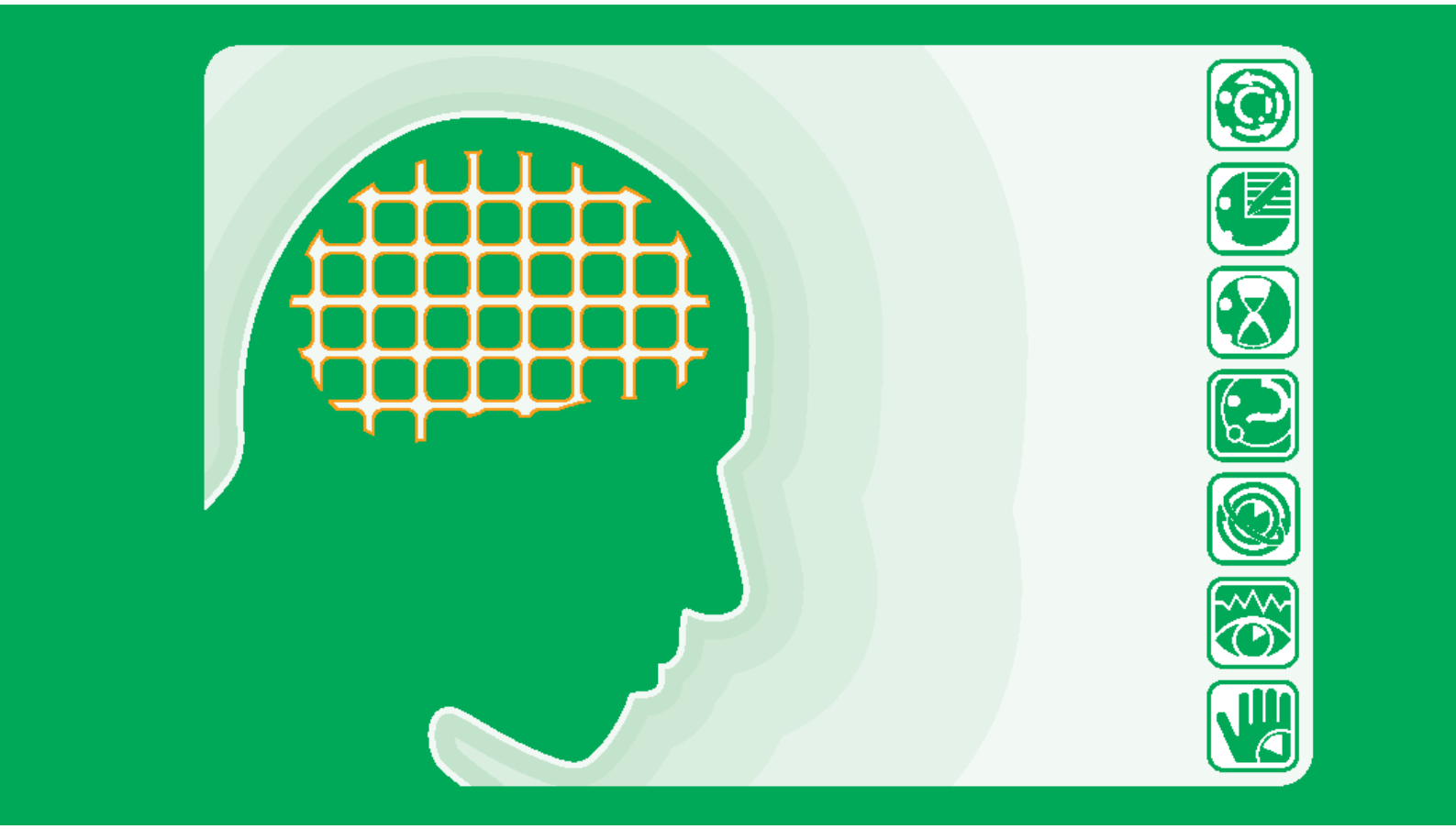
RehaCom

computer-assisted cognitive rehabilitation - brain performance training



Two-dimensional Operations

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HASOMED®

Hard- und Software für die Medizin

RehaCom®

computer-assisted cognitive rehabilitation

by Hasomed GmbH

This manual contains information about using the RehaCom therapy system.

Our therapy system RehaCom delivers tested methodologies and procedures to train brain performance .
RehaCom helps patients after stroke or brain trauma with the improvement on such important abilities like memory, attention, concentration, planning, etc.

