Occurrence and measurement of transfer in cognitive rehabilitation: A critical review

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REVIEW ARTICLE

OCCURRENCE AND MEASUREMENT OF TRANSFER IN COGNITIVE REHABILITATION: A CRITICAL REVIEW

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Objective: **To investigate the occurrence of transfer of cognitive strategy training for persons with acquired brain injury, and to investigate the way in which transfer is measured.**
Methods: **Electronic searches in PubMed, PsychINFO, EMBASE and CINAHL using combinations of search terms in the following categories: type of brain injury, transfer, type of disorder, type of intervention. A total of 39 papers was included in the review. The following aspects were judged: study design and participant characteristics, intervention characteristics and type of outcome measures used.**
Results: **Transfer outcome measures could be classified into 3 groups: non-trained items, standardized daily tasks and daily life. Most studies reported at least one type of transfer; however, the methodological quality of the studies was low. Cognitive strategy training in the evaluated studies focused on 7 domains of functioning: information processing, problem solving/executive functioning, memory/attention, language, neglect, apraxia and daily activities.**
Conclusion: **Transfer of training effects of cognitive strategy training has been evaluated in a relatively small number of studies. Outcome measures used in these studies could be classified into 3 groups. Most studies reported the occurrence of transfer of training effects, although some serious remarks can be made concerning the methodological quality of the studies.**

Key words: transfer, cognitive disorders, cerebrovascular accident, brain injuries, rehabilitation.

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INTRODUCTION

The exact meaning of the terms "transfer" and "generalization" lacks consensus. It is, however, agreed that both terms relate to the way in which prior learning affects new learning. In the context of rehabilitation, transfer of treatment effects is of great importance. The aim of a rehabilitation programme is to restore patients to their greatest potential and maximum independence, hopefully resulting in independent functioning, the return to their own home and participation in society (1). To achieve this goal, transfer of training results is necessary. For patients to function as independently as possible at home, tasks that are taught in the rehabilitation setting should be transferred to the home setting. Moreover, therapists cannot possibly train a patient to handle all the difficulties and tasks he or she will encounter after discharge. Transfer of skills from trained to non-trained tasks is therefore of great importance to the clinical success of a therapy programme.

In recent years, strategy training has become a widely used treatment method in cognitive rehabilitation of patients with acquired brain injury (ABI). This type of therapy is based on the assumption that restoration of cognitive functions to their pre-injury structure and efficiency is not expected to occur and that rehabilitation should therefore concentrate on teaching compensatory strategies (1). Cognitive strategy training is aimed at teaching patients new, general ways to compensate for problems in everyday life, resulting from a cognitive impairment (2). Compensation can be achieved by teaching patients to use external as well as internal strategies and techniques to reach their goals in alternative ways. People with severe memory problems can, for example, use external memory aids, such as pagers or appointment books, to enable them to remember their daily schedules. In addition, people can be encouraged to use their residual, internal, skills more efficiently by applying rehearsal strategies or mnemonics (1).

In the recent literature on cognitive rehabilitation, it is often stated that the occurrence of transfer is expected in strategy training, as the training programme is not aimed at re-learning specific tasks, but at teaching patients new ways to handle problems resulting from an impairment (3). Patients are therefore expected to be able to use the strategies in new settings and while performing new tasks, despite the lasting presence of the cognitive deficits. Therefore cognitive strategy training is not expected to transfer to neuropsychological test results, since the aim of the training is not to improve the impairment itself. However, Cicerone et al. (4, 5) point out that relatively few studies have tried to evaluate the occurrence of transfer by directly evaluating the transfer of treatment effects to everyday situations or behaviours.

The objective of this paper is therefore to investigate the occurrence of transfer of cognitive strategy training to everyday

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situations and behaviours. First, educational psychology literature is reviewed to clarify the concept of "transfer", as in rehabilitation research less attention has been paid to the definition. Secondly the paper discusses the results of a critical review of intervention studies evaluating transfer of cognitive strategy training. The paper attempts to answer the following questions: (*i*) How was transfer measured in these studies? and (*ii*) Does transfer occur? Finally, it reflects on the consequence of these results for clinical practice and makes suggestions for the design of future studies aimed at evaluating transfer of treatment effects.

TRANSFER

The term "transfer" is frequently used in spoken language and clinical practice. In addition, the term is commonly used in scientific research, in particular in contexts in which learning plays an important role, yet the exact meaning of this term lacks consensus. Nevertheless, it is agreed that "transfer" relates to the use of prior learning in new contexts, or, in other words, to the way in which prior learning affects new learning or performance (6–12).

Over the years, researchers have had difficulty demonstrating the occurrence of transfer. This is rather unfortunate as it has often been stated that it is essential to all situations in which learning is concerned and as transfer is said to be the main goal of all learning (6–8, 10). At the same time, it is also rather peculiar as transfer seems to occur frequently in everyday life, as it is by transfer of earlier experiences that people can function adequately in new situations, which are encountered almost every day (8).

Despite the lack of evidence of the occurrence of transfer, educational psychology has paid much attention to the question of how to promote transfer of learning. Based on literature, 6 prerequisites for the occurrence of transfer are:

- A person should know what transfer is and how it works (8, 13).
- A person should be aware of his own functioning before he or she will acknowledge that a strategy is needed to improve his functioning (14).
- A person should be able to judge when and where transfer can be applied (10, 15).
- General knowledge should be taught, as this type of knowledge is easier to transfer than specific knowledge (15).
- The connection between what is learned and the situation in which it is learned should be broken by practicing a strategy or skill while varying the practice situation as much as possible (8, 10, 15, 16).
- Transfer should be addressed during learning as it cannot be expected to occur automatically (8, 17).

We will now turn to the review of intervention studies evaluating transfer of cognitive strategy training.

