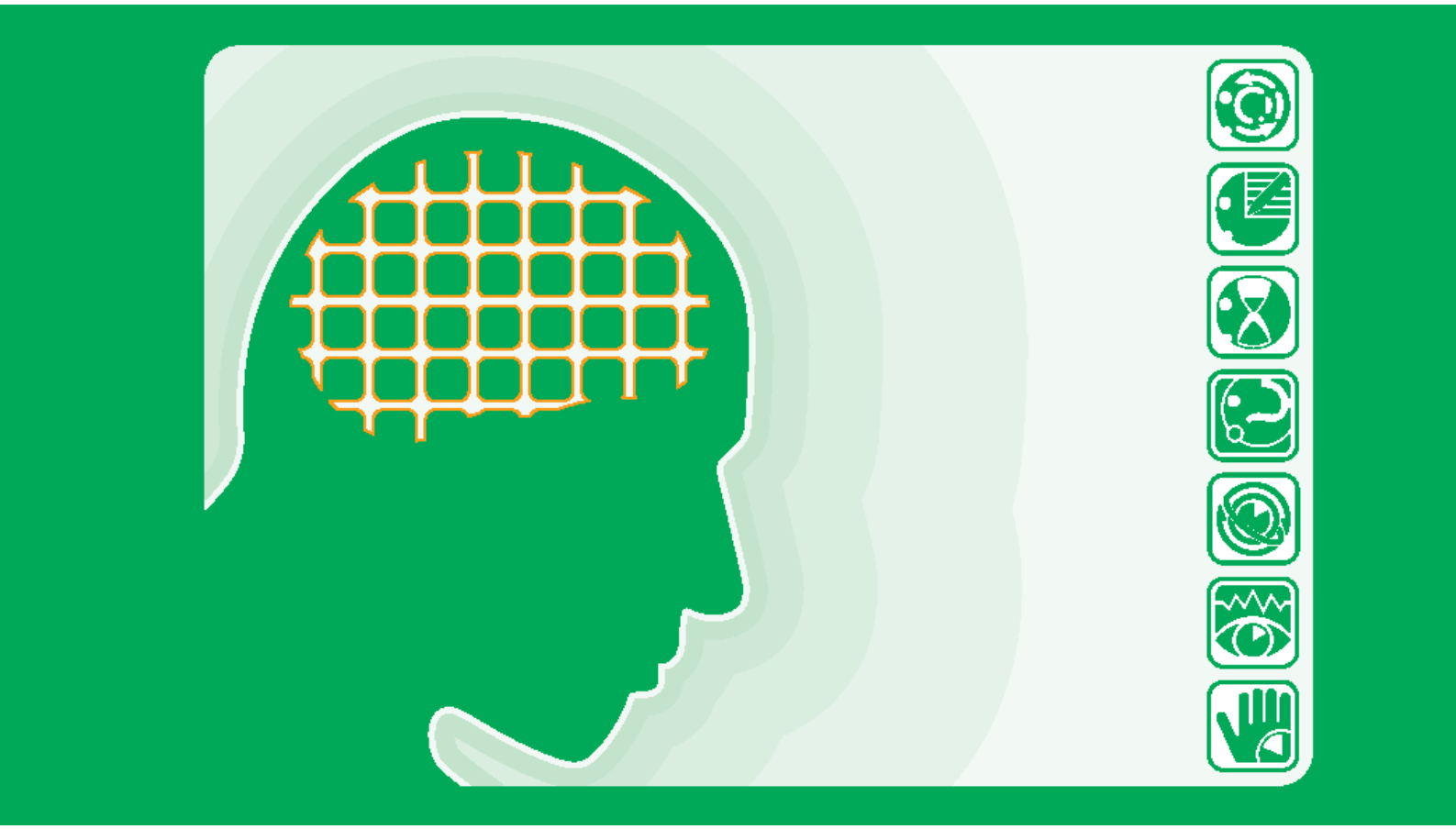
RehaCom

computer-assisted cognitive rehabilitation - brain performance training



Logical reasoning

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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 system for logic thought uses problem solving exercises. The type of exercises used are 'completion of a series'. The principle behind the training is that the problem solving exercises are very graphic and vivid exercises. The analysis of the problem situation and of its elements is primary. By the increasing the difficulty of the logic succession and the increasing supposition of several logic structures, the patient should learn to recognize the concepts underlying each problematic situation and to use these concepts to solve the logic problem.

