcomes.

Acute studies

One class I and two class II studies evaluated the effectiveness of attention treatment during the acute period of rehabilitation. The Class I study of Novack (1996) compared the effectiveness of 'focused' treatment consisting of sequential, hierarchical interventions directed at specific attention mechanisms versus 'unstructured' intervention consisting of non-sequential, non-hierarchical activities requiring memory or reasoning skills. Both groups improved, but there were no intergroup differences: the observed improvements are probably due to spontaneous recovery. One class II study (Ponsford and Kinsella, 1988) used a multiple-baseline design across subjects and evaluated a programme for the remediation of processing speed deficits in 10 patients with severe TBI (6–34 weeks post-injury). The authors reported no benefit or generalization of effects of attention training: however, improvement did occur in some patients when practice on attention training tasks was combined with therapist feedback and praise. In the other class II study (Sturm and Wilmes, 1991), 35 subjects with lateralized stroke showed beneficial effects of attention training on five of 14 outcome measures, especially on measures of perceptual speed and selective attention in left hemisphere lesions.

Post-acute

Two class I and two class II studies assessed the attention treatment effectiveness during the postacute period of rehabilitation. Gray *et al.* (1992) treated 31 patients with attention dysfunction, randomly assigned to receive either computerized attention retraining or an equivalent amount of recreational computer use. Immediately after training, the experimental group showed marked improvement on two measures of attention (but, when premorbid intelligence score and time since injury were added as covariates, the treatment effect was no longer significant); at 6-month follow-up, the treatment group showed continued improvement and superior performance in respect with the control group on tests involving auditory–verbal working memory. The authors suggested that the improvement, continuing over the follow-up period, was consistent with a strategy training model as it becomes increasingly automated and integrated into a wider range of behaviours (Gray *et al.*, 1992). In the second post-acute class I study (Niemann *et al.*, 1990) community-dwelling patients with moderate to severe brain injury were screened for orientation, vision, aphasia and psychiatric illness. The experimental attention training group improved significantly more than the alternative (memory) treatment group on four attention measures administered throughout the treatment period, although the effects did not generalize to the second set of neuropsychological measures. Sohlberg and Mateer (1987) employed a class II multiple-baseline design with four patients to evaluate the effectiveness of a specific, hierarchical attention training programme. All subjects showed gain on a single attention outcome measure administered after the start of attention training but not after training on visuospatial processing: this improvement also generalized to cognitive and everyday problems. Strache (1987) conducted a prospective class II study on patients with mixed trauma and vascular aetiologies, and compared two closely related interventions for concentration with subjects in an 'untreated' control group receiving general rehabilitation. After 20 treatment sessions, both attention treatments resulted in significant improvement on attention measures in respect of control subjects, with some generalization to memory and intelligence measures.

Within the attention domain, several attempts were made to establish the differential effectiveness of training for specific components of attention. Improvements in speed of processing appear to be less robust than improvements on non-speeded tasks (Ponsford and Kinsella, 1988; Ethier *et al.*, 1989; Sturm *et al.*, 1997). Moreover, several studies also suggest greater benefits of attention training on more complex tasks requiring selective or divided attention than on basic tasks of reaction time or vigilance (Sturm and Wilmes, 1991; Gray *et al.*, 1992; Sturm *et al.*, 1997). Wilson and Robertson (1992), implementing a series of individualized interventions intended to facilitate voluntary control over attention during functional activities, effectively decreased the attention lapses that the subject experienced when reading novels and texts.

Recommendation

During the acute period of recovery and inpatient rehabilitation, evidence is insufficient to distinguish the effects of specific attention training from spontaneous recovery or more general cognitive interventions for patients with moderate-to-severe TBI and stroke. Therefore, specific interventions for attention during the period of acute recovery are not recommended. On the other hand, the availability of class I evidence for attention training in the post-acute phase after TBI is compatible with a grade A recommendation.

Rehabilitation of memory

Memory impairment is a well-documented sequel following traumatic brain injury and has also been reported following stroke. The memory impairments described concern more general memory problems such as learning, retrieval or everyday functioning problems, address specific contents such as orientation, dates, names, faces, routines, appointments, or are orientated towards modality specific impairments such as visual versus verbal memory problems. Memory rehabilitation programmes are aimed at restoring, improving or maintaining memory functions using restorative and compensatory approaches and a variety of different techniques.

