Cognitive Rehabilitation in an Information-Processing Perspective

J.J. Diamant
P.J. W. Hakkaart

The aims of treatment of chronic psychiatric patients with or without brain dysfunction have undergone a considerable change in the last decade. The ambitions of the therapists have in general decreased and the expectations of the patients and their families have become more realistic. This process has been operationalized in terms of various concepts and theories.

Instead of eliminating or improving the cause of illness and repeatedly attempting to bring chronic psychiatric patients back into society, more attention is now being paid to the actual state of functioning of the patients and to the attempt to improve the quality of their life in the most suitable setting they need.

A relevant model was looked for that could enable the elaboration of an appropriate approach to this population and bring about observable change in behaviour and level of functioning within the limits given by the psychotic defect and/or brain dysfunction.

We find the competency model as presented by Townes, Martin, Nelson, Prosser, Pepping, Maxwell, Peel, and Preston (1985) a useful starting point The essence of this approach is to indicate the actual level of cognitive functioning of the individual patient in terms of an individualized skills profile derived from test results assessing various cognitive functions. The basis of this model is the brain-behaviour frame of reference. The operationalization of this approach has been realized in the form of neuropsychological screening with the Halstead-Reitan Neuropsychological Test Battery (NTB) as well as specific neuropsychological tests of different cognitive functions.

Our theoretical model is based on the conceptual model of behavioural correlates of brain function introduced by Reitan and Wolfson (1985, 1988). The results of the neuropsychological diagnostic process form the basis for elaboration of cognitive training procedures.

Cognitive rehabilitation (retraining, training, revalidation) has become increasingly popular in the eighties. There have been many attempts to create training techniques to improve the cognitive functioning of the chronic psychiatric patients. Hereby the neuropsychological model has frequently been applied with the implicit hypothesis that cognitive dysfunctions or defects in chronic schizophrenics were to a great extent similar to those in patients with brain dysfunctions based on observable or hypothesized brain damage. This hypothesis has received support in the literature (e.g., Klonoff, Fibiger, Hutton, 1970). So far, however, we cannot consider this hypothesis as satisfactorily confirmed.

Training of cognitive functions has become a still more frequently occurring activity of neuropsychologists and occupational therapists, as well as of nurses, although the training results till now, are not yet convincing. In fact there are still too many doubts concerning the usefulness and verifiable results of different training programs and methods. A ma or problem is reflected in methodological difficulties related to the process of evaluation. In the meantime, many training techniques as well as training programs have been developed (Gianutsos, Lynch, Bracy, Van der Werff, Oosterveld, et a]), most of them on an empirical basis.

Many negative or dubious results of the training programs used so far may be explained - in our opinion - by the fact that they are not based on a relevant neuropsychological theory or model. Bracy (1986) formulates the present situation as follows: "...a theory of brain functioning and of rehabilitation is necessary for assessment diagnosis, treatment planning, goal setting and providing therapy. Without a unifying and guiding theoretical framework, our efforts would not amount to much more than random stabs in the dark."

So far, there are two theoretical models available, that could be used as a model for cognitive rehabilitation. The model of Luria, recently operationalized by Bracy, Ruff and others and the model of Reitan (Diller, 1976; Reitan & Wolfson, 1985). In both cases, the information processing approach is underlying. A functional integration of these two approaches, representing behavioural neurology and clinical neuropsychology, has not yet been achieved.

In our article, we shall try to analyse the available models of cognitive rehabilitation, and to contribute to the elaboration of a working model suitable for our population.

Different Models of Cognitive Rehabilitation

The discrepancies between behavioural neurology and clinical neuropsychology in the field of neuropsychological assessment may be also found in different models of cognitive rehabilitation.

Descriptive (Procedure, Transcript) Models

Luria (1963) formulated his approach in the sixties. He proposed a syndrome analysis by which he tried to objectify different symptoms in order to find the underlying factors that cause some functional deficits. The relationships between different cortical functions are explained by means of Luria's theoretical model. The clinical findings as well as the results of data analysis form the basis of the applied rehabilitation strategies.