In the training, a picture series is shown with simple graphic figures. The patient must find the relationship between the individual links of the series and through Induction derive a rule (figure reasoning), which clarifies what the next link of the series is (von Cramon & Matthes-Crammon, 1993). When the patient has established what the rule is - he must then select the relevant picture from a matrix of pictures. The matrix of pictures can be used by the patient to check that he has derived the correct rule.

The picture series appear in the upper part of the screen (illustration 1). They consist of a minimum of 7 pictures and a max. of 14. If the picture number is greater than 7, the logical succession is distributed over two series or rows which are spaced out above each other. A tear-off edge clarifies that the entire logical succession must be solved from the two single series . The picture series is solved when the correct picture is placed in the empty field. This field is the one beside the large red arrow. The correct picture is selected from a matrix of pictures in the lower part of the screen.

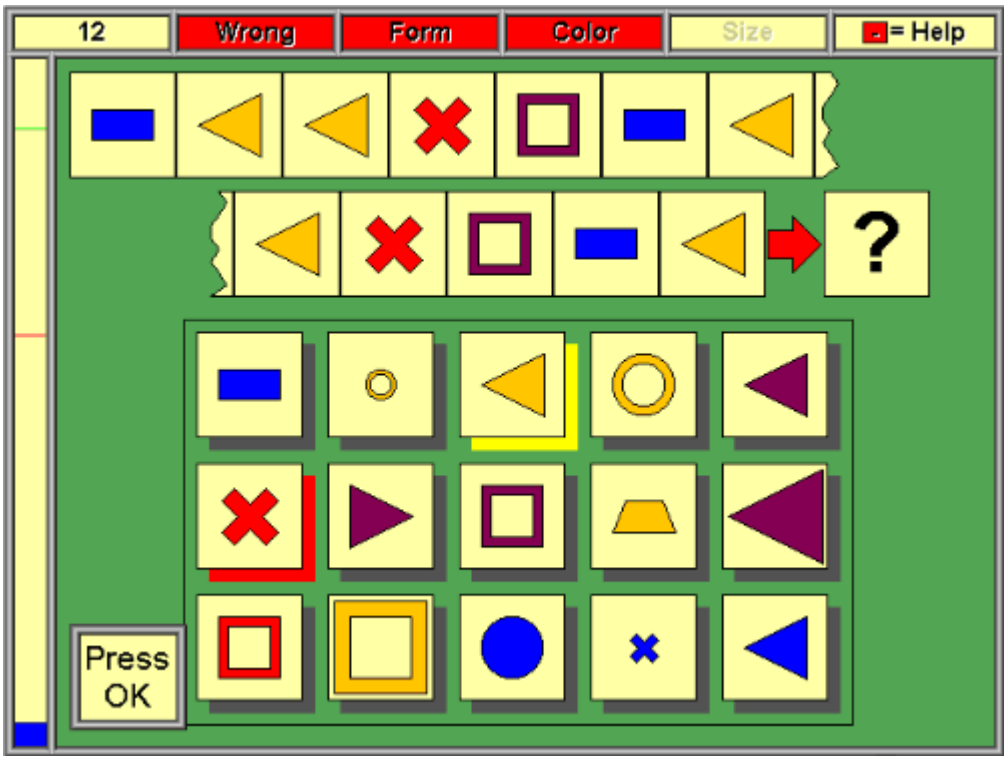

Illustration 1 shows the training screen at difficulty level 14 at the moment of a wrong decision. The correct element would have been the purple triangle marked with a yellow frame. The wrong element chosen (yellow triangle) is framed red. The red field "color" refers to a mistake during the selection of the color.