Since 1986 we develop the therapy system progressive.
It is our aim to give you a tool which supports your work by technical competence and simple handling, to support you at clinic and practice.

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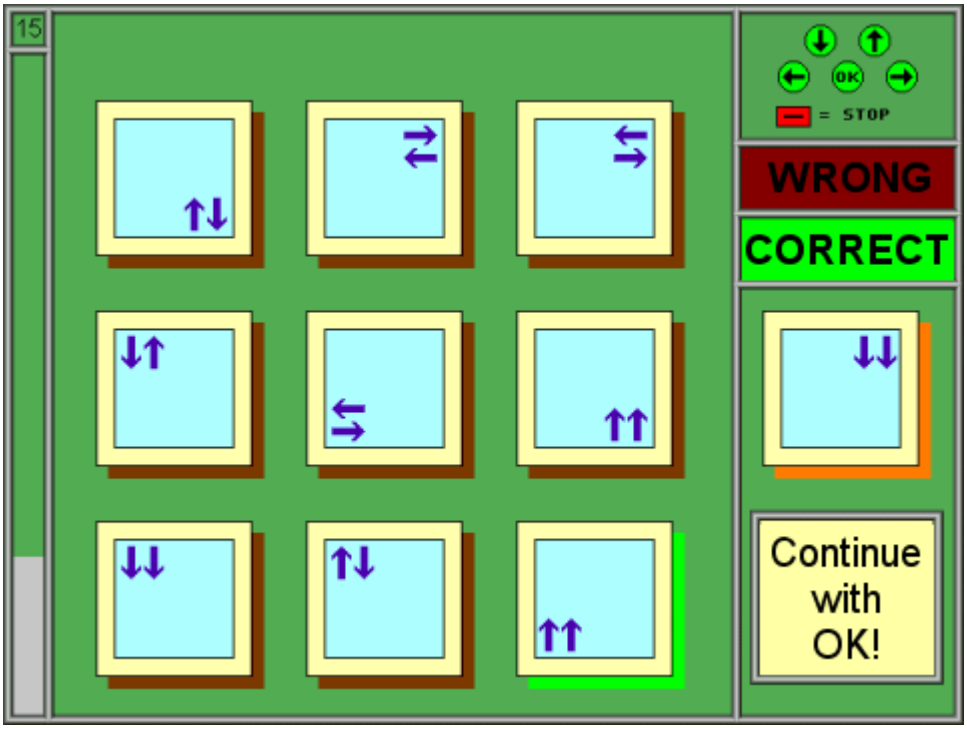
1 Training description

1.1 Training task

The procedure **Two-dimensional Operations** is used to train a patient's visual spatial operation, particularly the ability for mental rotation.

On the computer screen (see Picture 1), one can see a selection of different objects which have been placed in a matrix (3,6, 9). An separate individual picture, objects in the matrix, can also be seen. Only one of the pictures in the matrix is identical with the object of comparison. It's the patient's task to locate and **select** this picture from the matrix. However, the picture in the matrix, which has to be matched with the separate individual picture has been **turned**. In order to make the correct selection the patient has to exercise his ability for mental rotation of two-dimensional objects.



Picture 1. Training at level 15 - a matrix of 3 X 3 pictures. The selected picture has been marked. The "CORRECT" field signals that a correct decision has been made.

The patient can select the matching picture from the matrix by using the console (specifically designed with large keys), the mouse or the touch screen.

The **large keys** are used to move an orange frame from picture to picture in the matrix. In order to mark the selected picture, the OK-Key must be pressed. This facility is offered for patients with visuo-motor co-ordination problems, tremors and other such problems with hand movement. The large keys can, if necessary

be operated by foot. This is to facilitate for the handicap.

A very comfortable method of operation is with the **mouse**. An arrow is moved across the screen. If the arrow is over a picture, an orange frame appears around the picture. In order to confirm the selection one simply presses the space bar. As an alternative the more dextrous patients can confirm their selection by using the mouse key. Visuo motor abilities are trained in addition to the aim of the procedure.

The most simple form of use is that of the **touch screen** method. The patient touches a picture and an orange frame appears. As long as the patient still has their finger on the screen the frame can be moved from picture to picture. When the patient removes their finger from the screen then that picture is selected. This is the recommended form of training for children.

