The role of the neurologist in rehabilitation goes beyond diagnosing the patient’s disease and related functional disorders. This task, like dynamic diagnosis or the longitudinal evaluation of disease course and of the effects of treatments administered, can be carried out through consultations. In reality, the neurologist’s direct intervention is required and should be oriented in three complementary directions. The role of the neurologist should be: 1) to define therapeutic interventions, both integrative and facilitatory training of the still preserved functions; 2) to identify patients in whom effective intervention is possible; 3) to make provision for methods and instruments designed, in both the exploratory and the therapeutic stages, to maintain the efficiency of, and to improve, the task-independent central functions.

Motor pathology, whether of central origin secondary to pyramidal system damage, or of peripheral origin due to motor unit damage, falls within the field of task-specific executive processes.

In the first instance, in which it is the first motor neuron that is affected, the most feasible intervention, in both an extensive and an intensive sense, is positional feedback and electrical stimulation (PFST) to prevent disuse of the praxic engram centres.

In the second instance, in which it is the second motor neuron that is affected, the intervention is based mainly on classic physiokinesitherapy, in its various forms.

The sector of interest to this symposium is that of premotor pathology, and its three main systems: initiation of movement, impairment of which gives rise to akinetic and dyskinetic syndromes; coordination of movement with inhibition of the antagonist muscles, impairment of which gives rise to primary ataxic syndromes; and spatial and temporal programming, impairment of which leads to various forms of apraxia.

Furthermore, these three systems are associated, even at a preliminary level, with a structural resource and with two general mechanisms: mnesic memory stores and their coding and decoding function, impairment of which gives rise to phrenasthenic and dementia syndromes; and vigilance mechanisms, impairment of which leads to confusional states; and purposeful attention mechanisms, whose impairment leads to dissociative mental states.

Having identified the patients in whom integrative and facilitatory functions should be investigated, it remains to define the anatomical-functional substrate of these functions.

**INTEGRATIVE PROCESSES**

The basal state of vigilance that is crucial to protracted attention, from entry of information, through processing of information and output of appropriate executive commands, is provided by the ascending reticular activating system of Moruzzi, Magoun and Morrel, Jasper.

Control and guidance of the flow of impulses in the internal cortical-subcortical circuit, which represents both the content and the feeder of awareness, start from Jacobsen’s frontal area 45 and involve, at task-independent level, the basal ganglia and cerebellum. Initiative and affective pulsions stem from the limbic system.

**FACILITATORY PROCESSES**

Adopting a simplified scheme, analysis of psychomotor initiation, coordination and programming can focus on the threshold of the executive central nervous system. At the end of the premotor sequence, upon reaching the moment of actually performing an act (in which voluntary will determines a given behaviour), a volley of impulses leaves the internal cortical-subcortical circuit.

This volley is characterized by a certain frequency, and number of impulses and intervals that together generate specific patterns of innervation. Thus, the motor cortical area is facilitated until an over-threshold excitation is reached. Hence the motor units are recruited that are responsible for performing that given act. In this stage we have clearly moved from task-independent to task-specific processes. In the case of speech production, these will involve Broca’s area, which also has reinforced connections with Wernicke’s area.

The cortical area’s threshold is critical for the efficiency of the voluntary motor activity: a multisystemic loop of ganglia is involved in its control, even at rest, in a well-defined range of responsibility. The occurrence of any disease condition will cause an abnormal increase of the threshold with consequent decline of motor efficiency. A main task of neurorehabilitation is to avoid this decline.
There are three main mechanisms that contribute to maintaining optimal responsivity of the motor executive system. We will mention them here insofar as they are detectable and evaluated by means of a multiple delayed reaction methodology that we have developed in our laboratory.

1. The facilitatory process of working memory or purposeful attention starts, as temporal bridging (TB), from Jacobson’s frontal area 45; Dopaminergic preparatory effects exert a facilitating action on the pyramidal cortical threshold, starting from the extrapyramidal system, in excitatory-inhibitory superimposed neural loops.