For patients with motor difficulties in their hands or visual motor disturbances, should work with the panel . The patient then selects the picture in the matrix, when a yellow frame with the aid of that cursor sort on the patient panel, and moves the cursor from picture to picture is. If the frame marks the correct picture, the OK- key is to be pressed. The picture is inserted into the free field at the end of the series.

The arrow can also be moved quite simply with a Mouse. Both the mouse button and the OK- key of the patient's panel can be used for the confirmation of a selection. It is recommended to use one hand for shifting the mouse and the other hand for pressing the OK- key. Operation is simplest with a Touch screen. The patient touches the desired picture with a finger. A frame appears which can be changed with the movement of the finger of picture to picture. Selection is confirmed when the patient lifts their finger from the screen.

After each decision the patient is notified as to the Quality of their solution (correct or wrong) . In this way, advice is then offered which allows the patient carry out an error analysis.

A performance column is on the left hand side of the screen. The column increases with every correct reaction. If in the training process, the green marker is exceeded then, the patient is working well and a higher level of difficulty is set up with the next task. One switches to a lower level of difficulty if the column does not reach the red marker. Otherwise,as in the green marker has been reached but not exceeded the same performance level is repeated.

At the beginning of task, a patient can be ofered advice on how to complete the series. Every patient will develop his own solution strategy. The Therapy is required to support the patients with the tasks. One might point out already here that one should begin with the least difficulty too for patients with a high performance level. The patient then learns the connections and formation rules in training as they vary.

. the picture motives,
. picture colour and
. picture size.

1.2 Performance feedback

On several levels a performance feedback is provided.

If the correct picture was selected, a green "CORRECT" - field appears for short time. If a wrong decision is taken, a light will be shown (Error anaylsis), which will reflect each individual error, on one or several red mistake fields. The mistakes carry the captions "form", "colour" and "size". The correct picture is framed green. At the same time, an acoustic analysis acoustic analysis is also possible.

In reference to the performance column which has already be mentioned: the current level of difficulty appears above the performance column.

1.3 Levels of difficulty

An adaptive setting of the different levels of difficulty is guaranteed.

In order to generate new tasks a pool of 192 pictures, with 16 different motives, 4 variations in colour and 3 different sizes, are available.

The level of difficulty is set by altering the length and complexity of the picture series. Here the underlying formation of the Algorhythm can be modified. (see table 1).

In training there is always alternate abstraction levels available which can be practiced and all difficulty levels which have been practiced up to now can also be ***mixed*** and used for further training.

As in the case of all RehaCom systems, the performance requirements at lower levels of difficulty are purposely low. This provides for easier start to the training programme for patients with a lower level of performance.

A more efficient patient will complete these lower levels of difficulty faster and reach performance ranges better suited to his level.

If half of the tasks are individually solved under the reaction time of less than 5 seconds then this level is broken off and a higher level is established for the patient.

It is not recommended to immediately begin with a higher difficulty.

Table 1
The difficulty structure is validated within the framework of a study.

Level	Description
1	same pictures, small variations, use of the keyboard is learned.
2	Variation in the form (the picture motives) in a simple rhythm 1212 (e.g. *cross, square, circle, square*).
3	Mix
4	Variation of the colour in a simple rhythm 1212 (e.g.. *red, yellow, red, yellow*). Form and size stay constant.
5	Mix
6	Variation of the size in a simple rhythm 1212 (e.g. *big, small, big, small*). Form and colour stay constant.
7	Mix
8	Variation of the form or the colour or the size in rhythm 123123 (e.g. *cross, circle, square, cross, circle, square* or *red, yellow, blue, red, yellow, blue*)
9	Mix
10	Variation in the form or the colour or the size in a complicated rhythm like 112233 (e.g. *cross, cross, circle, circle, square, square, cross, cross..)* 123212321, 122122322122. Still only one component varies.
11	Mix

12	complicated rhythms like in Level 10, the form/colour or the colour/size or the form/size change in parallel. The third component stays constant.
13	Mix
14	2 components change in different but simple rhythms12123. The third component stays constant.
15	Mix
16	2 components change in different but complicated rhythms. The third component stays constant.
17	Mix
18	2 components change in parallel with each other with the same rhythm. The third component varies on a separate rhythm.
19	Mix
20	All 3 components vary in their own rhythm albeit in a simple rhythm. (e.g. form 1212, colour 123123, size 12341234).
21	Mix
22	All 3 components change in their own rhythm and in a somewhat complicated rhythm.
23	Mix

1.4 Training parameters

In the **RehaCom basic foundations**, general notes on training parameters and their effect are given. Furthermore, the following advice should also be considered.