METHODS

A literature search was carried out in PubMed (1984 – April 2005), PsychINFO (1983 – April 2005), EMBASE (1989 – April 2005) and CINAHL (1982 – April 2005), using Silverplatter's Webspirs retrieval software (18). Both controlled vocabulary words and free words in the article's title, abstract or keywords were combined in the searches. Details of the search are shown in Appendix I.

The first selection of papers was based on the title and the abstract. In some studies "transfer" was measured and discussed, but the term (or a synonym of it) was not mentioned in the title, abstract or keywords of the paper. As a result, these papers could not be retrieved from the databases. Therefore, the authors' private libraries on cognitive rehabilitation were reviewed and papers that mentioned strategy training and transfer of training effects were selected.

In addition to these 2 search methods, the reference lists of all included studies were scanned to further identify eligible studies.

Papers that were selected based on these 3 search methods were read by 1 of 3 reviewers (authors CvH, IW and CG). The following inclusion criteria were applied: (*i*) papers describe an intervention study; (*ii*) papers evaluate a cognitive strategy training. Cognitive strategy training was defined as a training that aims at teaching patients new ways to execute daily activities by using either internal or external strategies to compensate for cognitive impairments (19); (*iii*) participants are adults, clinically diagnosed as patients with ABI; (*iv*) outcome measures for transfer are used. Studies that evaluated transfer to new tasks as well as transfer to new situations were included. Studies that evaluated transfer of training effects to neuropsychological test results were not included in this review, as the aim of a strategy training is not to improve cognitive functioning, but to teach patients ways to function as independently as possible, despite the presence of the cognitive deficits; (*v*) papers are written in English. If uncertainty about compliance with the inclusion criteria still existed after the first reading, the paper was reread by 1 of the other 2 reviewers.

All included studies were judged on the following aspects, described in an adapted version of a rating list recommended by van Tulder et al. (20): study characteristics (design, number of participants, used type of outcome measures, used statistics), participant characteristics (age, time post-onset, type of injury) and intervention characteristics (intervention strategies used, duration of intervention, trainer characteristics).

RESULTS

A total of 83 papers were read. After checking the inclusion criteria, 39 papers, describing 41 separate studies were included in the review. Forty-four papers that did not meet the inclusion criteria were excluded for the following reasons: papers did not describe intervention studies (18); studies did not use cognitive strategy training (18); studies did not use transfer outcome measures (10) and study participants were healthy adults (8).

Included papers were divided into 6 groups, based on the cognitive domains on which the intervention focused (information processing, problem solving skills/executive functioning, memory/attention, language, neglect, apraxia). A seventh group of studies consisted of interventions aimed at the training of daily activities, not specifically aimed at a single cognitive disorder.

Table I displays characteristics and methodological aspects of all included intervention studies on transfer in cognitive strategy training, divided into the 7 categories described above.

Methods

Study design. Most studies had single subject designs (n = 20). Other designs that were used are randomized clinical trial de-

Table I. *Study characteristics and outcome*

Paper	Design	*n*	Mean age (range)	Mean time post-onset (range)	Type of injury	Intervention strategies	Trainer characteristics	Duration of intervention	Type of transfer measured	Transfer demonstrated
Information processing										
Dirette, 2002 (28)	Follow-up survey study	16	Intervention study: 21–56 years	Intervention study: 2–12 months	ABI	Chunking, pacing, verbalization	Not reported	Not reported	Daily life (self-report – questionnaire)	Yes, not statistically tested
Fasotti et al., 2000 (26)	Randomized clinical trail (TPM vs concentration training)	22	TPM group 26.1 years (18–45) Concentration group 30.1 years (22–38)	TPM group 9.8 months (3–43) Concentration group 8.3 months (3–20)	Closed head injury	TPM (awareness training, self-instruction)	Not reported	TPM group 1-h sessions, max 3 h/week for 2–3 weeks, mean 7.4 h total Concentration group 30 min sessions each day, max 2–5 h/week for 3–4 weeks, mean 6.9 h total	1. Daily tasks (observation of used preventive and managing strategies) 2. Psychosocial well being (self-report – questionnaires)	1. TPM group uses significantly more managing strategies than concentration group; no between group effects in use of prevention strategies 2. No significant changes found
Problem solving/executive functioning										
Cicerone & Wood, 1987 (29)	Single subject design	1	20 years	4 years	Closed head injury	Self-instruction, verbalization, training for transfer	Not reported	1-h sessions, 2 per week for 8 weeks, 16 h total	Daily life (report staff – rating scale)	Significant improvement on rating scale
Foxx et al., 1989 (32)	Non-randomized pre-test–post-test control group design	6	Experimental group 27.7 years (24–31) Control group 28.7 years (26–31)	Experimental group 6.7 years (3–9) Control group 9.3 years (7–12)	TBI	Generation of solutions to a specific problem	Not reported	Not reported	1. Different situation (interview) 2. Different situation (staged situations) 3. Non-trained tasks (different problems)	Experimental group improved more on all transfer measures than control group, not statistically tested
Levine et al., 2000 (30) (study 1)	Randomized clinical trial (GMT vs MST)	30	GMT group 29.0 years MST group 30.8 years	GMT group 3.7 years (3–4) MST group 3.8 years (3–4)	TBI	GMT	Not reported	GMT group 1 session, 4–6 h MST group not reported	Daily tasks (paper and pencil tasks)	Significantly less errors and significantly more time needed in GMT group than in MST group in 2 of 3 tasks
Levine et al., 2000 (30) (study 2)	Single subject design	1	35 years	5 months	Meningo – Encephalitis	GMT	Not reported	5 sessions	1. Daily tasks (paper and pencil tasks) 2. Daily tasks (meal preparation) 3. Daily life (self-report – diary)	1. Yes, decreased errors on 2 of 3 tasks, not statistically tested 2. Significantly better performance 3. Yes, improved performance, not statistically tested)
Liu et al., 2002 (33)	Single subject design	3	62–78 years	13–15 days	Stroke	Self-regulation	Not reported	1 week	Daily tasks (non-standardized finding)	Yes in one case, not statistically tested

Table I contd.

