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Published in:
Clinical Rehabilitation

DOI:
[10.1177/0269215510395791](https://doi.org/10.1177/0269215510395791)

Publication date:
2011

Document Version
Publisher's PDF, also known as Version of record

[Link to publication in Tilburg University Research Portal](#)

Citation for published version (APA):

Gehring, K., Aaronson, N. K., Taphoorn, M. J. B., & Sitskoorn, M. M. (2011). A description of a cognitive rehabilitation programme evaluated in brain tumour patients with mild to moderate cognitive deficits. *Clinical Rehabilitation*, 25(8), 675-692. <https://doi.org/10.1177/0269215510395791>

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A description of a cognitive rehabilitation programme evaluated in brain tumour patients with mild to moderate cognitive deficits

K Gehring¹, NK Aaronson^{2,3}, MJB Taphoorn^{4,5}
and MM Sitskoorn¹

Abstract

This series of articles for rehabilitation in practice aims to cover a knowledge element of the rehabilitation medicine curriculum. Nevertheless they are intended to be of interest to a multidisciplinary audience. The competency addressed in this article is cognitive rehabilitation.

Background: There is a paucity of literature on the rationale, design, and content of successful cognitive rehabilitation programmes. In the current paper, we describe in detail a cognitive rehabilitation programme that has previously proven effective in a randomized controlled trial in patients with primary brain tumours. The programme's content may be of practical interest to those working with populations of cognitively impaired patients.

Programme: The programme consists of six weekly, individual, 2-hour sessions plus homework, and incorporates both strategy training and attention retraining. The elements were taken from two of the few programmes that are evidence-based. Its design consists of psycho-education, teaching of strategies to compensate for problems in attention, memory and executive functioning in daily life. The retraining was based on the assumption that a target process can be improved by frequently practising exercises. It is focused on attention as intact attention may also be necessary for adequate functioning of other cognitive domains. The hierarchically organized exercises, embedded in a game-like computer program, were tailored to the needs of the individual patient.

Evaluation: Mean total training time was estimated to be 35 hours in seven weeks. Adherence to the programme was high. The majority of the participants found the programme to be (very) useful. However, older participants found the programme more burdensome than younger patients.

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Discussion: Splitting up and spreading out sessions may increase the feasibility and usefulness of the programme for older participants. Further suggestions for improvements and future studies on this programme are also provided.

Keywords

Cognitive impairment, brain tumour, cognitive rehabilitation

Introduction

In recent years, various studies and reviews have demonstrated the effectiveness of cognitive rehabilitation programmes for deficits in the areas of attention, memory and executive function.^{1–6}

Although there are some exceptions (e.g. ref. 7), few of the papers reporting on the effectiveness of cognitive rehabilitation have provided detailed information on the actual contents of the diverse programmes that have been evaluated. In their review of the literature on cognitive rehabilitation after stroke and traumatic brain injury, Cicerone and colleagues¹ emphasized ‘the need to provide greater specification of the theoretical basis, design, and components of interventions as a prerequisite to investigating the effectiveness of rehabilitation.’ Moreover, in clinical practice, detailed information on the content of programmes is needed in order to plan and employ a cognitive rehabilitation programme in patients with cognitive deficits. Thus, for both researchers and clinical neuropsychologists, content and background information can be used to select, revise or expand upon available programmes, and to develop novel rehabilitation programmes.

In the current manuscript, we provide a detailed description of, and describe our experiences with, a cognitive rehabilitation programme that was evaluated in 70 patients with a low-grade or anaplastic glioma (a primary brain tumour) as compared with a waiting-list control group in the context of a randomized controlled trial.⁸

In general, patients with a glioma seem to experience rather mild and diffuse cognitive deficits, and deficits are different from, for example, those secondary to strokes.^{9,10} Impairments are

often observed in various cognitive domains, including attention, memory, executive functioning and language.^{11–13}

To participate in the trial,⁸ patients had to be clinically stable (i.e. without any evidence of disease progression) for a minimum of six months prior to study entry, and could not have received any anti-cancer treatment during that period. Median disease duration was 5.2 years (range 0.7–38.9) for the intervention group. Most participants had a history of tumour biopsy or resection, and many had had radiotherapy. Only a few had received chemotherapy. In addition, both subjective and objective cognitive eligibility criteria were employed in order to identify patients who would be both motivated to participate in and potentially benefit from the cognitive rehabilitation programme.

In summary, the results of the randomized controlled trial in 140 patients with a glioma indicated that undergoing the programme had a salutary effect on short-term cognitive complaints, and on longer term cognitive performance and mental fatigue.⁸

Although the programme was evaluated in patients with a glioma, we believe that the programme’s content may be of practical interest and use to those working with other populations of cognitively impaired patients. Following a description of the rationale, design and content of the programme, we will discuss the participants’ evaluation of the programme and make some suggestions for further improvement of the programme.