The systematic review on cognitive rehabilitation for memory deficits following stroke, published in the Cochrane Library by Majid *et al.* (2001) includes four studies that meet the inclusion criteria, that is types of trials (randomized or quasi-randomized), participants (stroke patients), interventions (treatment group versus control group), and outcome measures. They identified only one study (Doornhein and de Haan, 1998) which met the criteria for inclusion in their review. These authors investigated six stroke patients and six stroke control participants 5 months post-onset who had shown memory impairment on the Dutch version of the Rey auditory learning test. Memory strategy training was performed with the target group for 4 weeks at two sessions per week. The training programme consisted of six memory strategies for the target group and non-specific training involving repetitive practice on memory tasks for the control group. Memory strategy training had no significant effects on memory impairment or subjective memory complaints. Majid *et al.* (2001) conclude that cognitive rehabilitation in the treatment of memory deficits following stroke cannot be supported or refuted by results from RCTs.

The Cicerone *et al.*'s (2000) review considered 42 studies meeting the criteria (dating from 1977 to 1998), which were assigned to classes I, II or III.

There were four RCT (Class I) studies of subjects with TBI (Kerner and Acker, 1985; Ryan and Ruff, 1988; Berg *et al.*, 1991; Schmitter-Edgecombe *et al.*, 1995), four class II studies (Freeman *et al.*, 1992; Parente, 1994; Goldstein *et al.*, 1996; Wilson *et al.*, 1997), and 34 class III studies.

All four class I studies cited in the Cicerone *et al.*'s (2000) review addressed the effectiveness of training compensatory strategies in memory rehabilitation. Berg *et al.* (1991) investigated 39 TBI patients (1–24 years post-injury) assigned to three different treatment conditions. The strategy-training group received individualized intervention according to the most salient memory problems identified. The pseudo-treatment group had to perform drill and repetitive practice on memory tasks. A third group received no treatment. Only the strategy-training group showed improved memory functions and the largest effect was observed

4 months after therapy. Kerner and Acker (1985) used computer-based memory training software in TBI patients with mild-to-moderate memory impairment. After 12 training sessions, psychometric measures showed improved memory performance, which, however, was not maintained at re-testing 15 days later. Ryan and Ruff (1988) investigated 20 TBI patients (1.5–7.5 years postinjury) with mild-to-moderate memory impairment randomly assigned to two different treatment groups. The experimental group was trained to use rehearsal and visual imagery strategies, whereas the other group received alternative treatment. After 6 weeks of training, both groups showed improved memory functioning. A differential training effect was only found after initial neuropsychological functioning was taken into account. Only subjects with mild memory impairment before treatment showed beneficial memory training effects. Schmitter-Edgecombe *et al.* (1995) compared eight TBI patients (two and more years post-injury) with mild memory impairment who received a 9-week notebook training treatment with a control group that received only supportive therapy. After treatment the notebook-training group reported significantly fewer observed everyday memory failures compared with the support treatment group. At 6-months follow-up three patients of the notebook training group still used the notebook actively and continued to report fewer everyday memory failures, although, at that time, there was no significant difference any more between the experimental and the control participants.

The effectiveness of memory notebooks as a compensatory strategy is also supported by several Class III studies (Burke *et al.*, 1994; Sohlberg and Mateer, 1989; Zencius *et al.*, 1990; Squires *et al.*, 1996). Other Class III studies investigated compensatory memory strategies such as rehearsal, semantic elaboration, visual imagery, prospective memory, specific mnemonic techniques with various degrees of success. Several Class III studies have shown the effectiveness of specific and individualized training intervention (Schacter *et al.*, 1985; Kime *et al.*, 1996) and the use of computer-assisted intervention (Kirsch *et al.*, 1987, 1992).

A literature search updating The Cochrane Review (Majid *et al.*, 2001) and the review by Cicerone *et al.* (2000) added five studies for consideration of which five studies, three were characterized as class I studies (Ownsworth and McFarland, 1999; Rose *et al.*, 1999; Wilson *et al.*, 2001), one as Class II study (Grealy *et al.*, 1999) and one as Class III study (van den Broek *et al.*, 2000).