Paper	Design	*n*	Mean age (range)	Mean time post-onset	Type of injury	Intervention strategies	Trainer characteristics	Duration of intervention	Type of transfer measured	Transfer demonstrated
Neistadt, 1994 (31)	Non-controlled pre-test–post-test design	23	Not reported	Not reported	Various	Saturational cueing Strategies (readying, imaging, focusing, executing, evaluating)	Occupational therapist	30-min sessions, 3 sessions per week for 5 weeks, 7.5 h total	Daily task (RKE-R: meal preparation test)	Significant improvement
Memory/attention										
Boman et al., 2004 (34)	Non-controlled pre-test–post-test design	10	47.5 years (27–60)	17.7 months (9–40)	Various	Various strategies (e.g. use of external and internal compensatory strategies)	Not reported	1-h sessions, 3 sessions per week for 3 weeks, 9 h total	1. Daily tasks (AMPS) 2. Daily life (self-report – EBIQ)	1. No significant improvements 2. No significant improvements
Cicerone, 2002 (27)	Pre-test–post-test matched group design	8	Treatment group 31.0 years Control group 34.8 years	Treatment group 8.3 months Control group 7.0 months	Mild traumatic brain injury	Psycho-education, verbal mediation, rehearsal, anticipation of task demands, self-pacing strategies	Not reported	1-h sessions, 1 session per week for 11–27 weeks	Daily life (self-report – Attention Rating and Monitoring Scale)	Treatment group reported significantly less problems than control group
Doornheim & de Haan, 1998 (36)	Randomized clinical trail (memory strategy training vs drill and practice)	12	Strategy group 51.3 years Drill and practice group 51.7 years	Not reported	Stroke	Mnemonics (association and organization)	Not reported	Strategy group 2 sessions per week, for 4 weeks Drill and practice group 2 sessions per week, for 4 weeks	Daily life (self-report – memory questionnaire)	No significant between group differences
Fleming at al., 2005 (23)	Single subject design	3	19–52 years	2–12 months	Various	Self-awareness training, use of organizational device, use of cueing device, organizational strategies, training for transfer	Occupational therapist	1–2 h a week, for 8 weeks	Daily life: 1. Prospective memory failure (self-report CAPM) 2. Use of organizational device (number of dairy entries) 3. Community integration (self-report SPRS)	1. Varying results, not statistically tested 2. Improvement in all cases, not statistically tested 3. Improvement in two cases, not statistically tested
Kaschel et al., 2002 (22)	Randomized clinical trail (imagery training vs pragmatic memory training)	21	Imagery group 36.6 years (21– 55) Pragmatic training group 41.9 years (27–55)	Imagery group 60 months (6–301) Pragmatic training group 65 months (1–80)	Various	Imagery group: imagery-based mnemonics strategy, training for transfer Pragmatic group: various standard internal and external memory strategies	Not reported	Imagery group 3 session per week, for 10 weeks Pragmatic training group 3 session per week, for 10 weeks	Daily life (self-report and report relatives – memory questionnaire)	Imagery group relatives report significantly less memory problems than pragmatic group relatives, no significant change in self-report patients

Kime et al., 1996 (24)	Single subject design	1	24 years	1.5 years	Status epilepticus following TBI	Multidisciplinary milieu approach, using mnemonics, organizational devices, cueing devices and training for transfer	Multi-disciplinary rehabilitation team	17 weeks	Daily life: use of organizational devices (e.g. checking dairy after cueing, number of dairy entries)	Significant improvements on all transfer measures
Milders et al., 1998 (37)	Pre-test–post-test matched group design, multiple baseline (TBI patients vs healthy controls)	26	39.0 years (24–57)	4.6 years (1.9–8.1)	Closed head injury	Mnemonics in name learning	Not reported	1–1.5-h sessions during 4 months, 8 sessions in total	Non-trained items: 1. Name learning test 2. Name-occupation-town learning test 3. Famous faces naming test	1. No significant between group differences 2. Patient group improves significantly more than control group 3. Patient group improves significantly more than control group
Wade & Troy, 2001 (35)	Single subject design	5	10–51 years	13 months–15 years	Various	External memory aid (mobile phone providing memory prompts)	Not reported	12 weeks	Daily life: self-reports on remembering to carry out 5 target tasks	Yes, improvement on self-initiated behaviours in all cases, not statistically tested
Language										
Hinckley et al., 2001 (38)	Pre-test–post-test control group design; randomized intervention groups and non-randomized baseline group (context based vs skill based vs baseline)	17	Context group 51.6 years (24–63) Skill group 50.3 years (34–63) Baseline group 59.6 years (52–70)	Context group 26.8 months (6–58) Skill group 26.8 months (4–102) Baseline group 49.6 months (21–82)	Stroke	Context group: practice of compensatory strategies during role play of a specific task (e.g. use of contextual cues, self-generated cues, problem solving strategies) Skill group: training accuracy and speed in picture and word naming (e.g. use of semantic and phonemic cues) Baseline group: traditional therapy	Clinicians, trained to perform the interventions	Context group mean 11.7 sessions in total, mean 275 min in total Skill group mean 11.8 sessions in total, mean 195 min in total	Daily tasks 1. Ordering articles from catalogue (written version) 2. Communication activities of daily living test (CADL) 3. Daily life (report caregivers – communication effectiveness questionnaire)	1. Yes, skill group improves more than context group not statistically tested 2. Yes, skill group improves more than context group, not statistically tested 3. Yes, skill group improves more than context group, not statistically tested
Hopper & Holland, 1998 (39)	Single subject design	2	39–62 years	21–53 months	Stroke	Use of w-questions to describe emergency situations	Speech and language therapist	45-min sessions, 4–5 sessions per week, max of 10 sessions total	Non-trained items	Yes, in one case, the other case shows limited transfer, not statistically tested

Table I contd.