The cognitive rehabilitation programme

In short, the programme ‘Strategy Training and C-Car’ (STCC) incorporates two training

approaches: (1) a strategy training that consists of teaching of strategies for improving attention, executive functioning and memory, and (2) a retraining that focuses on frequently practising attentional exercises in a game-like computer program ('C-Car'). (Note: STCC has not been developed for commercial purposes. Both components are available on request from the authors. The strategy training and the exercises of C-Car are presented in the Dutch language.)

Programme rationale

There is as yet no convincing evidence in the literature that one of the two training approaches has a greater effectiveness over the other. Whereas retraining is often used for mild cognitive impairment, teaching of (compensating) strategies are frequently employed in patients with more severe deficits.¹⁴ As the cognitive impairment stemming from brain tumours is rather heterogeneous, we chose to combine the two different approaches to benefit from the virtues of both methods, and hopefully to optimize programme efficacy.¹⁵

We will first describe the rationale behind the strategy training and then discuss the rationale behind the retraining programme.

Rationale strategy training

Strategy training is recommended as a practice standard for attention and memory problems by Cicerone and colleagues in their comprehensive review of cognitive rehabilitation approaches in patients with traumatic brain injury and stroke.¹ It is assumed that strategy training induces a compensatory process in the brain, in which patients learn to achieve the same behaviour in a different way by reorganizing intact neural circuits and thereby using different neuropsychological systems.¹⁶

As deficits in the broader cognitive domains of attention, memory and executive functioning are frequently observed in patients with a brain tumour, the strategy training component addresses the practical implications of these

deficits for daily functioning by making use of the intact cognitive abilities. In particular, as a result of their mental slowness, problems with dealing with time pressure is a frequently reported complaint of patients. Therefore, the training emphasizes improvement of attention, memory and executive functioning in daily life by teaching patients to carefully prepare and plan activities.

As noted in the introduction, the precise content of previous cognitive rehabilitation approaches has scarcely been described. It was therefore not possible to fully ground our strategy training on evidence-based models of cognitive rehabilitation. However, as many as possible (peer-reviewed and non-peer-reviewed) publications on strategy training of attention, memory and executive functioning were consulted. The few evidence-based elements of the training have been taken from Goal Management Training⁶ and Time Pressure Management training^{3,7} for use in the 'Planning and Regulation' session (session 4). Goal Management Training^{6,17} is directly based on a theory of deficits in goal management following dysfunction of frontal systems,^{6,18} which cause goal neglect or failure to execute intentions. It was designed as a training probe (rather than a full-fledged intervention protocol) for the rehabilitation of participants with impaired self-regulation affecting organization of everyday behaviour.⁶ Time Pressure Management training was originally developed to treat mental slowness in patients with traumatic brain injury.³ It consists of two types of cognitive strategies by which participants either learn to prevent or to manage time pressure.⁷ In this way, they are enabled to compensate for their slowness and deal with the task at hand.

Dutch-language self-help books (non-peer-reviewed)^{19–23} were also consulted, in particular for advice on psycho-educational topics, and attention and memory strategies. Finally, more fundamental information was obtained from handbooks on neuropsychological function^{24,25} and cognitive rehabilitation.^{26,27}

Rationale retraining

The method of retraining is based on another assumption, namely that a target process can be improved by frequently practising exercises ('repetitive stimulation'), thus making the skill more automatic.^{28,29} It has been suggested that retraining of a cognitive skill may induce restitution (i.e. restoration) of function in the brain.^{29,30}

The retraining component is specifically aimed at deficits in the attentional domain, as attention and information processing deficits are among the deficits that are most frequently experienced by glioma patients.^{11,31} Furthermore, since adequate attention is critical for many types of learning,³² it has been suggested that rehabilitation of attention deficits may also provide a more stable and effective substrate for other cognitive functions,³³ such as memory and executive functioning. In fact, some studies have demonstrated generalization to other cognitive domains.^{2,3,34,35} Robertson and Murre¹⁴ have suggested that an extended attention span may also provide improved input of therapy for other impaired functions^{14,36,37} (here, this would be the strategy training).

In fact, retraining of the specific subtypes of attention that have been discerned in the literature, has been suggested to have a greater likelihood of generalization to other cognitive domains and to daily living³² than non-specific attention training. Furthermore, incorporation of a hierarchically organization of these attention components in a treatment paradigm should also yield more successful results.^{38,39} Thus, a retraining programme that would address specific subtypes of attention in a hierarchical manner, and is tailored to the needs of the individual patient, was favoured. In addition, the programme had to provide participants with feedback on their results, as previous studies have demonstrated that this improves performance.¹ The use of a computerized programme was also considered to be of essential importance in order to allow participants to carry out the frequent repetition of

attention exercises independently of the trainer, and to do so in a structured manner. Moreover, a computer-based programme facilitates automatic registration of a number of variables of importance in both process and outcome evaluation (e.g. frequency with which the programme is used, time devoted to the exercises, performance on the various exercises, etc.). Finally, attractive exercises were required in order to stimulate patients to exercise frequently. These had to be presented in both the visual and the auditory modality, and had to include both verbal and non-verbal (i.e. numeric) stimuli, to facilitate a multifaceted generalization to daily functioning.