1.2 Performance feedback

After the patient has chosen a picture the procedure evaluates the decision:

- The green field "Correct" and/or the red field"Incorrect" is highlighted.
- A performance assessment column (in Picture 1 left) increases (with correct decisions) and decreases (with incorrect decision).
- When the acoustic feedback is activated the standard tones can be heard.

If the performance assessment column reaches it maximum point the task is ended. Similarly, if the patient makes a lot of errors and the scale reaches its minimum the task is also ended. A performance assessment is then shown. The next or the previous level of difficulty is then set up , depending on the assessment of the performance (successful - continue to the next level, unsuccessful -repeat the previous level) This occurs when the repetition mode is set up. Otherwise, the patient continues to train the same level of difficulty.

The number above the column shows the current level of difficulty.

1.3 Levels of difficulty

The level of difficulty can be set up in such a way that it is completely adaptive. Table one shows the level of difficulty. There are 8 levels with from 80 to 160 pictures, which vary from very simple objects to complex groups of objects.

By means of a study we were able to allocate the correct series of pictures to each individual level. (This was achieved by measuring the average time taken coupled with the number of mistakes made by the ample group. This also help us establish the criteria for the levels of difficulty). At higher levels of difficult,

there has been deliberate use of occasionally easier series of pictures, in order to maintain the patient's motivation.

For each of the 8 levels, there are also 3 individual stages of difficulty with 3, 6 to 9 pictures in the matrix. The ability to compare position, length, size, angle, distance, amount and pattern, by means of mental rotation, is developed by the procedure. The tasks with 3 pictures are naturally considerably easier than those with 6 or 9.

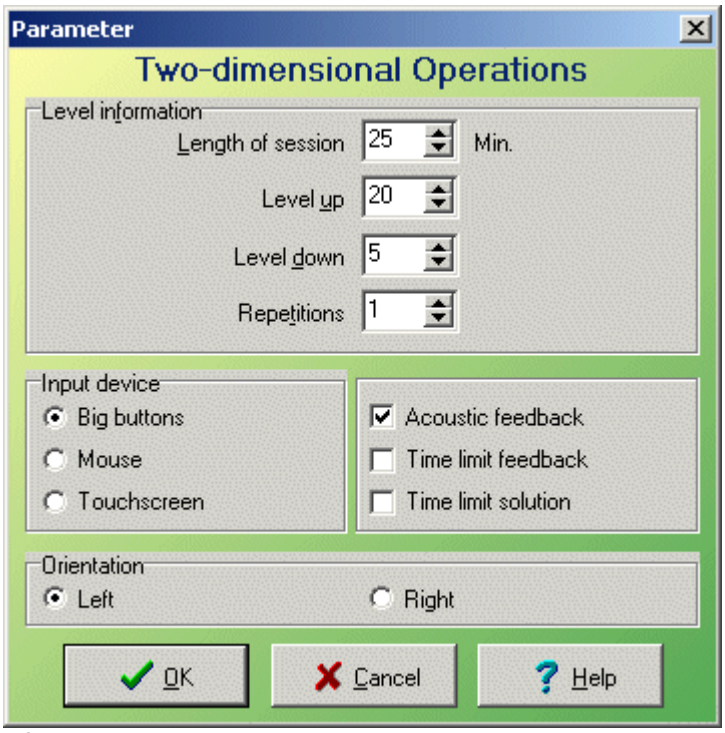
Table 1
Structure of the level of difficulty.

Level	Matrix	Stages of difficulty
1	3	Simple pattern, length, position and size comparison with minor demands on mental rotation.
2	6	Simple pattern, length, position and size comparison with minor demands on mental rotation.
3	9	Simple pattern, length, position and size comparison with minor demands on mental rotation.
4	3	Additional comparison of distance and angle with minor demands on mental rotation.
5	6	Additional comparison of distance and angle with minor demands on mental rotation.
6	9	Additional comparison of distance and angle with minor demands on mental rotation.
7	3	Objects rotated in 90° steps 2 elements per object must be taken into consideration. Mental rotation is required.
8	6	Objects rotated in 90° steps 2 elements per object must be taken into consideration. Mental rotation is required.
9	9	Objects rotated in 90° steps 2 elements per object must be taken into consideration. Mental rotation is required.
10	3	Any type of rotation. 2 elements to be taken into consideration.
11	6	Any type of rotation. 2 elements to be taken into consideration.
12	9	Any type of rotation. 2 elements to be taken into consideration.
13	3	Rotation 90°. 3 elements to be considered.
14	6	Rotation 90°. 3 elements to be considered.
15	9	Rotation 90°. 3 elements to be considered.
16	3	Any type of rotation. 3 elements to be considered.