Another descriptive model of cognitive rehabilitation is the model of Diller (1976,1981, 1987), derived from the concepts of clinical neuropsychology. Diller starts with identifying the defect of a certain ability. Then a task is chosen that appeals to the respective ability in an adequate manner. This task should be analysed in terms of stimulus and reaction qualities. The ability and the task are evaluated from the point of view of the activities of daily life (ADL), achievements on other tasks that may reveal abilities associated with the trained ability and with neurological correlates. Thus a rehabilitation diagnosis is formulated which forms the base of the training process.

Information Processing (Analytical) Models

In the recent years, information theory has been adopted as a basis of cognitive rehabilitation models. Attempts are made to integrate information theory with the neuropsychological frame of reference.

Reitan and Wolfson (1985, 1988) present a model with three levels of information processing. The first level implies attention, concentration and memory, the second level reflects the lateralized processes, i.e. verbal and language skills in the left hemisphere and spatial and manipulatory skills in the right hemisphere.

The highest level of information processing is considered as the central one, enhancing abstraction in the form of concept formation, reasoning and/or logical analysis. The basic concepts of this model are derived from clinical psychology and are to a certain extent similar to those used by Diller (1976) or Diller and Gordon (1981).

Bracy (1986) is influenced by the theoretical formulations of Luria. He tries to operationalize the three functional units of Luria in terms of locations and different cognitive processes which are considered typical for a specific functional unit. He defines the basic processes which must be trained first before specific and more complex processes can be trained.

We have tried to present models of cognitive rehabilitation that we consider representative for different categories so far described in the literature. A developmental trend may be seen from the descriptive to the information processing models, the latter offering a more relevant basis for deeper analysis of the underlying mechanisms of objectified functional deficits as well as a more operational background for the choice, timing and combination of the training techniques.

The comparison of the two information-processing models brings us to the conclusions, that both of them are based on the following principles:

