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# MODIFICATION OF FES - INDUCED MOTOR RESPONSE BY MEANS OF HYPNOSIS

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## Summary

The work on Functional Electrical Stimulation (FES) has shown that one of the factors responsible for the variability in the motor performance is of psychological origin.

To test this influence, several normal subjects were stimulated under hypnosis. It could be shown that for the same stimulus the motor response was very different, depending on the type of suggestion given to the subject. Thus hyper- and hypo-excitability to FES could be demonstrated as well as the effects of posthypnotic suggestions.

This work was introduced in order to study possibilities of improved motor control and rehabilitation for patients who are candidates for FES. It is assumed that a combined physical and psychological treatment will activate maximally all the possible neuromuscular reserves which might be still hidden in a paretic patient.

## Introduction

In past ten years Functional Electrical Stimulation (FES) has become a useful and recognized method in the rehabilitation of the disabled. Like with other methods, however, the patient's conscious involvement is relatively small. Whatever voluntary effort is expected from the patient using FES systems, it is directed to the control sites, and to a much lesser degree towards the paralyzed muscle. Since paretic patients still have some voluntary control over the affected muscle, it is interesting to see whether this control can be enhanced or diminished at the patient's will.

Models attempting to explain experimental results of combined functional stimulation and voluntary effort were published by Vodovnik and Reberšek (1). In these models it was suggested that the moment of a force M, developed because of combined electrical stimulation and voluntary effort, is :

$$M = ae + bv + cev - dev$$

where a,b,c,d are constants, e is proportional to the intensity of electrical stimulation, and v is proportional to the voluntary effort of a patient, which was assumed to be maximal. Rearranging the equation, we have :

$$M = ae + ( b + ce - de ) \cdot v$$

The first term depends only on the stimulation, whereas the second term depends also on the magnitude of v. In our former work we supposed that there was no way to influence v and that all changes in the force moment could be obtained only by varying e. In our present work, however, we shall attempt to discuss the possibilities of influencing the conscious effort in order to change the result of force moment M.

A successful rehabilitation program should be initiated by

adequate psychological treatment for motivation, which should be carried out in the following directions : increasing of motivation for cooperation in therapeutic program, cooperation in voluntary muscle contraction, increasing of concentration, and mobilization of neuromuscular reserves.

For a motivated patient there is at present one method only which seems to be able of modifying the conscious signals controlling human effectors : instrumental or biofeedback therapy.This method tries to increase the patient's "awareness" for his own performance by augmented sensory feedback (2).

Yet there is another way of modifying v : application of hypnosis. This method has been known since many years and has found rather extensive clinical applications (3),(4). Therefore we wanted to find out to what extent FES effects could be modified by appropriate suggestions to a hypnotized subject.

In the following paragraphs we shall be reporting on the concepts, experimental results, and the possible perspectives of using hypnosis, combined with FES, in the rehabilitation of physically disabled.

It is known that a normal man can become hypersensitive to stimuli and can produce supra-normal muscle forces under hypnosis. May we thus put forward our hypothesis that a man with sub-normal muscle forces could be induced to produce almost normal forces under hypnosis ?

On the other hand a person under hypnosis relaxes better than when awaken. Moreover, the person can become insensitive to external stimuli. If so, why shouldnot then hypnosis be used to diminish involuntary muscle contractions such as clonus or spasticity ?

One of major problems in FES is muscular fatigue.Could it not be at least partially decreased by neuromuscular reserves activated during hypnosis ?

It is quite obvious that any clinically useful method must influence the patient at his full awaken state, and not only under hypnosis. Therefore it has been quite clear to us since the onset of the experiment that post-hypnotic suggestions will be of major importance, if the patient should benefit from this method. Besides, the patient will consciously want to repeat his performance in awaken state, after he has learned about his acheivement during hypnosis.

We could then summarize our philosophy as follows : assuming that the patient has some unused neuromuscular reserves, these could be activated under hypnosis and, combined with FES, result in a better motor performance. By means of appropriate post-hypnotic suggestions, these reserves could well be activated after hypnosis also, FES being, in addition to its direct motor effect, the post-hypnotic conditioning stimulus. And also, the patient's capability will increase at his awareness of the step-increase in his performance.