Paper	Design	*n*	Mean age (range)	Mean time post-onset	Type of injury	Intervention strategies	Trainer characteristics	Duration of intervention	Type of transfer measured	Transfer demonstrated
Jacobs, 2001 (40)	Non-controlled pre-test–post-test design	5	44–79 years	19–198 months	ABI	Linguistic specific treatment: strategies to use correct grammatical structure in communication	Not reported	15–60 session in total	Daily task: rating of language samples by 1. Researcher: rating of communicative informativeness and efficiency 2. Naive listener: rating of effectiveness, informativeness, grammaticality and listening comfort	1. Significant improvement on efficiency 2. No significant improvements
Maneta et al., 2001 (41)	Single subject design	1	84 years	5 years	Stroke	1. Lip-reading (patient) 2. Communication strategies (spouse)	Speech and language therapist	Not reported	1. Non-trained items (auditory input test) 2. Daily life communication with spouse; language comprehension	1. No significant improvement 2. Significantly more correct responses, reduction in number and length of communication breakdowns. No significant improvement in language comprehension
Nitzberg Lott & Friedman, 1999 (42)	Single subject multiple baseline design	1	67 years	4 months	Stroke	Tactile-kinaesthetic strategy to improve letter-by-letter reading	Not reported	1-h sessions, 3 sessions per week, 81 sessions in total	1. Non-trained items (letters, words, non-words) 2. Daily life (self-report and report spouse – questionnaire)	Both types of transfer were demonstrated, not statistically tested
Robson et al., 1998 (43)	Single subject design	1	57 years	24 months	Stroke	Use of syllabic structure and first phoneme as a self-cueing naming strategy	Not reported	20-min sessions during 6 months, 40 sessions in total	1. Non-trained items (written picture naming) 2. Daily life (spontaneous speech – non standardized finding)	1. Significant improvement 2. Yes, not statistically tested

Robson et al., 1998 (44)	Single subject design	1	77 years	18 months	Stroke	Use of writing as communication strategy, training for transfer	Authors	45-min sessions, 59 sessions in total	1. Non-trained items (written picture naming) 2. Daily tasks (use of strategy in answering standardized questions) 3. Daily life (use of strategy in conversation – non standardized finding)	1. Significant improvement, only after specific transfer therapy 2. Significant improvement only after specific transfer therapy 3. Yes, only after specific training of functional use of the therapy, not statistically tested
Robson et al., 2001 (25) (study 1)	Single subject design	6	49–86 years	27.5 months (8–53)	Stroke	Use of writing as a communication strategy	Authors	45–60-min sessions, 12 sessions in total	1. Non-trained items (written picture naming) 2. Daily tasks (message assessment) 3. Daily life (use in conversation – non standardized finding)	1. No significant improvement 2. No significant improvements except for one participant 3. No improvement, not statistically tested
Robson et al., 2001 (25) (study 2)	Single subject design	3	49–86 years	24 months (16–38)	Stroke	Use of writing as a communication strategy, combined with message therapy	Authors	45–60-min sessions, 18 sessions in total	1. Non-trained items (picture naming) 2. Daily tasks (message assessment) 3. Daily life (use in conversation – non standardized finding	1. No significant improvements 2. Significant improvement in one subject on application of trained words, no improvement on non-trained words 3. Yes, improvement in all subjects, not statistically tested
Richards et al., 2002 (45)	Single subject design	3	44–71 years	2–2.5 years	Stroke	Priming of right-hemisphere intention mechanisms by movements of non-dominant hand	Not reported	45-min sessions, 30 sessions in total	1. Non-trained items (naming test) 2. Daily life (staff observation – non standardized finding)	1. Yes, in one case, not statistically tested 2. Yes, in one case staff notes strategy use in everyday situations and improvements in functional communication, not statistically tested

Table I contd.

Paper	Design	*n*	Mean age (range)	Mean time post-onset	Type of injury	Intervention strategies	Trainer characteristics	Duration of intervention	Type of transfer measured	Transfer demonstrated
Wambaugh & Martinez, 2000 (46)	Single subject multiple baseline design	1	38 years	6.6 years	Stroke	Rate and rhythm control by hand tapping to improve sound production	Authors	1-h sessions, 3 sessions per week, 20 sessions in total	Non-trained items (4 different types of words: same as trained, different stress pattern, different length, s-blend)	Yes, transfer to all types of words was demonstrated, not statistically tested
Neglect										
Antonucci at al., 1995 (47)	Randomized clinical trial (immediate vs delayed training)*	20	Immediate training 67.7 years Delayed training 70.2 years	Immediate training 75.3 days Delayed training 83.3 days	Stroke	Scanning strategy	Not reported	Immediate training 1-h sessions, 5 times per week for 8 weeks, 40 h total Delayed training 1-h sessions, 3 times a week for 8 weeks, 24 h total	Daily tasks (semi-structured scale for the functional evaluation of extrapersonal neglect)	Both groups improve significantly on transfer tasks after training
Bailey et al., 2002 (48)	Single subject design	7	60–85 years	13–46 days	Stroke	Scanning and cueing strategies (including lighthouse strategy) (5 subjects), left-limb activation strategy (2 subjects)	Not reported	Scanning and cueing group 1-h sessions, min. of 10 sessions in total Left-limb activation group 1-h sessions, min. of 10 sessions in total	Daily life (self-report, non-standardized finding)	Yes, one subject in scanning group and both subjects in LLA group, not statistically tested
Gouvier, et al., 1987 (49)	Single subject design	5	36–67 years	Start training for all subjects within 2 months post-stroke	Stroke	Scanning strategy, using anchor cues	Not reported	Not reported	Daily tasks (copying an address, wheelchair obstacle course)	Mixed findings, related to mental status of the cases, not statistically tested
Hanlon et al., 1992 (50)	Single subject multiple baseline design	1	69 years	6 months	Stroke	Scanning and cueing, visuospatial analysis and perceptuomotor integration	Multi-disciplinary rehabilitation team	Two treatment intervals of 5 weeks each	Daily tasks (ADL tasks – standardized observations)	Yes, not statistically tested