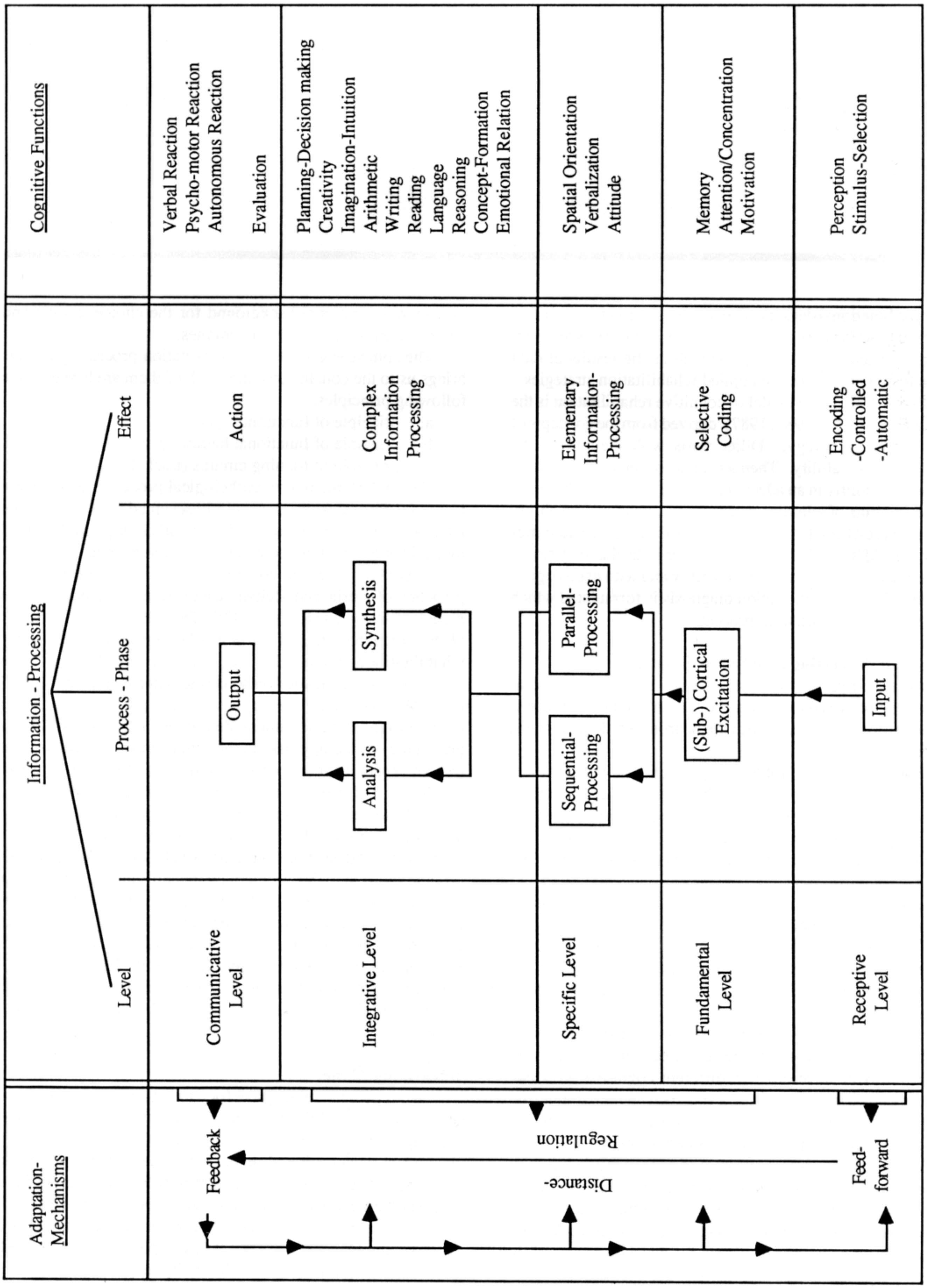

Figure 1. A theoretical model of the "Closed Circuit Approach".

a. principle of functional specifity,
b. principle of functional hierarchy, and
c. principle of training circuits (tracks).

The underlying neuropsychological processes and mechanisms are derived from the generally accepted facts know about lateralization, localization and functional circuits, as described by Luria and hypothesized by Halstead and Reitan.

There are, however, some principle differences in the approaches of Luria and Reitan, which remain inherent in the models of Bracy and Reitan and Wolfson. Bracy thinks in terms of the functional units of Luria and he sees no central aim for rehabilitation activities. He states, that "Successful therapy at the basic level will...enhance responses to other therapeutic activities". We must know the capacities of our patients in each area in order to focus our treatment, determine the proper models for presenting our therapy tasks to the patient and to determine what we can expect from our patients in the way of response (1986).

Reitan and Wolfson (1988) state that the training programs so far "have not been organized around a meaningful conceptualization of human brain-behaviour relationships". In their opinion the "Halstead-Reitan Neuropsychological Test Batteries provide solution to this problem by identifying the impaired or deficient neuropsychological functions of the individual within the framework of brain-behaviour relationships". They postulate that "abstraction, reasoning, and logical analysis abilities may be more fundamental than the specialized skills." They have designed five tracks of training with their Rehabit system (Reitan Evaluation of Hemispheric Abilities and Brain Improvement Training).

Integration Model

In our own model we have tried to further develop the basic ideas of Reitan and Wolfson and to integrate this approach with that represented by Bracy on the basis of Luria's model. Our theoretical model is based on the thesis that "brain is the organ processing distance between subject and object in terms of time, space and interpersonal relationships". The primary aim of the brain is to regulate the distance between the subject and the environment to increase the adaptation repertoire of the individual. In this respect speed and flexibility may be considered the basic dimensions of the distance manipulations processes. These processes form the general basis of the functioning of the brain and behaviour as well as of the adaptation process of the individual in the continuously changing environment (J.J. Diamant in press).

In this context cognitive training can be viewed as an attempt to correct or improve the distance regulating processes in order to achieve better adaptation. This can be achieved by decreasing the distance between the manner of information processing in the left and right hemisphere and by stimulation of the integration of these processes. Our training model continues the route started by Reitan in his Rehabit by trying to find a more general theoretical basis of the suggested training tracks or programs. Our expectation is that further elaboration of the application possibilities of this model will enable to elaborate more efficient and better timed training techniques and procedures.