## Experimental Procedure

Introductory experiments were done on four normal experimental persons selected from a group of student volunteers in an experiment of slow hypnotic induction. In addition, some standard psychological tests were done (Rorschach, O.I. tests). It was decided that the effects of hypnotic suggestions should be observed

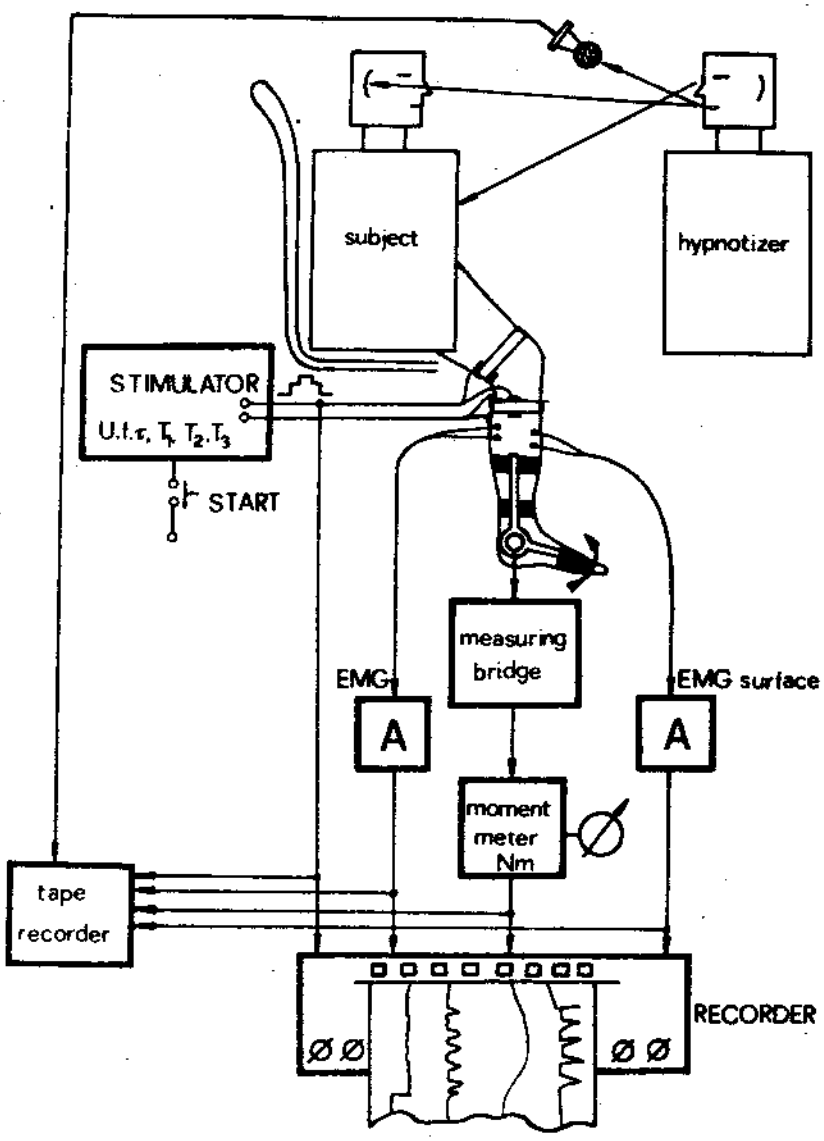



Fig. 1

Experimental Procedure

on dorsal and plantar flexion of the ankle joint. Therefore the force moment in ankle joint, in the direction of plantar and dorsal flexion, was measured by means of measuring brace, measuring bridge, and moment meter. The moment meter scale was calibrated in Nm, and the output was fed to the tape recorder as well as to the paper tape recorder - for convenient visual control.

To enable qualitative control as well, EMG of agonistic and antagonistic muscle groups (triceps surae and tibialis anterior) was recorded in the same way, after passing through corresponding amplifiers. The square pulse generator with digital display for frequency, pulse duration, and amplitude, with the possibility of programmed three-step train of stimuli,was used as electrical stimulator. The stimuli were applied to the motor nerves by means of cutaneous electrodes. The impulse frequency was set to 20 Hz, and the pulse duration to 0.3 msec. By means of a suitable microfone hypnotic suggestions were recorded on the voice channel of the tape recorder. The experimental person was comfortably placed in an armchair (fig.1).

Having fixed the under-knee part of the leg with belts to the measuring brace, and having applied the EMG cutaneous electrodes, the experiment began. It was carried out at three different states of the person submitted to it :

- at the awaken state ,
- at the hypnotic state ,
- at the awaken state, following the post-hypnotic suggestion.

Motor responses were observed by measuring the isometric force moments $M_i$, corresponding to the produced muscle force. These motor responses correspond to the three cathegories of motor activity, which are :

- maximal muscle force,
- muscle force modified by hypnotic suggestions of hypo- or hyper excitability,
- continuous muscle force at long intervals with the characteristic appearance of fatigue.