Niemeier et al., 2001 (51)	Non-randomized pre-test–post-test control group design (strategy training vs care as usual)	19	No significant between-group differences found; mean or range not reported	No significant between- group differences found; mean or range not reported	Various	Visual imagery scanning strategy: lighthouse strategy	Multi-disciplinary rehabilitation team	Strategy training group 30-min sessions, 3 sessions in total	1. Daily life (staff rating on FIM) 2. Daily task (route-finding)	1. Strategy group improved significantly more on 2 subscales than control group 2. Strategy group performed significantly better than control group
Pizzamiglio et al., 1992 (52)	Non-controlled pre-test–post-test design	13	63.1 years (58–74)	8.7 months (3–35)	Stroke	Scanning strategy	Not reported	5 sessions per week for 8 weeks, 40 sessions in total	Daily tasks (semi-structured scale for the functional evaluation of extrapersonal neglect)	Significant improvement
Pizzamiglio et al., 2004 (53)	Simple randomized pre-test–post-test design (strategy training vs strategy training including optokinetic stimulation)*	22	Scanning, no optokinetic stimulation 64.4 years (56–73) Scanning, optokinetic stimulation 62.7 years (46–79)	1–4 months	Stroke	Scanning strategy vs scanning strategy and optokinetic stimulation	Not reported	Scanning group 1-h sessions, 5 sessions per week, 30 sessions in total Scanning and optokinetic stimulation group 1-h sessions, 5 sessions per week, 30 sessions in total	Daily tasks: 1. Test of personal neglect 2. Semi-structured scale for the functional evaluation of extrapersonal neglect	1. No significant improvements in both groups, no between-group differences 2. Both groups improve significantly, no significant between-group differences
Webster et al., 2001 (54)	Case-control study (computer assisted training (CAT) vs usual care)	40	Experimental group 59.5 years Control group 60.2 years	Experimental group 173.3 days Control group 159.8 days	Stroke	CAT: scanning strategy, self-instruction	Not reported	CAT 45-min sessions, 12–20 sessions in total	1. Hospital incident reports (number of incidents) 2. Daily task (wheelchair obstacle course)	1. CAT group had significantly less incidents than usual care group 2. CAT group performed significantly better than usual care group
Apraxia										
Goldenberg & Hagman, 1998 (55)	Non-controlled pre-test–post-test design	15	55.7 years	6.1 weeks	Stroke	Training of details (inferring function of an object from its structure)	Occupational therapist	20–40-min sessions, 5 days per week, for 3 weeks plus training during the daily morning routine on each working day	Daily tasks (observations of errors)	No statistically significant improvements on non-trained tasks

Table I contd.

Paper	Design	*n*	Mean age (range)	Mean time post-onset	Type of injury	Intervention strategies	Trainer characteristics	Duration of intervention	Type of transfer measured	Transfer demonstrated
Goldenberg et al., 2001 (56)	Non-controlled pre-test–post-test design; subjects are also evaluated as single cases	6	58.7 years (31–68)	18.7 months (6–60)	Stroke	Exploration training (inferring function of an object from its structure)	Occupational therapist	1-h sessions, 6 sessions per treatment interval, 4 treatment intervals in total	Daily tasks (observations of amount of assistance needed and errors made)	No statistically significant improvements on non-trained tasks
Geusgens et al., 2006 (21)	Randomized clinical trial (strategy training vs usual care)	113	Strategy training group 67.6 years (47–93) Usual care group 63.3 years (38–88)	Strategy training group 100.2 days (19–393) Usual care group 102.9 days (26–418)	Stroke	Strategies such as using pictures and verbalization, focused on initiation/ orientation, execution, control/ correction	Occupational therapist	Strategy training group 8 weeks, mean 25 sessions in total, mean 15 h in total Control group 8 weeks, mean 27 sessions in total, mean 19 h in total	Daily tasks (observation of level of independent functioning)	Strategy training group improves significantly more on non-trained tasks than usual care group
Daily activities										
Gorman et al., 2003 (57)	Case study	2	31 years (both)	2 – 18 months	Various	ISAAC, assistive technology device: initiated prompting, procedural memory, logging of use	Rehabilitation therapists	No report on duration of initial training, use of ISAAC for 11–12 months	Daily life: 1. Performance of daily tasks 2. FIM rating	Yes, both types of transfer demonstrated in both patients, not statistically tested
Liu et al., 2004 (58)	Randomized clinical trial (MI vs FR)	46	MI group 71.0 years FR group 72.7 years	MI group 12.3 days; FR group 15.4 days	Stroke	MI of daily tasks	Occupational therapist	MI group 1-h sessions, 5 per week, for 3 weeks, 15 sessions in total FR group 1-h sessions, 5 per week, for 3 weeks, 15 sessions in total	Daily tasks (observation of level of independent functioning)	MI group performed significantly better on non-trained tasks than functional retraining group
O'Reilly et al., 1990 (59)	Case study	4	18–37 years	1–8 years	TBI	Checklist training to teach home accident prevention skills	Author	50-min sessions, 5 sessions per week, 17–34 sessions in total	Daily task (identification of potential hazards in a non-trained room)	Yes, two cases made large improvements on the transfer task, two cases made small improvements; not statistically tested