However, when we were choosing a computerized retraining programme for use in our study, we were unable to locate training programmes, either academic or commercial, that were appropriate in terms of theoretical background, content, form, mode of administration, and price. Although the Attention Process Training, developed by Sohlberg *et al.*,⁴⁰ meets most of the criteria we described above, it was not available in a computer-based format.⁴⁰ For these reasons, we decided to develop a new computerized training programme, named C-Car (Concentration Car⁴¹) that would meet our criteria.

Based on the clinical model of Sohlberg and Mateer,^{33,42} C-Car includes four subtypes of attention that are also used in the APT: sustained attention, selective attention, alternative attention and divided attention.^{33,42} Each of the subtypes is viewed as more complex and as requiring effective functioning at the previous level. Besides this hierarchy in the ordering of the retraining of these attentional subtypes, C-Car also incorporates a hierarchy of exercises within each subtype: the participant has to obtain at least 90% accuracy to proceed to the next, more complex exercise; otherwise the task is repeated until this level of success is obtained. In this way, the training is tailored to the needs of the individual participant. Another important characteristic of the computer program is its emphasis on real-time feedback to the

participant on how they have performed a given task, and on how they might perform better.

In order to make the programme attractive for frequent exercising, the C-Car exercises are imbedded in a game-like platform, in which driving an old-fashioned car (a Fiat 500) is simulated. The participant has to process and react to visual information displayed on road signs, or for auditory exercises, spoken text from the radio, while the car drives through different landscapes (e.g. a green valley, a desert or a horizon of snow-capped mountains), with old-fashioned cars in on-coming traffic.

Programme design

The total STCC programme, integrating both strategy training and C-Car retraining, consists of six weekly, 2-hour individual sessions plus several hours of homework. In the randomized controlled trial, participants were offered the choice of undergoing the sessions in their home or at their hospital. In the programme as evaluated, the C-Car retraining is completed at the same time as the strategy training. The individual weekly sessions are predominantly devoted to strategy training, while practising with C-Car retraining is part of the homework assignments.

Design strategy training

The strategy training consists of several elements. First, psycho-education is employed to inform patients about the basic workings of the cognitive functions, about factors that may influence these functions, and about the methods to rehabilitate these functions. Second, practical strategies for improving attention, executive functioning ('planning and regulation'), memory and general functioning in daily life are provided and practised by means of homework exercises. These practical strategies consist of both 'general conditions' and '(mental) strategies'. General conditions serve to accommodate good performance and can be employed beforehand (such as preventing time pressure, being

rested and relaxed). (Mental) strategies are commonly applied before and during the task at hand (e.g. repetition or structuring of information, preventing distraction). Finally, the use of external devices is promoted, in particular to help participants to cope with memory problems, to optimize daily functioning (e.g. diaries and to do-lists; placing an object in a noticeable location as a reminder to do something (with that object); always storing important belongings in the same place).

General conditions, (mental) strategies, and tips for use of external aids were integrated in six didactic chapters (corresponding to the six sessions) of a textbook. A workbook was developed to include six corresponding chapters of diary exercises, and exercises involving keeping logs of experiences with the application of strategies in daily life.

In general, each session/textbook chapter starts with psycho-education about the specific cognitive domain. Subsequently, general conditions, strategies and external devices to improve daily performance are discussed. In homework exercises the participant learns to apply the general conditions, strategies and aids to his or her personal daily situation. By discussing the specific problems of each patient's everyday live, the strategies were tailored to the needs of the individual patient.

More practically, participants are asked to read a textbook chapter in advance of each of the six sessions (except the first). The content is discussed individually with the trainer in that specific session. Subsequently, accompanying homework exercises are completed in the workbook and are discussed with the trainer at the start of the next session. In this manner, each session topic is discussed three times.

Approximately three months after completion of the programme as evaluated in the randomized controlled trial, participants had a telephone-based 'booster session' during which key aspects of the strategy training were reviewed.

The specific content of each session is summarized below.

Design retraining

The C-Car programme starts with the introduction of four basic information processing exercises that are used throughout the entire programme, and to which various elements are added in order to train more complex aspects of attention.

Although most of the C-Car exercises are done by the participant as homework on a notebook computer, the basic exercises are introduced by the trainer in the first of the six strategy training sessions (see below for a description of the basic exercises). The participant has to practise all four basic exercises under supervision of the trainer, until the trainer is convinced that the participant is able to exercise on his or her own.

Each basic exercise lasts for 3 minutes. Throughout the entire C-Car programme, all visual and auditory stimuli are presented every 1.8 seconds. The main action button is the space bar.