Theoretical Background of Our Training Model

The theoretical background of our organizational model "Closed Circuit Approach" (Diamant, 1980, 1982, 1987) is presented in Figure 1. This model is derived from the theoretical postulates dealing with "distance-regulation" of the brain (Diaman4 in press) and expressed in terms of information-processing i.e. phases related to different levels and effects of information processing. Differentiation in levels of information-processing is extended to input- and output- factors with regard to the basic idea of distance regulation (adaptation-mechanisms).

After describing the different levels of information-processing a hierarchy of cognitive functions (specific neuropsychological concepts) has been presented.

Our basic assumptions are that at the receptive level a careful screening must show that the sensory input channels are clear before a step to the fundamental level can be made. At the fundamental level, it is assumed that a sufficient level of arousal is necessary for adequate information processing, i.e. attention/ concentration, and memory (general cognitive functions). At this level, general cortical and subcortical involvement is assumed.

On the specific level of information processing a distinction is made between specific functions i.e. spatial orientation and verbalization which we supposed to be represented in the right and left hemisphere. The correlated information-process phases are sequential and parallel processing.

The next phase, the integrative level, is the level of complex information processing. Process-phases such as analysis and synthesis, are the main concepts whereupon the abstraction function (e.g. concept-formation, reasoning and planning) are based. At this stage, general cortical involvement is assumed.

The final level is the output-level. Verbal and psychomotor reactions can be objectified. Localized cortical involvement is assumed.

Organizational and Clinical Realization of the "Closed Circuit Approach"

The "Closed Circuit Approach" is organized as an individual, systematic training of specific cognitive functions and abilities in a multi-disciplinary design, including neuropsychological screening, re-screening and continuous evaluation of results.

This can be operationalized in four phases:

1. Organization frame-work

The neuropsychological assessment results are based on:

-behaviour observations (with rating scales)

-global neuropsychological screening (Halstead-Reitan Neuropsychological Test Battery (HRNTB)

-specific neuropsychological assessment (e.g., Benton Visual Retention Test)

-behavioural neurological assessment is sometimes used (Luria-Christensen or Luria-Nebraska Investigation).

2. Translation of specific neuropsychological concepts into:

-information-processing concepts in terms of information processing levels, process-phases and effects in line with our theoretical model

-behavioural neurology concepts: a tentative association with the involved circuits according to Luria is formulated -various training-situations: the involved rehabilitation-disciplines elaborate a translation of two or three selected cognitive dysfunctions which are to be trained in terms of their own specific situation.

For this purpose, a neuropsychological lexicon has been developed (Diamant, Hakkaart, 1986) in order to facilitate the translation (see Figure 2).

Function: Memory
Term: Anterograde Amnesia Explanation: Imprinting or learning capacity is reduced Example: Forgetting a newspaper-article just read
Neuropsychological Laboratory: Low-level functioning on tests as Wechsler Memory Scale, Auditory Verbal Learning Task Psychomotor Therapy Unit: Problems arise when the instructions are altered Occupational Therapy Unit: Client has forgotten the last week activities Creative Therapy Unit: Unexpected changes in style of expression Ward: Hangs his coat and places objects often in a wrong place

Figure 2. Example of functional impairment translated into different training situations.

3. Actual training-phase

First, a base-line is set including test methods which are compatible with the training-methods as used in the neuropsychological laboratory. During this phase, progress will be monitored according to a repeated measures design within the framework of a single case study. The cognitive functions which are selected as training-functions can be trained in a specific way i.e. aimed at specific cognitive functions as well as at specific facets in terms of stimulus modality, duration, etc. (see the tracks designed by Reitan and Wolfson, 1988). Next to specific cognitive training, non-specific training can be used dealing with the foundations of the cognitive processes that may be conceived as prerequisites (i.e. cognitive functions attention/concentration and memory). Training of cognitive functions is organized in the form of training-sessions in the neuropsychological laboratory which may be either computer- or neurotrainer assisted. This situation may be compared to "in vitro" -training in the training process where as many functions as possible are explicated. Complex situations are used for training of more complex skills ("in vivo" training). These situations are realized at the psychomotor therapy unit, the occupational unit, creative therapy unit and on the ward. The assumption is that the results of in-vitro training will generalize to a different degree in different situations. The most frequently trained cognitive functions so far are the following: attention, concentration, memory (STM/LTM), psychomotor functioning, visuo-spatial orientation, concept-formation and reasoning. Psychotherapeutic and/or evaluative contacts and contacts with the social network are additional interventions during the training-phase. Behaviour observations are repeatedly made during the whole procedure in the different situations.