2. Processes of programmatic reverberation, with re-afferent effects, occur in cortical-subcortical internal circuits in volving cerebellar and brain stem centres. Our methodology involves a sequence of psychomotor verbal reactions: simple (R,a) and choice (R,ab) reactions, immediate and delayed (Rd) reactions, passive (i.e., computer-initiated) and active (i.e., initiated by the subject, self-paced) multiple reactions.

The following functions can thus be measured:

1. Level of vigilance, which is tested using a preliminary warning signal.
2. Perceptual discrimination, measurable through recourse to choice (R,ab) or simple (R,a) reactions.
3. Purposeful attention and related facilitation processes. This knowledge of these processes is acquired by means of paired sequences of immediate and delayed reactions. These are performed using different foreperiods: 0.1, 0.5, 1.5, 4 and 10 seconds.

The difference between the immediate reaction time (tRim) and the delayed reaction time (tRd) will give us the facilitation time; the tRd can, in fact, be reduced as a result of the facilitation, i.e., lowering of the cortical motor threshold, which can be brought about during the foreperiod; during this Rd interval, the flow of impulses in the cortical-subcortical circuit will continue. The flow of these subliminal nervous impulses during the foreperiods, i.e., from the neural representations produced by the perception of the stimulus until the go signal, is called temporal bridging (TB). As a result of the previously mentioned processes, TB=tRim–tRd.

Further parameters concern the subliminal level, given that the subject has been ordered not to execute the task until the end of the foreperiod, when the signal to execute is given.

As the response we can choose freely among the various classic tests, pressing a key manually or using the foot, eye movements, speaking, all of which involve task-specific final channels. Our choice of verbal responses was justified by technical advantages, because verbal responses allow a more direct and flexible method of examination. More details of our methodology and its theoretical grounds, scope and applications are available in our works such as Brain Control and Behaviour (Basel, Karger 1997, p. 11 onwards) and Rappresentazioni e Processi del Parlare (Milan, Ambrosiana 1992, p. 71 onwards). Name reading reaction and figure-based tasks are reported in the publication Analisi della Attenzione Protratta (Pavia, edited by the Fondazione Maugeri, 1999).

The following parameters were measured: discrimination errors and delay, latency time of choice reactions (tR,ab) together with acousticogram (ACG) duration of the responses (D,ab), latency time of simple reactions (tR,a) together with duration of the ACG (D,a), difference between tR,a and between D,ab and D,a. Latency times of self-paced reactions (100) in relation to tR,ab are reported in series of 25 reactions to stimuli passively presented at relatively long intervals (3 sec) and the differences between them, intervals in the 100 self-paced reactions, and the TB value (tRd/tRim) in reference, broadly, to a foreperiod of 1.5 seconds.

We investigated 32 normal subjects aged 18-88 years and 79 patients, affected by a range of disorders (Table I).

We thus extracted constellations of symptoms indicating, in relation to each syndrome, the most significant alterations.

Table I - The diseases presented by the patient sample.

<table>
<thead>
<tr>
<th>Disease</th>
<th>N. of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parkinson’s disease (H&amp;Y I, II and IV)</td>
<td>29</td>
</tr>
<tr>
<td>Intentional tremor</td>
<td>3</td>
</tr>
<tr>
<td>Alzheimer’s dementia (2nd, 4th year)</td>
<td>4</td>
</tr>
<tr>
<td>Cerebrovascular diseases</td>
<td>2</td>
</tr>
<tr>
<td>Frenasthenic syndromes (IQ 75-80)</td>
<td>2</td>
</tr>
<tr>
<td>Multiple sclerosis</td>
<td>7</td>
</tr>
<tr>
<td>Primary ataxia</td>
<td>3</td>
</tr>
<tr>
<td>Depression</td>
<td>5</td>
</tr>
<tr>
<td>Dysthymic psychoses</td>
<td>4</td>
</tr>
<tr>
<td>Organic psychosis</td>
<td>1</td>
</tr>
<tr>
<td>Schizophrenia and mental automatism</td>
<td>4</td>
</tr>
<tr>
<td>Obsessive compulsive disorder</td>
<td>2</td>
</tr>
<tr>
<td>Frontal glioblastoma</td>
<td>3</td>
</tr>
<tr>
<td>Hemicrania comitata</td>
<td>4</td>
</tr>
</tbody>
</table>