After the introduction of the basic exercises, the actual training of the four different components of attention (modules) distinguished by Sohlberg and Mateer begins.^{33,42} Each training module starts with the introduction of the basic exercises, one visual and one auditory, that are used throughout that module.

At the end of each C-Car exercise, feedback is provided on accuracy of the responses in the current and previous exercises. A hint concerning false-positive responses or omissions is also given when performance is not sufficiently accurate; a compliment is made when performance is satisfactory. At that point, the participant also fills out a feedback form, consisting of graphs of the accuracy of his or her performance, based on the information on the screen. In each session, the trainer discusses progress through C-Car by using these feedback forms.

The participant is instructed to practise, independently of the trainer, for at least 45 minutes per week. In total, if the whole programme is completed without repetition of the same exercise due to failed attempts, a participant trains his or her attention for a total of almost 3 hours (178 minutes). After completion of all 32

exercises of the C-Car programme a certificate is displayed on the screen, in which the participant is congratulated for completing the attention training programme. This certificate can also be printed on paper, if desired.

For participants who complete all exercises before completion of the six strategy training sessions, a new C-Car account can be created with more difficult settings, such as a faster stimulus rate and a longer duration of exercises. In this way, they can exercise their attentional capacities on a higher level.

Essentially, it is also possible to add multiple 'components' to the basic exercises; thus, combining alternating exercises with distracting noise to ignore, and the moving pointer of the petrol gauge to which attention should also be paid. In our study, we did not use this possibility for the participants who completed all exercises, since we wanted all participants to practise the same training elements.

The specific content of the C-Car exercises and modules is summarized below.

Content of the strategy training

Session 1: Cognitive problems. Explanation of the meaning of the term 'cognitive functioning', discussion of the diverse brain functions and explanation of the difference between 'cognitive complaints' and 'cognitive deficits'. Review of the two methods of cognitive rehabilitation used in the programme (strategy training and C-Car retraining). Introduction of the strategy part by describing the various medical and psychological factors that influence cognitive functioning, and discussing the personal experiences of the participant with each of these factors.

The duration of the strategy part of this session is relatively short, as time is also devoted to the introduction of the C-Car retraining programme (see Content of the C-Car attention retraining programme).

Homework: Give examples of the positive or negative influence of presented psychological factors (such as interest, motivation, self-confidence, stress/strain, depressive feelings,

fatigue and pain) on cognitive functioning in your daily life. Keep a log of cognitive problems encountered on five days of this week: What was the cognitive problem? Where and when did it happen? Did psychological factors play a role? What did you do to deal/cope with the problem? Both exercise types are used to provide the trainer with insight into the cognitive problems experienced by the participant.

Session 2: Attention, memory and executive functioning. Discussion of the problems encountered in daily life, as reported in the homework exercises, and discussion of the implications of these problems for the training. Introduction to the cognitive functions attention, memory and planning, and the interrelationships among them. Overview of techniques, including: discussion of general conditions, presentation of (mental) strategies, and use of external devices to optimize daily functioning. Introduction of and practising progressive relaxation exercises.

Homework: Find personal situations or problems to apply the learned strategies. Keep a daily log of cognitive problems encountered in daily life: Was the problem related to attention, memory or executive functioning? Did psychological factors play a role? Which of the learned strategies or external devices could have been used? Describe activities that make you feel relaxed. Discuss at which cognitive problems the training should be aimed. Practice with relaxation exercises presented on CD.

Session 3: Attention. Discussion of completed homework exercises and of the implications of the problems reported in the exercises for implementing in the training. Explanation of the relevance of attention, and implications of attention problems for daily functioning. Discussion of selective, sustained, alternating and divided attention.⁴² Discussion of strategies^{21,22} for improving selective (prevention of internal and external distraction) and sustaining attention. Discussion of the psychological factors influencing attention, including motivation, interest and self-confidence.^{21,22}

Homework: Describe situations/activities in which internal or external distractions interfere with functioning and how distraction can be prevented. Describe situations in which you find it difficult to sustain attention: At which time of the day, after how much time, and for which activities do you experience problems? Which strategies can you apply? Apply as many strategies as possible in preparation of and during two activities that demand a good deal of your attention and describe your experiences.

Session 4: Planning and regulation. Discussion of attention homework exercises. Introduction to all cognitive aspects of planning and regulation (initiation, making a plan, structuring, flexible and purposeful execution of an activity, monitoring and correcting performance) and deficits in these aspects.³⁸ Discussion of how deficits in these planning and regulation components are reflected in daily behaviour and performance (e.g. in cooking, driving to a destination, filling out forms, work activities). Introduction to the use of 'Seven-Steps-of-Planning-Scheme' for planning a single activity and to prevent time pressure, based on both Goal Management Training⁶ and Time Pressure Management training.^{3,7} These seven steps concern: getting an overview of the task, subdividing the task into multiple steps, preparation, time scheduling, remembering, execution and self-monitoring. These steps are printed on a card for application in more complex daily situations. Participants are also encouraged to use the self-instructional method⁴³ (i.e. talking through a problem or situation in an inner dialogue). This technique has proven to be effective in the rehabilitation of diverse cognitive domains.¹ Other topics covered during this session are planning multiple activities and efficient diary use.