*Authors claim to have conducted a randomized controlled trial, in our opinion the study design was pseudo-randomized, as randomization was not conducted as is customary; group assignment took place based on patients' bed numbers and order of admission, respectively.
s-blend: word starting with "s" followed by two other consonants; FR: functional retraining; TBI: traumatic brain injury; ABI: acquired brain injury; TPM: time pressure management; MI: mental imagery; FIM: functional independence measure; MST: motor skill training; GMT: goal management training; CAT: computer assisted training; RKE-R: rabideau kitchen evaluation-revised; LLA: left limb activation; AMPS: assessment of motor and process skills; EBIQ: European brain injury questionnaire; CAPM: comprehensive assessment of prospective memory; SPRS: Sydney psychosocial reintegration scale.

signs (n = 8), non-controlled pre-test–post-test designs (n = 6) and non-randomized group designs (n = 6), of which 3 studies used matched groups. In one study, 2 randomized intervention groups and one non-randomized control group were used.

The sample sizes of the studies generally ranged from one to 46 participants, although most studies had a sample size of less than 15 participants (n = 28). Only one larger study was found, in which 113 subjects participated (21).

Participant characteristics. The mean age of the participants reported in the studies falls into a broad range (20–84 years), which can be attributed to the different types of injuries on which the studies focused. Most studies focused on patients after stroke (n = 24). Overall, participants in these studies were older than 50 years. In contrast, patients with traumatic brain injury formed a much younger group, with a mean age under 40 years. The time post-onset at the start of the therapy also had a broad range. It varied from 14 days to 25 years. Time post-onset also had large variations within studies itself, for example ranging from one month to 25 years in a randomized clinical trial (22).

Intervention characteristics. Most studies (n = 23) did not report trainer characteristics. Studies that did mention who performed the intervention, reported varying disciplines, such as occupational therapists, speech and language therapists and rehabilitation therapists. In 3 studies the entire rehabilitation team was reported to be involved with the cognitive training, whereas in 5 studies the training was reported to be conducted by the authors of the papers. The duration of the intervention ranged from one week to 6 months. Studies reported 1–5 training sessions per week. In most studies, training sessions lasted 30–60 minutes.

Three papers explicitly reported that during the intervention, "training for transfer" was used (23–25). In addition, 3 papers reported that during training, attention was paid to the enlargement of the patient's awareness of his own deficits (23, 26, 27), which is an important prerequisite for the occurrence of transfer (14). All other studies did not report using techniques to promote transfer.

The various intervention types can best be described based on the cognitive domains on which the intervention focused.

Information processing. Two studies were found describing strategies aimed at information processing. One study used strategies aimed at self-instruction by verbalization and at chunking and pacing the amount of information that had to be processed (28). Strategies used in the other study were aimed at reducing the load on information processing capacity by generating a plan of action before the performance of a task and by verbalization of the action plan during task performance (26).

Problem solving/executive functioning. Six studies were found describing strategies aimed at problem solving and executive functioning. In all studies self-regulation or self-instruction was used, aimed at either generating and adapting a plan of action before and during the performance of a task (29–31) or generating solutions to a specific problem (32, 33). In most studies, overt verbalization of the action plan was a key feature at the start of the training, generally fading into internalized speech.

Memory/attention. Eight studies were found describing strategies aimed at memory and attention. Three different strategies could be identified:

- Self-awareness training: information on the cognitive skills and on problems related to these skills is provided. Patients are helped to recognize the ways in which these problems affect their own situations (23, 27).
- External compensatory strategies: aimed at teaching patients to use a variety of external memory and planning aids, ranging from notebooks to cueing devices, such as pagers and mobile phones (22–24, 34, 35).
- Internal compensatory strategies: aimed at teaching patients internal strategies to facilitate memory function, mostly using mnemonics associating new information with old information and structuring and organizing new information (22, 24, 27, 34, 36, 37).

Most studies used a combination of these strategies.

Language. Eleven studies were found describing strategies aimed at language deficits (25, 38–46). In these studies, a large variety of strategies was used. However, 3 types of strategies that were used in more than one study could be identified. Strategies used in the other studies are summarized in Table I.

- Linguistic strategies: aimed at improving the grammatical structure of spoken language, hereby increasing the informativeness of the message (39, 40).
- External compensatory strategies: aimed at teaching patients and/or partners to use written instead of spoken language (25, 41, 44).
- Internal compensatory strategies: aimed at teaching patients to use self-cueing strategies such as tactile-kinaesthetic information to improve letter-by-letter reading or deriving a word from its first phoneme (38, 42, 43).

Neglect. Nine studies were found describing strategies aimed at visuo-spatial or perceptual neglect. In all studies one or a combination of the following strategies was used:

- Scanning strategies: aimed at teaching the patients to move their heads all the way from left to right. This strategy was used in all 9 neglect studies (47–54), sometimes combined with one of the following strategies:
  - Self-instruction: patients verbalize the command to turn their heads all the way to the left and move them all the way to the right.
  - Mental imagery: patients are taught to imagine their eyes are a lighthouse, scanning the sea all the way from left to right.
- Cueing strategies: aimed at guiding the patient's attention to an anchor cue on the left of the visual field (48–50). Patients are instructed to start scanning from the anchor cue. In one study, this strategy was internalized by teaching the patient to turn his head until the tip of his chin was in line with the top of his left shoulder and to move his head until the tip of his chin was in line with the top of his right shoulder (51).

Apraxia. Three studies were found describing strategies aimed at apraxia. Two strategies were aimed at teaching patients to infer the function of an object from its structure (55, 56). The other study was aimed at teaching strategies such as verbalization and the use of pictures to improve the internal concept of a task, the execution of a task, or the control over a task. One of these 3 interventions was chosen, depending on the type of problems a patient was experiencing (21).