## Results

### Maximal Muscle Force

The person submitted to the hypnosis was instructed to produce maximal muscle force in the direction of dorsal flexion, and the corresponding force moment was measured both in awaken and in hypnotic state. Only nonsignificant changes of isometric force moment were recorded.

### Muscle Force Modified by the Hypnotic Suggestion

Stimulus was applied to the electrodes to produce dorsal or plantar flexion of the foot. Each set of stimuli was composed of three consecutive trains, 2-3 sec. each. The amplitude of the first and the third was equal and slightly above the treshold, while the amplitude of the second produced a higher moment. In order to get some orientation about the repeatibility, every time five experiments were done consecutively at intervals of 10 sec. The envelope of the set of trains and the corresponding motor response are shown in Figure 2. Each series of experiments was

performed in awaken state, in hypnotic state with the sug= gestion of hyper- or hypo- excitability, and again in awaken state with the corres= ponding posthypnotic sugges= tion. The mean value of each group of five measurements on one subject and the cor= responding standard deviation and changes in per cents are shown in Table I and the diagram Figure 3 for one ex= periment.

It is quite obvious that the changes provoqued by hy= pnotic suggestions are highly significant. Besides, they are repeatable, as over 30 experiments have shown. It is necessary to underline here that the results greatly depend on the form and the method of suggestion. With more than significant quanti= tative effects (which at treshold excitation cause many 100% changes), we are, of course, interested in the cor= responding qualitative back= ground of changes in motor organization, For this reason EMG records of some experi= ments are shown in Figure 4 a, b, c and d .

Fig.4a shows EMG during stimulation in hypnotic sleep. Stimulus artefact does not permit us to identify motor responses. There is no dif= ference between this and the awaken state. In Fig, 4b suggestions of hyper-excitabi= lity during hypnosis are pre= sented. Repeatability of de= layed responses, which become regular, can be observed. In Fig. 4c similar conditions in case of posthypnotic sugges= tions can be observed. In Fif. 4d EMG, corresponding

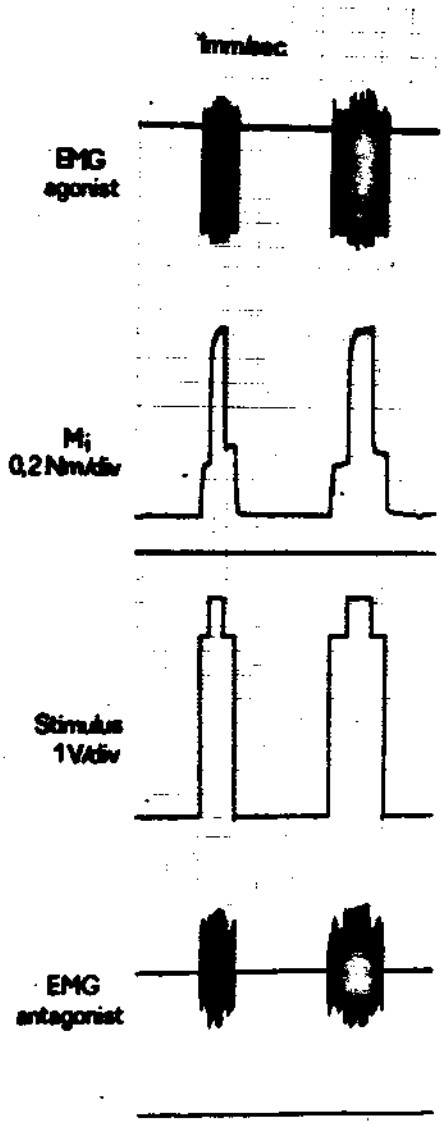



Fig.2

EMG, $M_i$ and Stimulus Records

to the voluntary contractions in awaken state, is shown.