Homework: Apply the 'Seven-Steps-of-Planning-Scheme' to at least two complex tasks/activities. Design a plan for a busy day. Answer questions regarding taking breaks, plans for the day, estimation of duration of activities, strategies to improve preparation

and execution of activities, and use of diary. Make a to-do list.

Session 5: Memory. Discussion of planning and regulation homework exercises. Discussion of the three stages of memory (encoding, storage, retrieval) and how deficits in these stages are reflected in behaviour. Discussion of the terms 'working memory', 'short-term memory' and 'long-term memory' and deficits in these components. Discussion of general conditions to optimize performance, and mental strategies. Most of these so-called 'mnemonics' focus on encoding of information in a way that is meaningful and elaborate, or on providing potential cues for easy retrieval,⁴⁴ for example, repetition, structuring, anticipating, using routines and imagination.^{20–22,45} The use of external devices (often reminding one to do something) is also taught. Examples are electronic devices, move a ring to another finger to remind you to do something, placing an object (e.g. a light bulb) on a table as a reminder to buy a new one.^{20–22} Some participants have difficulties accepting the use of external aids such as a shopping list, and have to be encouraged to use them. Provision of strategies to improve reading also takes place during this session.

Homework: Keep a log of memory problems, the interrelationships with deficits in attention and planning. Can you apply accommodating conditions, mental strategies and external devices to them? Find daily situations/activities to which you can apply the strategies, as presented in the exercise form.

Session 6: Summary. Discussion of memory homework exercises. A summary of the five previous sessions is integrated with recapitulating exercises. Re-emphasis and personal rating of usefulness of specific conditions, strategies and devices to improve attention, planning and memory. Filling out 'Seven-Steps-of-Planning Scheme' for an activity once again. Discussion and exercise of reading strategies.

(No homework.)

Content of the C-Car attention retraining programme

Basic exercises

- **Forming words (visual) (Figure 1):** The participant is presented with multiple two-letter combinations appearing on the 'road signs'. The participant has to decide whether two two-letter combinations form an existing four-letter word.
- **Counting letters (auditory):** The participant hears four-, five- and six-letter words (destinations such as cities, countries and rivers) from the car radio. After each word, a digit ('four,' 'five' or 'six') is spoken out loud. The participant counts the letters of the spoken word and decides whether the digit that follows, matches the number of letters.
- **Arithmetic (visual) (Figures 2 and 3):** On the road signs, the participant sees simple addition and subtraction sums, broken down into components. The first part of the sum (e.g. '8-') is presented on the first sign, the last part (e.g. '6=2') appears on the next sign. For each pair of signs, the participant has to decide whether the outcome of the sum displayed by the second sign is correct.
- **Alphabet of first letters (auditory):** The participant hears destinations from the radio. He or she is instructed to pay attention to the first letter of each destination and to decide for each pair of destinations whether their first letters are listed in alphabetical order. The participant must then press a button if the first letter of the destination that is heard last is later in the alphabet than the first letter of the previous destination. For example, in the series Belgium – Geneva – Madrid – Cairo, the participant should press the button immediately after 'Geneva', since G comes after B in the alphabet. After 'Madrid' the participant should press the button again, but after 'Cairo' he or she should refrain from pressing the button.

Figure 1. Basic exercise: Forming words.

The four attention modules

- **Sustained attention:** The participant learns to sustain his or her attention longer, as the duration of the two basic exercises ‘Forming words’ and ‘Counting letters’ is prolonged from 3 up to 5, 8 and 12 minutes.
- **Selective attention:** The participant learns to focus on a relevant task, while ignoring a distracting sound. First, the two basic exercises (‘Arithmetic’ and ‘Alphabet of first letters’) are done by the participant. Then simple noise (a radio conversation) is added to both of the exercises, which has to be ignored. Subsequently, these exercises are prolonged up to 7 minutes. Next, more complex noise is added (radio conversation mixed with digits spoken out loud) to 3-minute exercises, which are finally prolonged up to 7 and 12 minutes.
- **Alternating attention (Figure 4):** The participant learns to switch attention by practising a combined exercise in which stimuli of both visual exercises, or both auditory exercises, are presented simultaneously. The participant is instructed to attend to only one of the exercises and to switch exercise after a tone sounds. For example, for the visual exercises, word pieces are presented simultaneously with sum pieces. The participant must first pay attention and react according to ‘Forming words’. Then, when a tone sounds, she has to react to the pairs of sums of ‘Arithmetic’. With the next tone, she has to form words again. For the auditory exercises, the names of destinations alternate with digits. First, the participant has to count the letters of each destination, and when the tone sounds, she has to decide whether the destinations are listed in alphabetical order, and so forth. The duration of the exercises is prolonged from 3 minutes to 7, and finally 12 minutes.
- **Divided attention (Figure 5):** The participant learns to perform two tasks simultaneously. First, she has to combine an auditory basic task (‘Counting letters’) while (visually) checking on the petrol gauge, of which the rate varies over time, making its cycle rather unpredictable. The participant must press the space bar to react to the basic exercise, and the enter button if the petrol gauge is in the red zone. Subsequently, the participant has to perform the visual task ‘Forming words’ while keeping an eye on the petrol gauge. The duration of the exercises is, again, prolonged from 3 to 7 minutes, and finally to 12 minutes.