Illustration 2 shows the parameter menu.

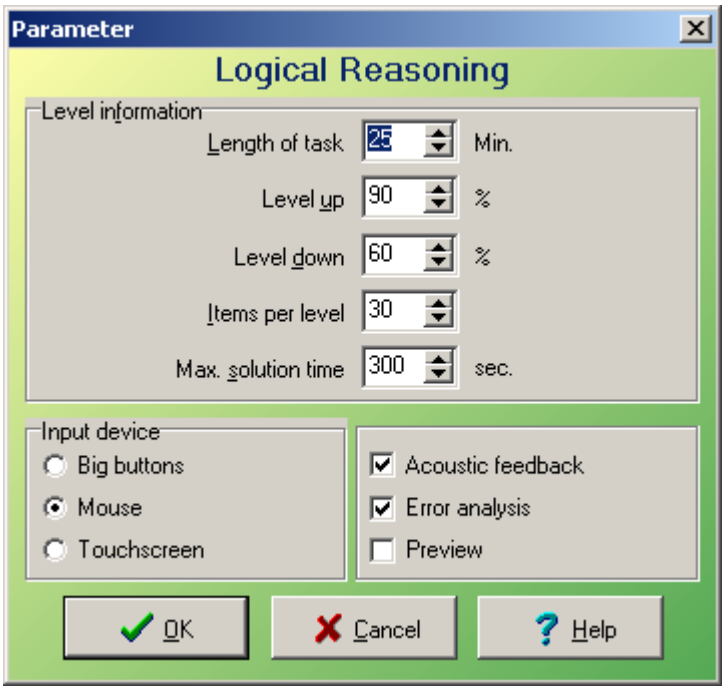

Illustration 2. Parameter-Menu.

Current level of difficulty (at therapists-menue)***:***
The level of difficulty can be set from level 1 to level 23.

Length of task:
Training duration/consultation in mins.
A training time of 25-35 minutes is recommended.

Level up (Continue to the next level)***:***
After the patient has worked through the number of **items per level** from the tasks, a percentage is computed. The percentage represents the number of the correct decisions in relation to the number of the items.
Only a mistake is registered per task in each case, independent of the types of error (form, colour, size) . If the percentage exceeds the threshold **'continue to the next level'** (few mistakes), the patient then moves to a higher level of difficulty.
At the beginning; for patients with a lower performance level this threshold can be reasonably reduced . In this way, it becomes simpler to achieve a higher level and the motivation for training increases. However, if the performance stabilises, the parameter should be increased again .

Level down (Repeat previous level)***:***
If the percentage falls below the threshold **'repeat the previous level'**, the patient then switches to a lower level of difficulty. For patients with a lower performance level, it is then reasonable to reduce this threshold at the beginning

of the training. In this way, it becomes easier to work in a level achieved which the patient has already experienced. A higher number of mistakes is then tolerated by the system before the patient is sent back to a previous level of difficulty.

Items per Level:
It is firmly established how many picture series a patient has to solve at each level of difficulty.

Maximum solution time:
In the set time, the patient has the possibility to make a decision, so that the picture series continues. After this he receives the next task. An unresolved task, during this time is evaluated as wrong (Time error). A default value of 5 minutes is set for these tasks (300 seconds). This time is sufficient in order to solve the task without time pressure according to our experience. With high performance patients, a time pressure device can be added and this then limits the solution time e.g. 30 seconds. In this way, this patient group benefits from the higher requirements and thus the motivation is increased.

Input device (Operation mode)***:***
For the operation possibilities; the system will give the appropriate advice.