Daily activities. Three studies were found describing strategies specifically aimed at improving the performance of daily activities (57–59). No overall strategies could be identified as the studies used widely differing interventions, namely checklist training, the use of an assistive technology device and the use of mental imagery of daily tasks.

Measurement of transfer

A variety of outcome measures was used to asses transfer. All outcome measures could be classified in one of the following 3 outcome types:

- Non-trained items (n = 11): transfer of treatment is measured by assessing performance on items similar to the items that were used during training.
- Daily tasks (n = 23): transfer of treatment is measured by using standardized observations of a simulated performance of daily tasks in a laboratory environment.
- Daily life (n = 21): transfer to daily life situations is measured. In this type of transfer measurement, 3 different perspectives can be distinguished:
  - Patients (self-reports): the patient judges his or her own functioning. Outcome measures are questionnaires (focused on quality of life, the use of compensatory strategies or experienced problems due to the cognitive deficit), diary entries and non-standardized remarks.
  - Caregivers: people living with the patient judge the patient's functioning. Outcome measures are questionnaires focused on experienced problems due to the cognitive deficit and non-standardized remarks based on coincidental observations.
  - Staff: members of the rehabilitation team judge the patient's functioning. Outcome measures are standardized rating scales and non-standardized remarks based on coincidental observations.

Most studies used a combination of these 3 outcome types.

Outcome

At least one type of transfer was demonstrated in 36 of the 41 evaluated studies. However, in 15 of these studies, the transfer effect was not statistically tested. As was mentioned before, most studies evaluated more than one type of transfer. Table II displays the data, arranged in the 3 types of transfer.

In a relatively large number of studies, transfer to daily life was evaluated (n = 22). This type of transfer was demonstrated in 18 of the 22 studies. However, transfer effects were not statistically tested in 12 of the 18 studies that demonstrated transfer to daily life.

Table II. *Number of studies that evaluated and demonstrated the 3 types of transfer*

Type of transfer	Total number of studies (transfer demonstrated)	Transfer demonstrated – statistically tested	Transfer demonstrated – not statistically tested
Non-trained items	11 (8)	3	5
Daily tasks	23 (19)	15	4
Daily life	22 (18)	6	12

A total of 39 papers, describing 41 studies was included in this review; several studies evaluated more than one type of transfer.

Transfer to daily tasks was the most often evaluated type of transfer. Twenty-three studies evaluated this type of transfer and it was demonstrated in 19 of these studies. Fifteen of these studies did statistically test the positive research findings; 4 did not.

Transfer to non-trained items was demonstrated in 8 studies, 3 of which used statistical testing.

Only 12 evaluations of all types of transfer combined did not demonstrate transfer. Ten of these negative findings were statistically corroborated, 2 were not. No similarities could be identified in the studies reporting negative findings.

DISCUSSION

A literature search was performed in order to inventory studies evaluating transfer effects of cognitive strategy training. A total of 41 relevant studies were identified. This is a small number of studies, compared with the large number on cognitive rehabilitation that was reviewed by Cicerone et al. (4, 5). Many different strategies and many different outcome measures were used in the studies. However, most strategies could be classified as the classical intervention strategies used in cognitive rehabilitation (60). Outcome measures could be classified in 3 groups: non-trained items, daily tasks and daily life. The studies we evaluated include the cognitive domains that were also identified in Cicerone et al.'s review (4, 5). In addition, a seventh group of studies was identified, consisting of strategies aimed at the training of daily activities, not specifically at a single cognitive disorder. In accordance with Cicerone et al. (4, 5), we found relatively large numbers of studies evaluating transfer of training effects in the domains of neglect, memory and language, compared with the other domains. This reflects the fact that the domains of neglect, memory and language are, in general, studied more often than other cognitive domains.

Limitations of the review

We acknowledge that we could have missed articles that did measure "transfer" if the term was not mentioned in the abstract or keywords of the paper. We therefore reviewed an independent sample of articles that were included in the updated review of Cicerone et al. (5) containing all recently published studies on cognitive rehabilitation. Our sample consisted of 15% of the studies that were included in the updated review; that is, 13 of the 87 studies that were included by Cicerone et al. (5).

Studies were selected from each category in proportion to the number of studies Cicerone et al. included in the different categories they distinguished. Of these 13 studies, 3 turned out to be included in our review and 2 studies were retrieved by our search strategy, but were not included in our review as they did not meet with our inclusion criteria. Seven studies could be excluded, based on our exclusion criteria. Thus, the conclusion of this sample is that we missed one out of 13 studies. In our opinion, this is an acceptable result.

Limitations of the evaluated studies

Methodological issues. Many studies used single subject designs or had a small sample size. Furthermore, it should be noted that many positive results were not statistically tested. This was especially the case in studies that evaluated transfer to daily life. In 6 studies the demonstration of transfer to daily life was based on coincidental observations of people living with the patient, or on coincidental remarks the patient made. In these studies, identifying transfer to daily life was not formulated as an aim of the study beforehand, and therefore it was not measured in a standardized way.

Choice of outcome measures. A type of transfer we excluded from this review is transfer to neuropsychological tests, measuring transfer effects of cognitive strategy training to cognitive functions. The aim of strategy training is not to improve cognitive functioning, but to teach patients ways to function as independently as possible, despite the presence of the cognitive deficits. Therefore, little change in cognitive deficits is expected in cognitive strategy training (2). However, the 13 studies we included in our review did evaluate transfer effects of strategy training to neuropsychological test results in addition to one of the other types of transfer we distinguished (22, 23, 26, 27, 29, 31, 34, 36, 47, 48, 50–52). Eleven studies did report transfer to neuropsychological test results. Two of these studies did report that their findings are surprising, since cognitive functioning was not expected to improve (23, 26). Two other studies distinguished between neuropsychological tests in which the trained strategy could not be used vs tests in which the strategy could be used, because the components of the test reflected the focus of the training (22, 29). In this way, the fact that in most neuropsychological tests subjects are not allowed to use the strategies they learned to use is annulled.