Figure 2. Basic exercise: Arithmetic – first component of sum.

Figure 3. Basic exercise: Arithmetic – second component of sum.

Evaluation of the cognitive rehabilitation programme

In this section we will evaluate the cognitive rehabilitation programme. After more objective measures of programme participation (i.e. attrition, compliance, programme duration, training time) have been described, we will elaborate on the subjective evaluation of the programme based on the

evaluation forms that patients filled out after completion of the cognitive rehabilitation programme in the randomized controlled trial.

Objective indicators of programme participation

All participants but one chose to undergo the programme at home rather than in their

Figure 4. Alternating attention – visual exercises.

hospital, when offered these alternatives in the randomized controlled trial. Six participants discontinued the cognitive rehabilitation programme. Two participants had medical reasons, including progressive disease and cerebral ischaemia. Three participants reported practical and/or psychosocial factors that led to programme drop-out, including serious financial problems needing attention, serious psychological distress, and need to care for an ill mother. One patient indicated mid-programme that he was not sufficiently motivated to continue.

The mean duration of the cognitive rehabilitation programme was seven weeks ($SD = 1$). In total, mean time devoted to the entire programme was estimated to be 35 hours; up to 30 hours for the strategy component and almost 6 hours for the C-Car retraining component.

With regard to the strategy training, we did not ask the patients to register systematically the time devoted to this component. Based on their spontaneous reports, we estimated that they spent about 3 to 3.5 hours on homework in preparation of each of the five sessions. Combined with the six 2-hour sessions, we estimated that, on average, respondents spent about 30 hours on strategy training.

At least 50 of the 54 participants (93%) who were queried about their compliance with the strategy training homework indicated having read the entire textbook chapter in advance of a session. Depending of the specific session, 9 to 17 patients (16–33%) of the participants reported having completed only a portion of the workbook exercises in preparation of a session. One to four patients (2–8%), varying over sessions, indicated that they had not completed any of the workbook exercises for a particular session.

The C-Car programme automatically registers a large number of process and outcome variables, the most salient of which will be reported here. Fifteen participants (23%) did not complete the whole C-Car programme, 41 patients (64%) completed C-Car at least once, and 7 patients (11%) completed it at least twice (with more difficult settings the second time). One participant started a third round of C-Car.

The C-Car programme has 32 exercises if completed once. The mean number of exercises completed was 39.6 ($SD = 16.4$). The mean total exercise time was 5.8 hours ($SD = 3.0$). Six patients did not follow the advice to exercise 45 minutes or more in preparation of each of the five sessions (exclusion of the first session;

Figure 5. Divided attention – Forming words and Petrol gauge.

at least 3.8 hours). For patients who did not complete C-Car at least once, mean total training time was 3.9 hours ($SD = 1.9$), with a median of 24 of the 32 exercises (range 8–30) completed.

A limitation of the current version of the C-Car programme noticed by the cognitive trainers is that sometimes complications occurred with faster than standard rates of stimuli appearance (rounds 2 or 3).

Patients' subjective evaluation of the programme

In addition to the objective and subjective measures of cognitive functioning used in the study⁸ to evaluate the effect of the intervention, participants in the intervention group also filled out an evaluation form, in which they were queried about their experiences with the programme immediately after completion of the programme and at six months follow-up. A total of 60 of the initial 70 patients in the intervention group completed the form. None of those who discontinued the programme completed this form. For an

additional four participants, evaluation forms were missing.

In reply to the specific questions on the separate training components, a substantial number of respondents indicated that the time required by the strategy training (text and exercises combined in homework) was large (Table 1), although only a few indicated that it was too burdensome. Univariate correlation analyses indicated that participant age was correlated significantly with perceived programme burden, with older patients reporting more burden ($r = 0.39$; $P = 0.002$). As spontaneously reported by the participants and noted by the trainers, session 4 on 'Planning and Regulation', was particularly heavy. That session covered a large number of topics and involved many exercises. The difficulty level of the strategy training, though, appeared appropriate. The large majority found all components of the strategy training to be (very) useful, although the relaxation exercises were rated less highly.