17	6	Any type of rotation. 3 elements to be considered.
18	9	Any type of rotation. 3 elements to be considered.
19	3	Rotation 90°. >3 elements to be considered.
20	6	Rotation 90°. >3 elements to be considered.
21	9	Rotation 90°. >3 elements to be considered.
22	3	Any type of rotation. >3 elements to be considered.
23	6	Any type of rotation. >3 elements to be considered.
24	9	Any type of rotation. >3 elements to be considered.

1.4 Training parameters

In the **RehaCom basic foundations**, some general information (references) is given on the Training Parameters and their properties. This information (references) should be taken into further consideration. Picture 2 shows the parameter-menu.



Picture 2. Parameter-Menu.

Current level of difficulty:
The level of difficulty can be set up from level 1 to 24.

Duration of the training/Cons. in min:

A training time of 20 to 30 minutes is recommended.

Continue to the next level:
The next level of the procedure is set up when the have been correctly solved in a row (established value of 'continue to the next level') and/ or if the top level of the performance column has been reached. Incorrect reactions cause the performance column to sink and one has to compensate for this with correct decisions. The aspects of the parameter option 'repetition' should also be taken in to consideration.

Repeat previous level:
The previous level of the training is set up when the established number of tasks have not been solved in row (established value of 'repeat previous level') and/or if the lowest level of the performance column is reached. The aspects of the parameter option 'repetition' should also be taken in to consideration.

Input mode:
The various ways of operating the procedure have been described in the section on Training tasks.

Orientation:
The training field can be displayed on the left or the right. This option can also be used for patients with specific deficits or for patients with a particular screen preference(e.g Patients who suffer from Neglect).

Repetition:
The level changes if the number of established tasks with "repetitions" is successfully solved and vice versa. The level is only changed if a consolidation of performance - positive or negative - occurs. If the parameter is set to 0 the after each task is solved - the level then increases and vice versa.

Acoustic feedback:
When the parameter "acoustic feedback" is activated, then a typical error tone can be heard if the patient makes an incorrect decision. If there is more than one person training in the room then this may cause interference. In this case then the acoustic feedback should be deacticated or head phones could be used.

Time limit for solution:
When activated ([X]), the patient only has a limited time to solve a task. This time is dependent on the level of difficulty and is set at a minute for the easiest task in level 1. This time advances by 5 seconds per difficulty stage, and consequently, reaches approx. 3 minutes at the highest level of difficulty. When this parameter is switched off ([ ]) then the patient has an unlimited period time to solve a task.

Time limit - Error display:
After choosing a picture the patient receives a 'correct' or 'incorrect' feedback. A 'correct' notification stays on the screen for 3 seconds. This can be shortened by pressing the OK-key. When the parameter "limited error readout" is inactive, (in the case of an incorrect decision) the patient can compare the pictures without time limit and therefore which find the differences and determine the cause of the incorrect decision. The 'correct' picture is framed by an orange frame. The 'incorrect' picture has a red frame. The next task appears only after the patient has pressed the OK-key. When the parameter "limited error readout" is active, then the patient only has ten seconds to compare the pictures. After this a new object is shown. Therefore, it is a bit more difficult to solve a task.

With each new set up of the training the following defaults are automatically installed (middle standard level):

Current level of difficulty:	1
Duration of training/Cons.:	25 Minutes
Continue to the next level:	20
Repeat previous level:	5
Input mode:	large keys
Orientation:	left
Repetition	1
Acoustic feedback	on [X]
Time limit for solution:	off [ ]
Time limit - error display:	off [ ]

1.5 Data analysis

The diverse possibilities of data analysis for the determination of the further training strategy are described in the
RehaCom basic foundations.