Ownsworth and McFarland (1999) investigated the remediation and assessment of everyday memory impairment in 20 randomly selected patients between 4 and 37 years post-injury, randomly assigned into two treatment groups. Each group received 4 weeks of treatment, which was compared with a baseline condition. The two different types of training approaches used were Diary Only (DO) training and Diary and Self-Instructional Training (DSIT). Comparing DO and DSIT training showed that no significant difference was found in the total number of diary entries made, that the number of diary entries made varied according to the week of treatment, and that the DO group showed a greater decline in the percentage of total diary entries made during the first and second weeks of treatment, suggesting that the DSIT group maintained a more consistent use of the diary strategy over time. Furthermore, the DSIT group reported a lower level of memory difficulties and rated the strategies used as more helpful than the DO group.

Wilson *et al.* (2001) investigated the effectiveness of a portable externally programmed paging system (Life-minder, formerly NeuroPage, Atlanta, CA) in 143 participants with TBI (about 44%), stroke (about 25%) or other conditions (about 31%) with memory and/or planning/organizational problems. After a 2-week baseline period, participants were randomly assigned to the treatment (pager) group (A) or to the waiting list (group B), and conditions were switched after 7 weeks. Measurements were taken at baseline, and 7 and 14 weeks post-baseline. More than 80% of the patients who completed the 16-week trial showed a significant improvement in carrying out everyday activities (such as self-care, self medication and keeping appointments) when using the pager compared with the baseline condition. For most this improvement was maintained when they were evaluated 7 weeks after returning the pager.

One class I study investigated the effect of active and passive participation in a non-immersive virtual environment on spatial memory in stroke patients. Rose *et al.* (1999) compared 48 vascular brain injured patients with non-impaired controls, randomly assigned to an active or a passive performance group. The stroke patients as well as the controls showed better performance in the active, than in the passive, spatial recognition task. However, whereas passive controls performed better on the object recognition task than active controls, the patients did not show any difference on the active versus passive object recognition task. One explanation suggested was that there was no enforced procedural component in the active exploration condition, which might have overcome any memory impairment.

Grealy *et al.* (1999) (class II study) investigated the impact of non-immersive virtual stimulating exercise environments on attention, information processing, learning and memory. The study compared 13 TBI patients with a control group of previous TBI patients of similar age, severity and time post-injury. Cognitive functions were assessed with psychometric tests before and after a 4-week intervention programme which consisted of exercise on a bicycle with a virtual environment presented on a screen mounted at eye level. The participants had to steer a course around a virtual world or race against other virtual riders. A comparison of the pre- and post-intervention scores showed significant improvements on the tests of attention, information processing, verbal and visual learning. No improvement was found on memory functions tested by the logical memory test and the complex figure test.

A class III study by van den Broek *et al.* (2000) aimed at training five patients in using another external electronic memory aid called the Voice Organizer (VO), which can be trained to recognize a patient's individual speech patterns, store messages dictated by the user and replay messages at pre-specified time periods. All subjects demonstrated substantially improved scores in experimental task I, and four of the subjects improved scores in experimental task II.

Recommendation

The evidence is compatible with grade A recommendation for compensatory memory training for subjects with mild memory impairments, and grade B recommendation for specific intervention techniques directed at facilitating the acquisition of specific skills and domain-specific knowledge. No evidence is available concerning effective restoration of memory functions in patients with severe memory impairment. No specific recommendations are made for different diagnostic groups. Finally, it must be mentioned that, despite the numerous studies investigating memory rehabilitation, the problems raised in previous reports concerning the heterogeneity of the population studied (in terms of age, aetiology and type of brain damage, severity of brain damage, severity of functional impairments and time post-onset) should not be underestimated. It is conceivable that the type and intensity of training has different effects depending on the neural circuits damaged, the functional impairment profile, the age of the patient, the time post-injury, the education level of the patient and other external factors. The number of variables involved may make generalization across individuals difficult and favour training programmes tailored to the individual circumstances. What is still lacking are studies that directly compare patients with different aetiologies and types of brain damage, age or stage of recovery. Furthermore, most studies have investigated TBI patients and evidence for memory rehabilitation in stroke patients remains scarce.