The participants rated the C-Car exercises as (very) useful and indicated that both the

Table 1. Ratings of strategy training aspects immediately post intervention ($N = 60$)

Difficulty of	(too) easy	just right	(too) difficult
Text(book)	(2%) 19%	70%	11% (2%)
Exercises	(2%) 16%	56%	19% (2%)
Sessions	(2%) 14%	71%	15% (–)
Amount/number of	(too) little	just right	(too) much
Text	(–) –	64%	36% (7%)
Exercises	(–) 2%	59%	36% (3%)
Sessions	(–) 9%	85%	9% (–)
Duration of	(too) short	just right	(too) long
Sessions	(–) 3%	79%	17% (–)
Usefulness of	very useful	useful	not useful
Text	38%	60%	2%
Exercises	30%	65%	5%
Sessions	55%	43%	2%
Relaxation exercises	10%	45%	45%
Application of learned (strategies) in daily life	often/regularly	sometimes	seldom/never
	87%	12%	2%

In parentheses: percentage of patients who rated aspect as 'too' (easy, little, etc.).

difficulty and the amount of the exercises was appropriate (Table 2).

In the evaluation of the total STCC programme (Table 3), the majority of the participants reported that the content of the programme largely/completely addressed their cognitive problems (Table 3), that they used

the learned strategies regularly/often in daily life, and indicated a decrease in the impact of cognitive problems on daily functioning. At the six-month follow-up assessment, these proportions were largely maintained.

Participants also answered a few open-ended questions on the evaluation forms. They

Table 2. Ratings of C-Car retraining aspects immediately post intervention ($N = 60$)

Difficulty of attention exercises	(too) easy (9%) 32%	just right 54%	(too) difficult 14% (2%)
Number of attention exercises	(too) few (3%) 29%	just right 42%	(too) many 19% (2%)
Usefulness of attention exercises	very useful 46%	useful 48%	not useful 7%

In parentheses: percentage of patients who rated aspect as 'too' (easy, few, etc.).

Table 3. General ratings of aspects of the cognitive rehabilitation programme immediately post intervention ($N = 60$)

Content addressed daily problems	fully/largely (20%) 80%	partly 18%	not 2%
Six months follow-up ^a	(20%) 70%	29%	2%
Application of learnt (strategies) in daily life	often/regularly (40%) 87%	sometimes 12%	seldom/never 2% (–)
Six months follow-up	(15%) 70%	29%	2% (–)
Impact of cognitive problems has changed	yes, positively 79%	no 19% ^b	yes, negatively 2%
Six months follow-up	63%	31% ^c	6%
Coping with cognitive problems has been changed	better coping 73%	no 27% ^d	worse coping –
Six months follow-up	65%	35% ^e	–
Capability/professionalism of trainer	excellent/good (58%) 98%	sufficient 2%	insufficient/poor –
Contact with trainer	(67%) 100%	–	–
Materials	(30%) 91%	9%	–
Overall rating of the programme	(28%) 92%	7%	2% (2%)
Six months follow-up	(25%) 88%	10%	2% (–)

In parentheses: percentage of patients who rated aspect as 'fully/often/excellent'.

^aBased on the responses of 49 respondents.

^bNo change, there was no impact on daily life (2%), or no change, impact remained the same (17%).

^cNo change, there was no impact on daily life (6%), or no change, impact remained the same (25%).

^dNo change, coping is still good (24%), or coping is still not good (3%).

^eNo change, coping is still good (25%), or coping is still not good (10%).

indicated that the most appreciated components of the programme were: (1) strategies for planning, prioritizing, structuring and organizing daily activities; (2) psycho-education on and acceptance of the cognitive problems; (3) acceptance of the use of strategies and aids; (4) awareness of the importance of the general conditions to improve functioning (preparation); and (5) psycho-education to raise awareness of the inter-relationships among the various cognitive functions.

When they were asked to provide feedback on things that the participants missed in the programme, they most frequently reported: specific memory training or games, contact with fellow-sufferers, more integration of psychological issues in the programme, and individual feedback on neuropsychological test scores, which was not done in the randomized controlled trial.

The most frequent recommendations regarding the existing programme were to have an interval of two weeks rather than one week between sessions, to have the entire programme extend over a longer period of time, adding more breaks during the sessions, and providing information on the duration of each C-Car exercise.

Discussion

In this paper we have described in detail the nature and content of a largely individually tailored cognitive rehabilitation programme 'Strategy Training and C-Car' (STCC) that has been proven effective in 70 glioma patients participating in the intervention group of a randomized controlled trial.⁸

In conclusion, the majority of the participants found the programme to be useful and not too burdensome. Patients particularly appreciated the programme components on psycho-education, on acceptance of the use of strategies and aids, and on preparing, organizing and structuring activities.

Compliance to the programme was generally high. We believe that the home-based nature of

the intervention played an important role here; patients did not have to travel for the sessions. A drawback of the home-based nature of the programme was that patients did not get into contact with fellow-sufferers, a shortcoming that was frequently reported by participants.

The individually tailored approach to the cognitive rehabilitation may explain the high ratings of usefulness of the programme by the participants, and also its effectiveness. Moreover, our study suggests that it is feasible to evaluate an individually tailored programme in a group study.