In the pictures as well as the tables, alongside the setting for the trainings parameter, the following information is available:

Level	current level of difficulty
Training time (effective)	effective Training time
Pauses	Number of pause by the patient
Number of decisions	Number of solved tasks
Number of Errors-choice	Number of incorrect decisions

Number of Errors-Time	Error too much time used (only, when the Parameter "limited" solution time" is activated)

The reaction time is calculated as the time from the appearance of the matrix to the selection of the OK-Key

Reaction time Quartile 1	1. Quartile reaction time
Reaction time (Median)	Median the reaction time
Reaction time Quartile 3	3. Quartile reaction time

2 Theoretical concept

2.1 Foundations

One defines **visual spatial performance** as perception abilities which require a visual comparison of spatial stimulus without manual effort from the patient. In contrast to this, **spatial-constructive performance** demands this exact manual-constructive component to be under visual control (cf.Kerkhoff, Münßinger & Marquardt, 1993).

The precondition for a valid visuo-constructive performances is an intact visual-spatial perception.

The visual-spatial perception is a component of elementary visual efficiency and consists of the following basic functions (Kerkhoff, 1988):

Visual spatial perceptive performance

- Distance estimation (horizontal / vertical),
- Estimation of distances,
- Estimation of relative positions,
- Estimation of angles,
- Main visual spatial (subjective perpendicular / horizontal),
- Subjective straight ahead direction / subjective middle.

Visual spatial operation

- mental rotation,
- Transformation performance (measure, angle, size transformations, tasks with varied spatial systems).

In contrast to the visual spatial perception, with visual room operations it is a question of cognitive services which require a intermediate step separated by the stimulus material.

Basic functions of the visual spatial perception are in everyday life, in particular in traffic, of great relevance. From the straight line directing while walking to fine motor adjustment while reading, (which are dependent on the elementary aspect of visual performance), spatial disturbances can affect all practical everyday activities which require a visual spatial operation or a partial spatial-constructive performance. Patients with technical professions who suffer from these deficits will often loose their positions and therefore are clearly more affected than others.

Several investigations into the predicators of the rehabilitation (v. Cramon & Zihl, 1988; Kerkhoff & Marquardt, 1995) showed a statistical connection between visual-constructive and visual-spatial problems and impaired ADL-activities (activities of daily living); where a causal relationship was discussed. This is not surprising when one only considers some examples from everyday life, where there is dependency on an intact visual-spatial perception and/or spatial-constructive subsets of the system:

. Dressing
. Folding of washing
. Estimating and separating amounts
. Decorating a table
. Tidying
. Grabbing objects
. Estimating the depth of steps/stairs
. Reading of plans or sketches
. The filling in of forms and documents
. Maintain lines and columns while drawing
. Finding the way
. Wheel chair navigation

More complex disturbances to perception are often a result of disturbances to the elementary visual efficiency, like the *depth perception*.
Loss of depth of vision means that everything appears to be flat (e.g. a dye appears to be a six cornered object). The trouble with disturbances to depth of vision is that it is sometimes combined with changes in the perception of the sizes of objects (Micropsia and Macropsia), however, it can also affect the appearance of objects and faces.

The latter is also occurs in the case of cerebral amblyopia, an impairment in perception of form and colour perception which results from postchiasmatic injuries.

A damaged visual localization of stimulus affects the appraisal of distances. The

patient then over or under estimates distances.

Impairments in the appraisal of the main visual spatial directions leads, in most cases, to a shift in the subjective vertical, in the horizontal and in the straight line directions. In the case of unilateral lesions, vertical and straight line directions normally become shifted to the opposite side on which the brain damage occurred - the horizontals are mostly displaced equally to the vertical axis (v. Cramon, 1988).

Visual-spatial orientation problems express themselves in the loss of the spatial organization of a pattern of stimuli, which is often coupled with "difficulties in measuring" through impairments in the recognition or localizing of spatial positions and regions as well as the *ability for spatial imagination.*

The impairments which occur as a result of visual spatial perception are often correlated with those which occur as a result of visuo-constructive deficits (v. Cramon, in 1988), where a causal relationship is being discussed.

Spatial-constructive problems or **constructive apraxia** refer to the decreased ability or inability in patients, with brain damaged, to draw 2 dimensional or 3 dimensional shapes and figures correctly and/or to join elements of a figure together to form a total figure.

In processing such task length and angular distortions may also occur, size modifications or an erroneous order of individual elements of the total figure which is sometimes also reconstructed in a completely fragmented manner. In addition independent constructive abilities like the drawing of spatial orders of a room for example, with above mentioned deficits is just not possible.