Acoustic feedback:
The parameters for acoustic feedback can be set, in such a way, a typical tone is sounded, if a wrong decision is made during the picture series. The mistake tone can cause disturbances if several patients are training in the one room. The audible feedback should then be eliminated.

Error analysis:
If the Error analysis is activated, then during an incorrect decision the correct picture is highlighted in green from the picture matrix. With the three mistake fields "form", "colour" and "size", the patient is informed which variations during his decision found no regard. With high performance patients or in the case of specific solution strategies, this option can be eliminated. A red "wrong" reference field then appears for a second without designating the mistake (form, colour, size). The error analysis should in general be turned on.

Preview:
If the preview mode is activated,the currently selected picture will appear at the end of the row or series. For particular patients this will greatly simplify the tasks.

In the case of redefinition of a patient, the system sets the following default values automatically:

Difficulty level	1
Training duration/consultation	25 Minutes
Next Level	90 %
Repeat previous Level	60 %
Items/Level	30
Max solution time	300s = 5 Minutes (no time pressure)
Operation mode	Mouse
Acoustic Feedback	on
Error analysis	on
Preview	off

1.5 Data analysis

The diverse possibilities of data analysis for the determination of the further training strategy is described in the **foundational material of Reha Com**.

In the graphics as well as the tables, and in addition to the following information the Trainings parameter is also available:

Level	current level of difficulty
Training time (effective)	effective training time
Pauses	number of the interruptions by the patient
Number of items	number of the picture series/ difficulty
Number of mistakes	number of the picture series not correctly solved
Number of mistakes in form	number of mistakes in the case of form
Number of mistakes colour	number in the case of the colour mistakes
Number of mistakes size	number at the size mistakes
Number of mistakes in time	number of the mistakes through exceeding the given time
React.-time Quarter 1	reaction time 1st Quarter in ms
React.-time median	reaction time median in ms
React.-time Quarter 3	reaction time 3rd Quarter in ms

In this way, it becomes possible to refer the patient to specific deficits and to draw conclusions for further training.

2 Theoritical concept

2.1 Foundations

Conclusive thinking and **problem solving** are among some of the most complex human abilities. They are assigned to the so-called **executive functions** which are always activated, if a person is confronted with new, complex situations and question formulations, for which no previous approach is available (Matthes-von Cramon,1999).
When we talk of conclusive thinking we refer to a process by which people develop and evaluate logical arguments (Anderson,1988). Sohlberg & Mateer (1989) have distinguished three categories of higher thought processes.
In addition you have *concept formation* which is the ability to analyse relationships between objects and their qualities. Schaefer (1985; cf von Cramon & Matthes-von Cramon, 1993) clarify *problem solving thinking*, as logic-analytical, precise thinking; the transportation of a given *initial* or *actual state* into an other, wanted state (end or expected status). The discrepancy between initial and target operating state can be reduced by different means - depending on problem - (cf. & Matthes-von Cramon, 1993).
Problem solving processes represent *integrated cognitive functions*, which require ***basic abilities*** like *attention, memory, an intact visual perception* and *voice processing* (cf.Sohlberg & Mateer, 1989).
The success of an action is strongly dependent on *internal control processes*. The precondition for *successful self control* is the conscious level of someone's attention as well as the *continuous retention* and active use of information. The primary purpose and the secondary subgoals must be continuously internally represented , in order to allow individual execution of measures. The ability to integrate internally represented information and to precisely utilize the operative control, is designated as *working memory.* It represents a decisive assumption in the realm of problem solving thinking.
In the models of information processing of Rowe (1985) or Sternberg (1985) (cf. von Cramon & Matthes, 1993) the following components of problem solving processes are stated:

- Problem identification and analysis,
- Generation of (alternative) hypotheses,
- Selection of suitable solution strategies,
- Modification from response internal solution strategies according to or external and
- Evaluation of efficiency of the chosen solution procedure.

These components are designated as so-called *meta cognitive* processes which control and control functions (executive functions see above) come up within the information processing activity. Sternberg (1985, cf.von Cramon & Matthes-von

Cramon, 1993) distinguishes these as meta components of components of low arrangement which are required for carrying out of different strategies during problem processing.