Rehabilitation of apraxia

Although the incidence of apraxia after acquired brain damage is considerable, the literature on recovery and treatment is very minimal. Several reasons for this lack of evidence can be identified (Maher and Ochipa, 1997). First, patients with apraxia often seem to be unaware of their deficit and rarely complain; secondly, many researchers believe that recovery from apraxia is spontaneous and treatment is not necessary; thirdly, some authors believe that apraxia only occurs when performance is requested of patients in testing situations, and that correct behaviour is displayed in natural settings. By now, however, there is agreement that apraxia hinders ADL independence and treatment of apraxia should definitely be part of the overall neurorehabilitation programme after brain damage. In this brief summary, studies examining the effectiveness of treating apraxia will be reviewed. The studies are labelled either observational or experimental and the quality of the studies is described.

There are two recent RCTs on the rehabilitation of apraxia, providing class Ib evidence. Smania *et al.* (2000) assessed in an RCT the effectiveness of a rehabilitative training programme for patients with limb apraxia. Thirteen patients with acquired brain injury and limb apraxia (lasting more than 2 months) as a result of lesions in the left cerebral hemisphere participated in the study. The study group underwent an experimental training for limb apraxia consisting of a behavioural training programme with gesture-production exercises. The control group received conventional treatment for aphasia. Assessments involved neuropsychological tests of aphasia, verbal comprehension, general intelligence, oral apraxia, constructional apraxia and three tests concerning limb praxic function (ideational and ideomotor apraxia and gesture recognition). Everyday activities related to each test were used to measure the outcome. The patients in the study group achieved a significant improvement of performance in both ideational and ideomotor apraxia tests. They also showed a significant reduction of errors in ideational and ideomotor apraxia tests. Control patients did not show any significant change in performance. The results show the possible effectiveness of a specific training programme for the treatment of limb apraxia. Donkervoort *et al.* (2002) determined in a controlled study the efficacy of strategy training in left hemisphere stroke patients with apraxia. A total of 113 left hemisphere stroke patients with apraxia were randomly assigned to two treatment groups: (1) strategy training integrated into usual occupational therapy and (2) usual occupational therapy only. The primary outcome measure was a standardized ADL observation by a blinded research assistant. Additional ADL measures were used as secondary outcome measures (Barthel ADL index, ADL judgement by occupational therapists and by patients). After 8 weeks of treatment, patients who received strategy training ($n = 43$) improved significantly more than patients in the usual treatment group ($n = 39$) on the ADL observations. This reflects a small-to-medium effect (effect size 0.37) of strategy training on ADL functioning. With respect to the secondary outcome measures a medium effect (effect size 0.47) was found on the Barthel ADL index. No beneficial effects of strategy training were found after 5 months (at follow-up).

Several class II studies also support the efficacy of apraxia rehabilitation. Goldenberg and Hagman (1998) studied a group of 15 patients with apraxia, who made fatal errors in activities of daily living: an error was rated as fatal if the patient could not proceed without help or if the error prohibited the patient from accomplishing the task successfully. The study design was as follows: each week an ADL test was performed; between tests one of three activities was trained, whereas support, but no therapeutic advice, was given for two other activities. Each week another activity was trained. Van Heugten *et al.* (1998) performed a study evaluating a therapy programme for teaching patients strategies to compensate for the presence of apraxia. The outcome was studied in a pre-post test design; measurements were conducted at baseline and after 12 weeks of therapy. Thirty-three stroke patients with apraxia were treated at occupational therapy departments in general hospitals, rehabilitation centres and nursing homes. The patients showed large improvements in ADL functioning on all measures and small improvements on the apraxia test and motor functioning test. The effect sizes for the disabilities, ranging from 0.92 to 1.06, were large compared with the effect sizes for apraxia (0.34) and motor functioning (0.19). The significant effect of treatment is also seen when individual improvement and subjective improvement are considered. These results suggest that the programme seems to be successful in teaching patients compensatory strategies that enable them to function more independently, despite the lasting presence of apraxia. Poole (1998) published a study examining the ability of participants with left-hemisphere stroke to learn one-handed shoe tying. Participants with left-hemisphere stroke with and without apraxia and control participants were taught how to tie their shoes with one hand. Retention was assessed after a 5-min interval during which participants performed other tasks. All groups differed significantly in regard to the number of trials to learn the task. However, on the retention task, the control adults and the stroke patients without apraxia required similar numbers of trials whilst the participants with apraxia required significantly more trials than the other two groups. All groups required fewer trials on the retention task than on the learning task.