An innate medical history of the complaints is only worthwhile with patients without visual neglect, anosognosia or anosodiaphoria. For the patient group with reduced insight Kerkhoff & Blaut have developed (1992, cf.Kerkhoff, Münßinger & Marquardt, 1993) a clinical hetero-medical history curve. For the diagnosis of performance in visual-spatial perception, the following tests are suitable, for example line orientation, line halving, spatial sub tests in intelligence tests or the computer-assisted procedure is also suitable(cf.Kerkhoff, Münßinger & Marquardt, 1993). The latter registers elementary performances of the visual spatial perception in contrast to all other procedures. The tests for visual object and spatial perceptions (VOSP,Warrington & James, 1992) also tests the visual basic functions problems which often occur together with constructive apraxia and are possibly its cause. For the diagnosis of the spatial-constructive troubles - the free copying of geometric or other patterns, the copying of perspective drawings or the drawing test according to Grossmann (1988) are suitable. The mosaic test or the sub test 'figure placing' from the Hamburg change/switching

intelligence test (HAWIE-R, Tewes 1991), the Benton-Test (Benton, 1981) or the Rey-Osterrieth-Figur (Osterrieth, 1944) are also suitable as diagnostic instruments. However there are in part particular aspects; partial combination of many aspects of more complex functions registered. i.e. several spatial basic functions are tested simultaneously.

2.2 Training aim

The aim of the procedure **Two-dimensional operations** is the training of the spatial operations, in particular the mental rotation of two-dimensional objects. These cognitive transformation performances require basic visual-spatial abilities .

After improvements in the visual-spatial basic function therapeutic benefits in relation to more complex problems can be expected, for example, improvements to visuo-constructive abilities, as these deficits are more likely caused by impairments in the basic perception.

It is to be expected, that the training has a favourable effect in the ADL- area (Activities of Daily Living) , since problems with spatial perception and spatial operations hinder numerous practical activities, in particular, if these activities depend on a precise *visual-motor co-ordination*.

Under the premise of maximum specificity of therapy, one should always precede with a differentiated problem specific neuro psychological diagnostic (for specific tests see basic functions).

For additional training, the RehaCom-procedures **visual spatial operation** (RAUM) and **visuo-constructive abilities** (KONS) can be used to treat this complex type of disturbance. The training procedure **Two-dimensional operations** can also be used as a cognitive type of training for attention deficits. In this case the procedures **Attention and Concentration** (AUFM) can be used. However, this procedure does not contain the aspect of spatial rotation but is constructed in a similar way.

2.3 Target groups

The procedure Two-dimentional operation is recommended for patients who suffer from impairments to their visual spatial perception and their spatial construction. It is mainly patients whose brain has been damaged after posterior and/or parietal-occipital uni- and bilateral lesions or injuries to the visual system, who are affected. In particular visual-spatial problems often occur after right-hand parietal lesions.

The visual-spatial functions can be affected by injuries to the brain which have different origin (insult, Hypoxia, SHT, tumours). Additional patients who will also benefit from this training are patients with visuo-constructive problems, visual neglect, field of vision problems and patients with impairments to their objective perception due to deficits in their elementary visual capabilities.

For patients with to the right hemispheric injuries to the brain there is a clear indication of a covariance between impairments to the visual spatial perception and visual constructive problems (cf.Kerkhoff, 1988). Also a decreased ability for mental rotation, which is observed after right- and left hemispheric posterior lesions, impairs the visual constructive performance.

In addition to a half-side paralysis, visual-constructive and visual-spatial problems is the most important predictor for the rehabilitation process in patients with injuries the right hemi-sphere of the brain(cf.basic foundations). It was repeatedly found, that in particular patient groups with deficits of visual perception to the left hemispheric a more unfavourable rehabilitation process was observed.

The procedure can be used with children from 10 years and older provided they do not have any developement problems. So far there has been no problems, but it is recommended that a therapist is present during the early stages of training. From a diagnostic point of view it is recommended that individuals with serious intelligent deficits be excluded from the training process.

Friedl-Francesconi (1995) tested several RehaCom-procedures - among them - **Two-dimensional operations** - on patients who suffer from dementia and discovered an improvement in memory and attention functions. In an additional effectivity study (Friedl-Francesconi, 1996) on trauma patients improvements in the visual short-term memory and in the visual spatial capability.

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