Such performance components are

- the encoding of stimuli,
- the matching and combination of information and
- the analogy of the application of previous-knowledge to new situations.

The ability to *solve problems, reasoning* and *planning* are assigned to the functions of the frontal brain. A conclusive pure model introduction of mechanisms which are involved in these integrated functions for neural-anatomical correlates and the mode of operation does not exist up to now (Sohlberg & Mateer, 1989).

Among other things, frontal structures of the following functions are definitely involved:

- Selection of primary purpose,
- Selection of information,
- Planning and initiating actions,
- Control and Self regulation of own actions,
- Learning from responses,
- Anticipation from active consequences and
- Ending intended actions.

Among the cognitive components of the problem solving and of the reasoning, the **inductive thinking** is of the greatest practical importance. As inductive thinking the ability is designated to derive general rules, models, concepts or regularities from particular experiences and at new events to apply (Waldmann and Weinert, 1990). Typical tasks for these processes of hypothesis formation and hypothesis examination are:

- Analogies
- Completion of a series
- Matrix tasks
- Classification and concept tasks
- Word location tasks
- Metaphors and proverbs
- Estimation procedure

When we refer to **deduction** we refer to a systematic thought process which are derived from specific premises and a use of logical rules. These lead to specific conclusions. (Waldmann und Weinert, 1990). A logic system consists of final rules which allow us to derive true inferences from true premises (Anderson, 1988). Prototype tasks are mathematical evidence and syllogism (item pairs which have a specific relationship to each other). One distinguishes categorical, conditional and linear syllogism (cf.Anderson, in 1988; Sohlberg & Mateer, 1989).

Problem solutions are designated as *creative* if they are at the same time ingenious, expedient, useful, correct and valuable for a given task and procedure is rather heuristic than algorithmically. In contrast to *convergent thinking*, where it is a question of the information analysis of a central topic (Discrimination between relevant and irrelevant information) and there is often only a single valid solution per task; it is creative where it is a question of the quantity of ideas in relation to open problems without determined approach, which are assigned as *divergent thinking*.

A special case in problem solving thinking is **planning** of actions . The term planning means - as a kind of imaginative test action - which explores and coordinates all the achievements of the objectives and the required shared variables. Simultaneously there are mental planning sequences, drafts of actions with flexible and reversible process components, in which individual actions are examined to their conclusion. Chains of actions are again tested in connection with the above, for their part, for possible consequences. (cf.von Cramon & Matthes-von Cramon, 1993).

The ability for logic reasoning was understood as a central aspect of *intelligence*. Intelligence is, in the opinion of Rösler & Szewczyk (1987) the collective abilities which characterise the level and the quality of the thought processes of a personality. In Groffmann's opinion (1983), intelligence is understood to be the ability of the individual to think vividly or abstractly in linguistic, numeric or spatial-temporal relationships. The degree of intelligence is a precondition for the quality of the analysis of pure and practical situations, the recognition of associating, of the adaptation to situations as well as the solution and modification of situations (Wolfram, in 1986).

Factor analytical oriented intelligence theories have a special importance . These theories claim from one or several general factors, which have an important impact on intellectual partial performance, but are combined very strongly with the performance aspects of the logical-conclusive thinking and of the abstractive capability (Hartje & Sturm, 1989; Klix & Lander, 1967). Although the isolated consideration of individual intelligence factors, e.g. within the framework of diagnostic, can be reasoned, the boundaries between the cognitive functions are