Further evidence is provided by single case studies. Wilson (1988) studied a female adolescent with extensive damage to the brain following an anaesthetic accident. One of the most disabling consequences of the damage was apraxia, which made her almost completely dependent in daily life. Wilson concluded that the step-by-step programme was successful in teaching the patient some tasks, but generalization to new tasks was not found at follow-up. Maher *et al.* (1991) studied the effects of treatment on a 55-year-old man with ideomotor apraxia and preserved gesture recognition. Daily 1-h therapy sessions were given during a 2-week period. During therapy sessions many cues were offered which were withdrawn systematically while feedback and correction of errors were given as well. The production of gestures improved qualitatively. Ochipa *et al.* (1995) subsequently developed a treatment programme aimed at specific error types. Praxis performance was studied in two stroke patients. It appeared that both patients achieved considerable improvement in performance but the observed effects were treatment-specific: treatment of a specific error type did not improve across untreated gestures. Jantra *et al.* (1992) studied a 61-year-old man with a right-sided stroke followed by apraxic gait. After 3 weeks of gait training supplemented with visual cues, the patient became independent with safe ambulating. Pilgrim and Humphreys (1994) presented a case of a left-handed head injured patient with ideomotor apraxia of his left upper limb. The patient's performance on the 10 objects was measured before and after training in three different modalities. A mixed design analysis of variance (ANOVA) was carried out showing a positive effect of therapy, but little carry-over to everyday life. Bulter (1997) presents a case study which explores the effectiveness of tactile and kinaesthetic stimulation as an intervention strategy, in addition to visual and verbal mediation, in the rehabilitation of a man with ideational and ideomotor apraxia following a head injury. The results indicated some improvement after a training period and limited evidence of the effectiveness of additional sensory input.

Recommendation

There is grade A evidence for the effectiveness of apraxia treatment with compensatory strategies. Treatment should focus on functional activities, which are structured and practised using errorless learning approaches. Recovery of apraxia should not be the goal for rehabilitation. Further studies of treatment interventions are needed which also address how generalizable treatment effects are to non-trained activities and situations.

Rehabilitation of acalculia

Disorders of number processing and calculation (DNPC) may occur after many types of brain damage. Depending on the underlying disease and on lesion location, the frequency of calculation disorders in patients with neurological disorders has been estimated to range between 10 and 90% (Jackson and Warrington, 1986).

Two main types of rationales have been applied to DNPC. One, the 'reconstitution' or 're-teaching' approach consists of extensive lost or damaged abilities by way of extensive practice. The other, indirect approach promotes the use of 'back-up' strategies based on the patient's residual resources (Girelli *et al.*, 2002). In this case, the treatment would not merely point to restore the functionality of the impaired component but rather to exploit the preserved abilities to compensate for the deficit. Both types of remediation employ step-by-step training consisting in presentation of problems of increasing difficulty, facilitation cues and other types of assistance which are eventually faded with progressive recovery; in all cases direct feedback is provided to the patient on his/her accuracy and errors.

Outcome measures typically compare individual's pre- and post-treatment performance in transcoding tasks, simple and complex calculation. Most research designs and statistical evaluation procedures are taken from the field of single-subject research (Kratochwill and Levin, 1992; Randall *et al.*, 1999). The amount of functional disability on daily life is rarely assessed or estimated in this corpus of studies.

As a literature search based on data banks proved unsatisfactory, the authors have reviewed the existing literature themselves and have used a pre-existing overview related to the topic (Girelli and Seron, 2001).