DISCRIMINATORY AND INHIBITORY PROCESSES AND PSYCHOLOGICAL COGNITIVE TYPES. APPLICATIONS IN NEUROREHABILITATION

Let us now analyse the cerebral processes implicated, respectively, in choice (R,ab) and simple (R,a) reactions, starting from the studies of Craig, and going right through to the most recent contributions in this field, namely those of Brebner and Cooper, McNeil, Goode, Klapp and Duncan. The latter has shown how Lange’s distinction between muscular type and sensitive or sensory type can influence the ways in which these two psychomotor reactions can be executed.
According to Craig’s elementary equations, \( t_{R,ab} \) should be greater than \( t_{R,a} \) as \( R,ab \) involves a process of perceptual discrimination (Pd) that is absent in \( R,a \). Thus \( t_{R,ab} = t_{R,a} + t_{Pd} \). However, it has been observed that when, in the psychomotor \( R,a \) task, the task-to-be-executed stimulus is preceded by a warning signal, the subject is able to respond upon presentation of that signal because he already knows what the task-stimulus will be. Hence, in order to perform the task in the prescribed manner, he must activate an inhibitory process (IH). Thus, we arrive at the following formulae: \( t_{R,a} \rightarrow (t_{R,a} + t_{IH}) > t_{R,ab} \) if \( t_{IH} > t_{Pd} \), or \( t_{R,a} = t_{R,ab} \) if \( t_{IH} = t_{Pd} \).

We examined 18 normal subjects, applying MDRV (Multiple Delayed Reaction Verbochronometry) not only as \( R,a \) and \( R,ab \) with immediate responses, but also with foreperiod Rd of 0.1, 0.5, 1.5, 4 and 10 sec, and self-paced \( R,ab \) over 100 trials. Twenty-four hours later, we applied the following psychological tests:

1. The MF (matching familiar) figures test for distinguishing between similar figures (after Cornoldi) to measure cognitive styles in relation to the impulsive and reflective subject types.
2. The Big Five Questionnaire (BFQ) to measure 5 major factors: energy, agreeableness, conscientiousness, emotional stability, mental openness.

An equal latency time for \( R,a \) and \( R,ab \) was recorded in significantly more impulsive than reflective subjects, with an exceptional value of \( t_{R,a} > t_{R,ab} \) in one subject.

An explanation for the equivalence of reaction times for the two types of immediate reaction may lie in the complex condition of preparation and programming of response, which may take longer in impulsive-type subjects.

We are extending our studies with the aim of establishing correlations with cognitive factors closer to Lange’s muscular vs sensitive or sensory types, and with already studied cognitive styles by means of psychophysiological methods of investigation, like the field-dependent and field-independent ones. We will also seek correlations with factors linked to the patient’s previous activities, and the modalities he adopted to carry them out. In addition, we believe it would be interesting to take into account also the actual parameters measured using the MDRV and in particular the performance on passive reaction tasks (in which the subject responds to stimuli presented by the computer) in relation to performance on active self-paced reaction tasks, in which it is the subject himself who regulates the appearance of the stimuli, one after the other.

Even this datum could generate useful pointers to aid the decision of whether to engage the subject more actively in training, or whether he would benefit more from additional external support, advice, assistance, suggestions and encouragement.

By moving in this direction, we are convinced that it will be possible to achieve neurorehabilitation with reinforcement of integrative and facilitatory processes, with psychomotor reactions no longer being used only in evaluation, but also for training purposes. The tests that, to date, have proved to be the most congruous with this objective are: 1) self-paced psychomotor reactions, and 2) delayed reactions centred on the foreperiods in which the patient shows maximum facilitation. It has been found that patients engaging in these tests not only declare that they have benefited from them, but actually ask to repeat them. To date, the best investigated cases, studied for up to three months, concern the sequelae of traumatic head injury with cerebral concussion, sequelae of mental asthenia with mental concentration difficulties, and subjects with previous organic psychotic states of cerebrovascular origin.