cancelled increasingly for the benefit of a more integral point of view (Klix, 1971). Other authors to a large extent refuse, in the case of the description of cognitive functions, to use the term intelligence (von Cramon & Zihl, 1988).
Instruments for a valid, reliable and economic diagnostic of these complex brain performances are a scare commodity. Except for the usual intelligence tests, there has been, up to now, no test procedure for a diagnostic of problem solving abilities which would be able bear up to all test control criteria. In contrast to complex problems in the profession and everyday life situations, psycho metric tests employ most clearly defined problems, with which the proband has sufficient information about actual and expected status and instructions refer explicitly to allowed and/or not allowed courses of action. When considering the complexity of *problem solving*, disturbances in the construct of this ability spectrum should occur through broad diversified investigation means, which also include a systematic behavior observation oriented towards everyday life and relevant problem solving situations. There are numerous tests which are used for diagnostic of problem solving thinking. In addition to estimation scales which are used for judging the disturbances to the Meta cognitive functions, tasks should also be used for the inductive and deductive thinking. One finds further diagnostic instruments for disturbances in logical thinking and in problem solving in von Cramon & Matthes-von Cramon (1993) and Sohlberg & Mateer (1989).
Numerous performances in diagnostic instruments which are used in the clinical neural psychology can be damaged through disturbances in problem solving thought - e.g. which can be seen, e.g. through inadequate assignment analysis, before jerk action, control violations, cognitive in flexibility, express idea lack or decreased action and plausibility checks. Furthermore, massive influences on the basic abilities which are required during the process, may complicate the problem solving process (attention, memory, voice workmanship, visual functions) and Meta cognitive components a neuro psychological diagnostic and/or its interpretation.

The *Behavioral Assessment of the Dysexecutive Syndrome* (BADS Wilson et.al.; 1998) contains tasks which in combination with behavior observation in the case of the Testing, which in the above mentioned Symptomatic are registered in very differentiated manner. In particular the partial tasks "*action task*", "*zoo task*" and "*six element test*" supply important references on problem solving - and planning deficits.

In the case of the Therapy relating to this problematic complex, it is especially important to establish and/or support Meta cognitive abilities. Just a *symptom complex* from troubles of action planning, of the memory, of the problem solving thinking and of lacking illness insight can complicate therapeutic measures because an independent use of strategies often occurs at inadequate measure.

2.2 Training aim

The aim of the training is an improvement in the conclusive thinking and in the problem solving. A training of more complex thinking functions must also consider training of basal deficits cognitive functions, in addition to practicing contents-related aspects of problem solving. With the System **Logical Thinking** there is a special form of conclusive thinking - the completion of a series - which is trained by means of induction.

Altogether, at the foundation stage of an extensive neuropsychological diagnostik , here it should be decided, which therapeutic procedures is appropriate. This must, in particular in the case of complex abilities such as conclusive thinking attention and memory functions (in particular the working memory), register visual perception/exploration and visual-spatial functions as well as the voice processing in a differentiated manner, since deficits of these basic functions can damage the logic intellectual capacity.

Such functional deficits are to be treated with priority (cf.Sohlberg & Mateer, 1989). However also motivation problems and behaviour conspicuousness, those are better dealt with in connection with problems in the executive finctions and possibly represent an important subproblem of the functional deficits and must be given serious considered.

In order to support the problem solution abilities and especially to develop particular strategies, it is necessary to encourage the patient during the development and setup of these strategies. During therapeutic support of the meta-cognative process, the following aspects should be supported systematically:

- Recognition and considering solution relevant information
- Developing precise hypotheses and approaches
- Plan and analysis of the approach to the solution in parts.
- Recognition of mistakes and solution steps, which are not target orientated
- Error correction and development of alternative approaches

In relation to the reasons for faulty or damaged solution processes or reactions while processing complex tasks - and also while processing a completion of a series tasks - it can be helpful to direct the patient introspectively through the problem solving processes.
From this information the type and extent of required supports can be indirectly derived. Some patients gain for example by non-particular reference stimuli which guide the attention process to preceded to subsequent solution steps. These structural help supports act as advice points / tips, which guide the patient in the direction of the relevant information, without affecting the internal results. In

this way, the insight into the organisation of material is supported .

The procedure offers the therapists the possibility to elaborate on solution tactics performed interactively with the patient above for *improvement* in the *conclusive thinking*. More complex problem solving processes whose practice destination it is to find out different available components and to select the correct or most efficient one can be selected on this basis.

Preliminary investigations showed that the employed task model makes relatively high orders on the short-term and work memory. Before one begins with training, basal abilities with further RehaCom procedures and **attention & concentration** (AUFM) and the **visual memory** (PICTURE) can be practiced. The everyday life oriented action planning competence can be practiced with **Plan A Day** (PLAN).