4. Evaluation-phase

Implies repeated testing with specific test methods and finally a repetition of the original neuropsychological screening. The average duration of a training program is twelve to sixteen weeks. Another training program or several training programs may follow.

Case Study

A forty-year old male patient was seen in January 1987 with psychiatric problems and neuropsychological dysfunctions as a consequence of closed head injury (July 1986). He had been in coma for five days with an epidural hemorrhage (left-sided) and concussion (mainly right-sided).

At the age of twenty years he was involved in a car-accident with coma lasting approximately ten hours.

We started with a global neuropsychological screening and a specific neuropsychological investigation. The results indicated in terms of our theoretical model that there were no significant problems at the receptive level i.e. only some slight mistakes occurred in the simple sensory-perceptual examination.

At the fundamental level, however, major dysfunctions were objectified in relation to attention/concentration and memory. This low-level functioning is assumed to influence test results at the so-called "Higher" levels i.e. the specific, integrative and communication levels.

It was decided that training of cognitive functions should be organized primarily on the fundamental level of information processing (memory, later also concentration). The expectation was that improvement in these cognitive functions would be followed by improvement in the elementary and complex information processing as well as by increased psychomotor output.

The training program was realized in the following settings:

1. Neuropsychological Laboratory:
   a) computer assisted, e.g. "Memo" (Oosterveld) and
   b) neurotrainer assisted (paper and pencil tests) for memory training (see Table 1).
2. Occupational therapy unit: e.g. carry out a logical sequence of necessary actions to construct an object with or without time schedules. This method was designed to improve the psychomotor reactions.
3. Psychomotor therapy unit: the trainee is asked to perform specific exercises he/she had learned a week earlier. This method was introduced as a memory training strategy within the context of psychomotor therapy.

After the translation of the trained cognitive dysfunctions into the above mentioned training settings, the base-line was established with the help of a short assessment procedure. Besides the three trained cognitive functions, a control function (verbalization) was introduced. The evaluative testing was repeated half-way the training process and after completion of the whole training program.

The results of the training program indicate some improvement manifested in terms of better results on some tests, like Tactual Performance Test (Memory), Speech Sound Perception Test and Tapping Test. The effects were, however, small in size. The Impairment Index in the Halstead Reitan Neuropsychological Test Battery has decreased from 1.0 to 0.7.

The level of the control function (verbalization) has remained unchanged during the repeated evaluative testing.

We may conclude that these results of our training activities are related mainly to the achieved higher level of arousal in the sense of the functioning of Luria's Unit 1, that in turn can be associated with improved selective coding on the fundamental level of information processing. Later on positive changes have also been observed on the communication level (psychomotor reactions), which is in line with our expectations.

Discussion

The "Closed Circuit Approach" tries to integrate the information processing model as represented by Reitan, R.M. & Wolfson, B. (1988). The aim of the introduction of our theoretical model is to facilitate the realization of the efficient theory based training-programs (e.g. interventions that would improve disturbed cognitive function of the patient).

The most complex problems in our view are related to the translation of the results of neuropsychological screening into relevant training strategies in relation to different training situations. We do not find the traditional concepts and classifications of cognitive functions useful for this purpose. We realize that different competencies involve various cognitive functions to a different degree.

Our conviction is that the information processing model will bring us closer to functional coordination of both sets of investigated phenomena: behavioural manifestations and the underlying brain-dysfunctions.