Studies are mostly 'quasi-experimental' using a single-case or small-group approach guided by the principles of cognitive neuropsychology (Shallice, 1979; Caramazza, 1989; Riddoch and Humphreys, 1994; Seron, 1997) and single-subject research (Kratochwill and Levin, 1992; Randall *et al.*, 1999) (Classes II and III evidence). Group studies using control groups are considered inadequate by most authors due to known reasons (problems with patient selection, group homogeneity, and heterogeneity of subjacent deficit and pre-morbid functional level).

Rehabilitation of DNPC may be grouped into several areas of intervention. Rehabilitation of transcoding ability (the ability to translate numerical stimuli between different formats) has been successfully performed in several studies (Deloche *et al.*, 1992; Sullivan *et al.*, 1996), mostly by re-teaching the patient the required set of rules. Impairments of arithmetical facts (simple multiplication, addition, subtraction or division solved directly from memory) were the target of several rehabilitation studies (Miceli and Capasso, 1991; Hittmair-Delazer *et al.*, 1994; Girelli and Delazer, 1996; Whetstone, 1998; Girelli *et al.*, 2002). In all studies, extensive practice with the defective domain of knowledge, i.e. multiplication tables, determined significant improvement. A positive outcome was also reached by a rehabilitation programme based on the strategic use of the patient's residual knowledge of arithmetic (Girelli *et al.*, 2002). This specific case suggests that the integration of declarative, procedural and conceptual knowledge critically mediates the reacquisition process. Miceli and Capasso (1991) have successfully rehabilitated a patient with deficient arithmetical procedures (the knowledge required to solve multidigit calculations). Deficient arithmetical problem solving (the ability to provide a solution for complex, multistep arithmetical text problems) has also been treated in one study (Delazer *et al.*, 1998). The study was rated as partly successful by the authors, as patients benefited from the cueing procedure engaged and generated a higher number of correct solution steps, but did not show a prominent effect on the actual execution process.

Recommendation

Overall, the available evidence suggests that rehabilitation procedures used to treat selected variants of DNPC were successful. Notably, significant improvements were observed even in severely impaired and chronic patients. Several caveats need to be mentioned in this context. At present, little is known about the prognosis and spontaneous recovery of DNPC, thus, the effects of different interventions in the early stages of numerical disorders may be difficult to evaluate. Moreover, different underlying neurological disorders (e.g. stroke, dementia and trauma) have only partly been compared as to their specific effects on DNPC. Furthermore, it has not been studied in detail how impairments of attention or executive functions influence the rehabilitation process of DNPC.

General recommendations

There is enough overall evidence to award a grade A recommendation to some forms of cognitive rehabilitation in patients with neuropsychological deficits in the post-acute stage after a focal brain lesion (stroke, TBI). These include neglect and apraxia rehabilitation after stroke, attention training after TBI in the post-acute stage and memory rehabilitation with compensatory training in patients with mild amnesia. This general conclusion is based on a limited number of RCTs and is supported by a considerable amount of evidence coming from class II and III studies. In particular, the use of a rigorous single-case methodology has been considered by the present reviewers as a source of acceptable evidence in this specific field, in which the application of the RCT methodology is difficult for a number of reasons, related to the lack of consensus on the target of treatment, the methodology of the intervention and the assessment of the outcomes.

Future developments

What has been concluded above leaves the field open to a debate about the future of studies on the effectiveness of cognitive rehabilitation. One approach is to propose large-scale RCTs of a simple methodology of intervention in a broadly defined clinical condition (for example, the assessment of the efficacy of an intervention for ULN after RH stroke on long-term motor disability). Another approach is the assessment of a specific, theoretically driven treatment on a well-defined area of impairment using a single-case methodology (for example, the effect of a linguistically driven intervention compared with simple stimulation on the ability to retrieve lexical items belonging to a defined class). The former approach is probably the only one to have appeal for the clinical neurologist, whilst the latter appears at the moment as a basic research endeavour. To the present panel, both represent important and potentially fruitful avenues for research in this field. Future studies should also aim at a better clinical and pathological definition of the patients included in the trials. The gross distinction between stroke and TBD used in the present review is clearly insufficient: a separation amongst the main categories of cerebrovascular pathology, and the subdivision, on pathological grounds, of survivors of TBD can be expected to improve the quality of rehabilitation studies.

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