2.3 Target groups

The training system '**Logical thinking**' has been developed for all patients with **impairments to the executive functions**, in particular in reference to area of the problem solving.

Disturbances in logical thinking and in the required basic functions basic functions are widespread, in the case of patients who suffer from brain damage of different etiology.

In particular, after uni- or bilateral frontal damage to the brain (frontal lobe damage), it frequently comes to a conglomerate of cognitive, emotional and Behavioral disturbances, which according to functional aspects below the term **Dysexecutives Syndrome** (Baddeley & Wilson, 1988) will be summarized. These can include:

- Troubles of attention control (selection, focusing),
- Disturbances in vigilance,
- Increased distraction/ interference in susceptibility,
- Disturbances of memory,
- Decreased learning ability,
- Disturbances in the ability of aim-oriented action,
- Disturbances in the logical problem-orientated intellectual capacity,
- Decreased abstract thought capability,
- Incapacity, problems in distinguishing between important or unimportant (information selection),
- Decreased ability in relation to initiating and the completion of sequential actions,

- Preservation tendency, Rigidity,
- Disturbances in feeling in relation to temporal sequences,
- Impulsiveness or loss of initiative,
- Difficulties, in responses,
- Lacking in mistake location and correction,
- Dissociation between knowledge and action,
- Disturbances in Anticipation of action consequences (foresighted thinking),
- Disturbances in self regulation and self perception,
- Inadequate social behaviour (understanding and evaluating social situations),
- Lacking in illness insight, Anosognosia.

In addition to *frontal damages* of different genesis (vascular cerebral damages and infarcts and hemorrhages, cranial trauma, tumors) are above-mentioned troubles which also after numerous *diffuse brain damages* (primary- and secondary-degenerative brain illnesses, Hypoxia, infections, etc.) are to be observed.

Patient who suffer from brain damaged often have, through deficits in subsets of the system or the dysexecutive syndrome, difficulties to solve problems in everyday life. The co-operation of *attention*, *memories*, *action plans* and *behaviour disturbances* underlying to the syndrome represents a special challenge, to therapists, in the field of the Neuropsychology.

There are additional complications in that, with brain damage, and often damage to basal cognitive performances (attention, visual-spatial performance, memory, language and motor) there they are more or less seriously affected and these deficits in turn affect the more complex functions and in particular in relation to an immanent illness, these represent a part of the more complicated disturbances.

Disturbances in thought, in particular as they are to be observed after damage to frontal lobe, encompass difficulties, which affect the analysis of the conditions of a problem and the ability to recognize important relationships. The sequence of precise operations seems, with such patients partly removed and haphazard. They ignore the stage of the preliminary investigation of the conditions and limitations of a problem and replace it with purely intellectual operations which are unrelated, impulsive actions. Patients with brain damage often have difficulties in forming superordinate categories. They are not able to think abstractly, that is, free from a concrete stimulus and often find themselves being overtly pensive when it comes to a task.

An additional possible application of the system, outside the area of *neuropsychological rehabilitation* for cognitive therapies in education, would also

in the field of *geriatrics*.

The application of the system is dependent on the kind and scale of the deficits and to the level of intelligence. **Logical thinking** can be used with children from about 12 years and the patient should be supported by a therapist if used for further clinical purposes.

In order to use reasonably the system the patient must have an intact visual working memory and must be in the right state of mind for these attention demanding tasks. Patients who suffer from a serious form of amnesia and have with serious deficits of the short-term and working memory should receive special therapeutic relief or resort to practising less complex procedures.

Puhr (1997) examined the effectiveness of cognitive training of several functions with a RehaCom training battery on a random sample of stroke patients. Depending on profile of the disturbances, particular training procedures were selected. The current status of the ability of conclusive thinking was registered with the Coloured Progressive for Matrices. A transfer effect of first and third arrangement (training effect and effect on the field activities of daily living) could be proved by training. Cognitive deficits were decreased.

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