However, a limitation of our former randomized controlled trial in which the effectiveness of the programme was evaluated is that its design did not permit direct assessment of the relative effectiveness of the C-Car retraining versus the strategy training, or a possible synergistic effect of the combination of the two approaches. We can use the nature and pattern of change of neuropsychological test functioning over time as measured in the randomized controlled trial to speculate on the relative effects of both training components. With a retraining effect only, we would at least have expected an immediate effect on neuropsychological test functioning and not merely a delayed intervention effect *per se*. Conversely, strategy training may require a longer period of time to integrate learned material (i.e. strategies) into patients' daily routine,^{4,46-48} potentially reflected in the delayed intervention effect on the neuropsychological measures that was observed. However, a long-term effect on subjective cognitive functioning would then also be expected. A strategy training effect is also more plausible considering the larger amount of time devoted to strategy training as compared to retraining (30 versus 6 hours). On the other hand, it may be suggested that the structured and rather predictable neuropsychological tests that have been administered leave little room for strategy use as taught in the strategy training, which may imply that the measured cognitive improvement is an effect of retraining. A final possibility is a synergistic effect of both training components.

Robertson and Murre¹⁴ have suggested that an extended attention span may also provide improved input of therapy for other impaired functions. This might imply that, in the current study, improvement of attention due to retraining of this skill may have facilitated learning of the strategies.

A more complex trial with four arms (retraining only, strategy training only, combined C-Car retraining and strategy training, and a control group) should provide insight into the effectiveness of the elements of the programme. Such a study may also provide some cautious suggestions on the underlying processes involved in the rehabilitation.

A limitation of the programme itself is that older patients reported more difficulty with the amount of strategy training homework involved than younger participants. Moreover, these results are in line with the results of our analysis of predictors of neuropsychological improvement after programme participation.⁴⁹ Logistic regression analyses indicated that older participants benefited less from the programme than younger patients.

Taken together, these results suggest that older patients experience more burden of the programme and benefit less from it. It may be useful for them to increase the number of sessions by spreading and splitting them up,⁵⁰ and reduce the amount of material covered per session.⁵⁰ In fact, these suggestions were also made by participants on the open-ended questions of the evaluation form. In particular, session 4 of the strategy training was spontaneously reported to be particularly heavy, by both the participants and the trainers. Thus, it might make sense to split this session into two sessions.

A practical limitation of the retraining part of the rehabilitation programme is that (with faster than standard rates of stimuli appearance) complications sometimes occurred in the current version of C-Car. We are planning to revise the C-Car software in order to solve this problem. At the same time, we will consider the possibilities of wider accessibility of the cognitive rehabilitation programme.

Adapting both the C-Car retraining and strategy component of our cognitive rehabilitation programme to an Internet-based platform might provide us with the possibility to have more patients benefit from the programme. Many studies have already been conducted on Internet-based cognitive behavioural therapy. Although this type of therapy has a different purpose and targets a different patient population, the successes observed in these studies suggest that Internet-based cognitive rehabilitation should be considered as a serious option for future research.⁵¹

Finally, it may also be of interest to study the effectiveness of the current cognitive rehabilitation programme in other patient populations, as the broad-spectrum elements of the intervention may be useful for other types of patients, provided that they have mild to moderate cognitive deficits.

In our opinion, future efforts should aim at better understanding and, where needed, improving existing training programmes. Toward this end, it is important to provide detailed information on the underlying theoretical basis, the design and the content of available cognitive rehabilitation programmes. Finally, it is also essential to gain better understanding of the types of patients who benefit most (and least) from currently available programmes. Ultimately, this should lead to evidence-based, tailored cognitive rehabilitation programmes.

Clinical messages

- The strategy training and C-Car programme may be useful for patients with mild to moderate impairments in attention, memory and/or executive functioning.
- Increasing the number of cognitive rehabilitation sessions, and splitting complex sessions into smaller sessions may increase the feasibility and usefulness of the programme for older participants.

Acknowledgement

We would like to thank Charlotte Bogaerts, Elke Eggens, Ester van der Sluis, Floor Bouwman, Janneke Veeffkind, Jurriaan Witteman, Lucinda Niezen, Marieke Sikkes, Marylou Apfel, Mathilde Hagen, Sue-Ann Lourens, and Saskia Mulder for carrying out the cognitive training and neuropsychological assessments; Vincent Terlingen, Gijs ten Cate en Arjan Huis in 't Veld for their work on developing the software for the C-Car program; Patrick Maitimo for his supervisory role in the programming of C-Car, and Miriam Salden, for lending her voice to the auditory stimuli in C-Car.

Funding

This work was supported by the Dutch Cancer Society (UU2003-2783) and the Health Insurers Innovation Foundation (RVVZ; file 504). The development of the C-Car program was funded by NeuroCognitief Centrum Nederland (M.M. Sitskoorn) without commercial interest.

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