Evaluation of the effectiveness of a rehabilitation programme should be attuned to the results that are to be expected of this programme. When evaluating the effectiveness of a rehabilitation programme, the study ideally should be aimed at assessing transfer to daily life, as teaching patients to function as independently as possible in their own home and in society is considered to be the primary goal of rehabilitation practice (1, 61). Unfortunately, it seems to be difficult to evaluate this type of transfer in a standardized way. Most studies we identified measuring transfer to daily life, made use of self-reports of the patients by analysing questionnaires, diary entries and coincidental remarks the patient made. The standardization of the latter 2 methods can obviously be doubted. However, one can also argue about the reliability of a self-report questionnaire completed by a patient with ABI (62). There appears to be a lack of reliable, standardized instruments to measure this type of transfer, making it difficult to evaluate the effectiveness of a rehabilitation programme.

Although, of course, demonstrating transfer to daily life is the best way to prove the clinical effectiveness of a rehabilitation programme, demonstrating transfer to (simulated) daily tasks, performed in standardized laboratory settings can be seen at “the next best thing”. We identified 23 studies evaluating this type of transfer, 15 of which demonstrated it statistically.

General conclusions

Transfer of training effects of cognitive strategy training has been evaluated in a relatively small number of studies. Outcome measures used in these studies could be classified into 3 groups: non-trained items, daily tasks and daily life. Most studies reported positive results with regard to the occurrence of transfer of training effects, although some serious concerns may be raised about the methodological quality of the studies.

Recommendations for future research

To be able to evaluate the effectiveness of cognitive strategy training, more studies are needed that are specifically designed for measuring transfer effects. In accordance, a workshop organized by the National Center for Medical Rehabilitation Research in the USA recommends that more attention should be paid to the investigation of transfer of rehabilitation programmes; particularly to transfer of functionally important tasks in meaningful task environments (63).

While designing a study to measure transfer effects of cognitive strategy training, 2 important factors should be taken into account. First, before starting the study, measuring transfer should be set as the primary aim of the study, hence making sure that transfer effects can be measured and statistically tested in a standardized way. Secondly, outcome measures should be chosen carefully, taking into account what the aim of the therapy is and whether reliable, standardized instruments exist to evaluate this aim. Studies aimed at evaluating transfer should use measures of activities as their primary outcome, demonstrating whether or not the strategy actually reduces limitations on activities, thus measuring transfer effects to daily tasks. In the studies we included in our review, this type of transfer was assessed by using standardized observations of a simulated performance of daily tasks in a laboratory environment. However, standardized observations of the simulated performance of daily tasks can also be made in daily settings, for example by observing a participant who performs a specific task in his own home environment. This outcome measure provides more information on the participant’s functioning in daily settings, although, of course, it is not an exact reflection of the participant’s performance in everyday life.

In addition, studies investigating whether and in what way transfer itself can be trained could provide valuable information for clinical practice. The prerequisites for the occurrence of transfer derived from educational psychology that were described in the introduction of this paper, could be considered to be a good starting point for answering this question.

In clinical practice several of these prerequisites for the occurrence of transfer are already being applied. Three of these recommendations were actively used in the studies we described. Firstly, 3 studies explicitly described that during training attention was paid to the enlargement of the patient's awareness of his own deficits (23, 26, 27). This is an important prerequisite for the occurrence of transfer, as someone must acknowledge that there is a need to adapt his behaviour (14).

Next, it was stated that general knowledge is, by definition, easier to transfer than specific knowledge (15). This distinction corresponds to the distinction between strategy training and task specific training. Strategy training is said to be more generally applicable than task-specific training (3). All studies included in this review evaluated transfer effects of cognitive strategy training.

Lastly, a small number of studies specifically used "training for transfer" (23, 24, 44), corresponding with the statement that transfer does not occur automatically and that it takes place during learning, not afterwards (8, 17). However, 3 recommendations of educational psychology do not reappear in the strategies that were described in the papers. Possibly, they have been used during training, but were not described in the papers.

The aim of this paper was to investigate the occurrence of transfer of cognitive strategy training for patients with ABI. We hope that, by means of this paper, clinical practitioners as well as researchers working in rehabilitation settings become more aware of the importance of transfer for the clinical success of a rehabilitation programme, and of the way in which transfer of training effects should be evaluated. We are certain that this awareness will make a vast difference while applying and studying rehabilitation practice.

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Appendix I. *Details of literature search*

Category	Terms
Controlled vocabulary words (combinations of these terms)	
Type of brain injury	Brain injury TBI, cerebrovascular accident, CVA, brain contusion, brain concussion
Transfer	Transfer (psychology), transfer (learning), generalization (psychology), generalization (learning), learning, transferability, learning environment – clinical, activities of daily living
Type of disorder	Neurobehavioral manifestations, cognitive impairment, cognitive defect, cognition disorders, cognition (OMAHA)
Type of intervention	Rehabilitation, cognitive rehabilitation, neuropsychological rehabilitation, rehabilitation - community based, home rehabilitation, education
Free text words (combinations of these terms and in combination with controlled vocabulary words)	
Type of brain injury	"traumatic brain injury", stroke, contusion, CVA, "cerebro vascular accident"
Transfer	Transfer, generalisation, generalization, "environmental validity", "environmental valid", "activities of daily living", ADL
Type of disorder	"Cognit* disorder", "cognitive impairment"
Type of intervention	Rehabilitation, remediation, compensation, strategy, "compensatory strategy", "compensation training", "compensatory training", "strategy training", "cognitive training", "cognitive retraining", "cognitive rehabilitation", "cognitive remediation", "remediation strategy"

TBI: traumatic brain injury; CVA: cerebrovascular accident; ADL: activities of daily living.