Table 1
Translation of Test-Results

Trained Cognitive Dysfunction	Level:	Process:	Expected Training Result:	Training Agent:	Training Method:
Attention/Concentration	Receptive Fundamental	Excitation (Stimulation)	Improved Selected Coding	Computer	Foundation Skills (Bracy, All items) “Konsentratie” 1-2-3-(v.d. Werff)
				Neurotrainer	Cancellation-Tasks Kraepelin-Methods
				Occupational Therapy Unit	Construct objects within a certain Regular time-schedule (sustained attention)
				Psychomotor Therapy Unit	Activities so structural that interference with distracting events in the gymnasium will not occur
Memory Visual Auditive STM/LTM	Fundamental	Excitation Extended Sequential/ Parallel Processing	Improved Elementary Information-Processing	Computer	Memo (Ooterveld)
				Neurotrainer	Memory-S (Wordconstruction)
				Occupational Therapy Unit	Variable amounts of verbal instruction have to be remembered
				Psychomotor Therapy Unit	Registration of trainee’s performance in specific actions that were performed a week ago (This time without instruction)
Psychomotor Reaction (Speed and Coordination)	Communicative	Output	Improved Quantity and Quality of action	Computer	Visuospatial (Bracy, 1 ¾ 5/6)
				Neurotrainer	Schoppe-Method Both-Method
				Occupational Therapy Unit	Carry out a logical sequence of necessary actions to construct an Object with or without time-schedules
				Psychomotor Therapy Unit	Accent on faster movements

Conclusions

We have tried to demonstrate the relevance of the information therapy approach to the training of cognitive functions by patients with brain dysfunctions. We have worked out an information-processing scheme involving different levels of processing with related process-phases and effects. We assume that the feed-forward signal-detection is transformed by means of distance-regulations into feedback, which may form the impetus for the next feed-forward.

The translation of objective test-achievements into cognitive functions and process-phases of a training program are the most complicated issues on the way toward, more efficient realization of our "closed circuit" approach to individual clinical cases.

REFERENCES

Bracy, O.L. (1986). Cognitive rehabilitation: A process approach. *Cognitive Rehabilitation, 4*(2), 10-17.

Diamant, J.J. (1980). Training inpatients with cerebral dysfunctions. In A. Jennekens-Schinkel, J.J. Diamant, H.F.A. Diesfeldt, R. Haaxma (In Dutch). In: Neuropsychologie in Nederland, Van Loghum Slaterus, Deventer.

Diamant, JJ. (1982). Training of cognitive functions in psychiatric patients with brain dysfunctions: an attempt at integration of behavior therapy methods (In Dutch). *Gedragstherapie*, *15*(3), 22-39.

Diamant, JJ. (1987). Training of cognitive functions in patients with cerebral dysfunctions (In Dutch). *Metamedica, 66,* 148-160.

Diamant, J.J. (in press). Recovery and neuropsychological treatment of cognitive function disturbances (In Dutch). Tijdschrift voor Ergotherapie.

Diamant, J.J., Hakkaart, P.J.W. (1986). Neuropsychological Lexicon (In Dutch). Internal Report. St. Willibrord, Heiloo: Psychiatric Center-

Diller, L. (1976). A Model for Cognitive Retraining in Rehabilitation. *The Clinical Psychologist, 26,* 13-15.

Diller, L., Gordon, W.A. (1981). Rehabilitation and clinical neuropsychology. In S.B. Filskov and TJ. Boll (Eds.). *Handbook of Clinical Neuropsychology*. New York: John Wiley.

Diller, L. (1987). Neuropsychological Rehabilitation. In Neuropsychological Rehabilitation, M.J. Meier, A.L. Benton and L. Diller (Eds.). Edinburgh, Churchill Livingstone.

Klonoff, H., Fibiger, C.H. & Hutton, G.H. (1970). Neuropsychological Patterns in Chronic Schizophrenia. *Journal of Nervous and Mental Disorders*, *150*, 291-300.

Luria, A.R. (1963). Restoration of Brain Function after Brain Injury. New York: MacMillan.

Reitan, R.M. & Wolfson, D. (1985). The Halstead-Reitan Neuropsychological Test Battery. Theory and clinical interpretation. Tucson: Neuropsychology Press.

Reitan, R.M. & Wolfson, D. (1988). Traumatic Brain Injury, Volume II: Recovery and Rehabilitation. Tucson: Neuropsychology Press.

Townes, BD., Martin, D.C., Nelson, D., Prosser, P., Pepping, M., Maxwell, J., Peel, J. & Preston, M. (1985). Neurobehavioral Approach to Classification of Psychiatric Patients using a Competency Model. *Journal of Consulting and Clinical Psychology. 33,* 33-42.