Repeating the experiments in intervals of two weeks, regular activity as shown in Fig. 4d evolves in generalized activity during each single train of stimuli already. At the suggestion of hypo-excitability, similar effects as described

in the above antagonist can be observed.

| | | C. J. hyper 26.12.74. M [Nm] | | | I. M. hypo 29.5.74. M[Nm] | | |
|---|---|---|---|---|---|---|---|
| awaken | $\bar{M}_i$ | 0.5 | 5.7 | 1.7 | 2 | 10.3 | 3.7 |
| | S | 0.2 | 0.4 | 0.3 | 0 | 0.5 | 0.3 |
| hypnosis | $\bar{M}_i$ | 0.6 | 4.7 | 1.7 | 1.8 | 10 | 3.8 |
| | S | 0.2 | 1.1 | 0.8 | 0.1 | 0.3 | 1 |
| | $\Delta$% | 23 | 17 | 0 | -7 | -3.1 | 3.3 |
| hypnosis a. suggest. | $\bar{M}_i$ | 11.3 | 30 | 17.7 | 0.2 | 5.6 | 1.5 |
| | S | 1.7 | 1.6 | 1.9 | 0 | 0.5 | 0.2 |
| | $\Delta$% | 2063 | 428 | 956 | -90 | -45 | -59 |
| posthypn. suggest. | $\bar{M}_i$ | 2.7 | 8.2 | 5.6 | 1.2 | 7.3 | 1.7 |
| | S | 1.7 | 2 | 1,5 | 0.4 | 0.9 | 0.5 |
| | $\Delta$% | 428 | 45.2 | 235 | -38 | -29 | -52 |

tab. I

Changes of Motor Response at Hypnosis, Hypnotic Suggestion and Post-hypnotic Suggestion

The Influence of Hypnosis on the Temporal Development of Fatigue

If temporal development of motor response at long interval's is observed, it becomes clear, that in most cases the moment decreases exponentially. The speed of decreasing depends on the parameters of electrical stimulation, especially on the frequency. It is interesting to note that the course of decreasing is slower if the person is under hypnosis. Hypnotic suggestion almost eliminates fatigue, which is clearly shown in Figure 5. Figure 5a shows the decreasing of the moment at continuous

electrical stimulation during awaken state, while Fig. 5b shows

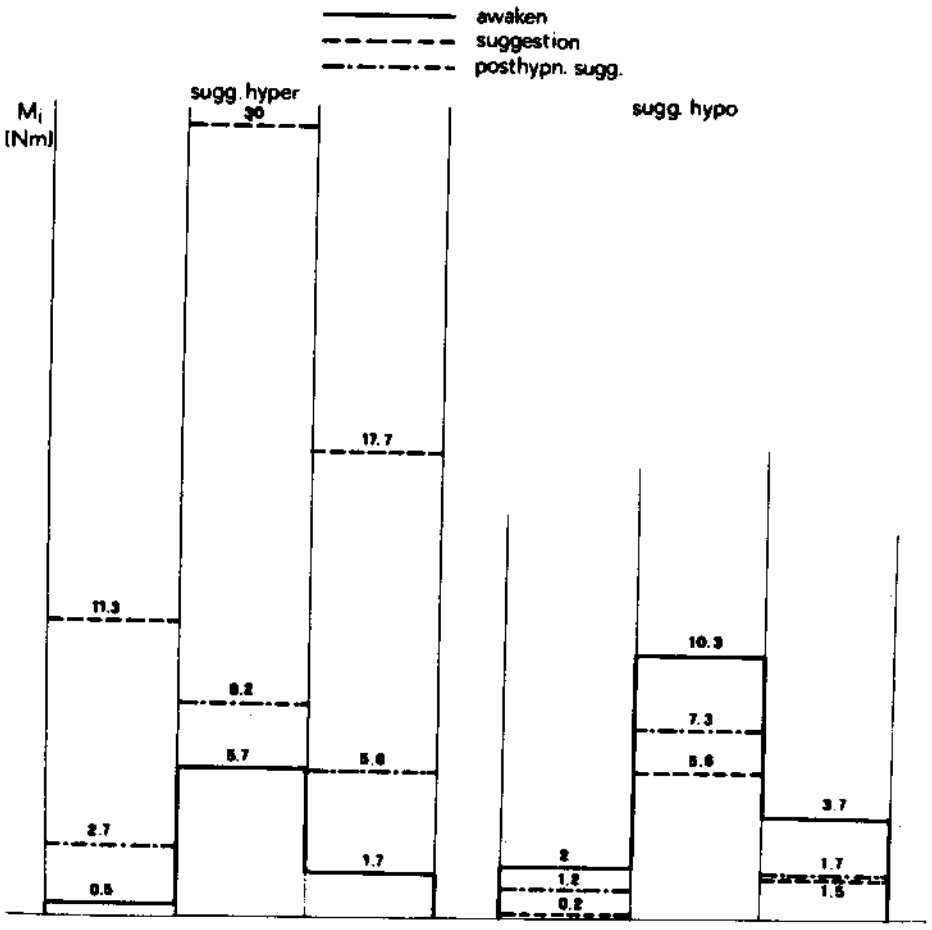
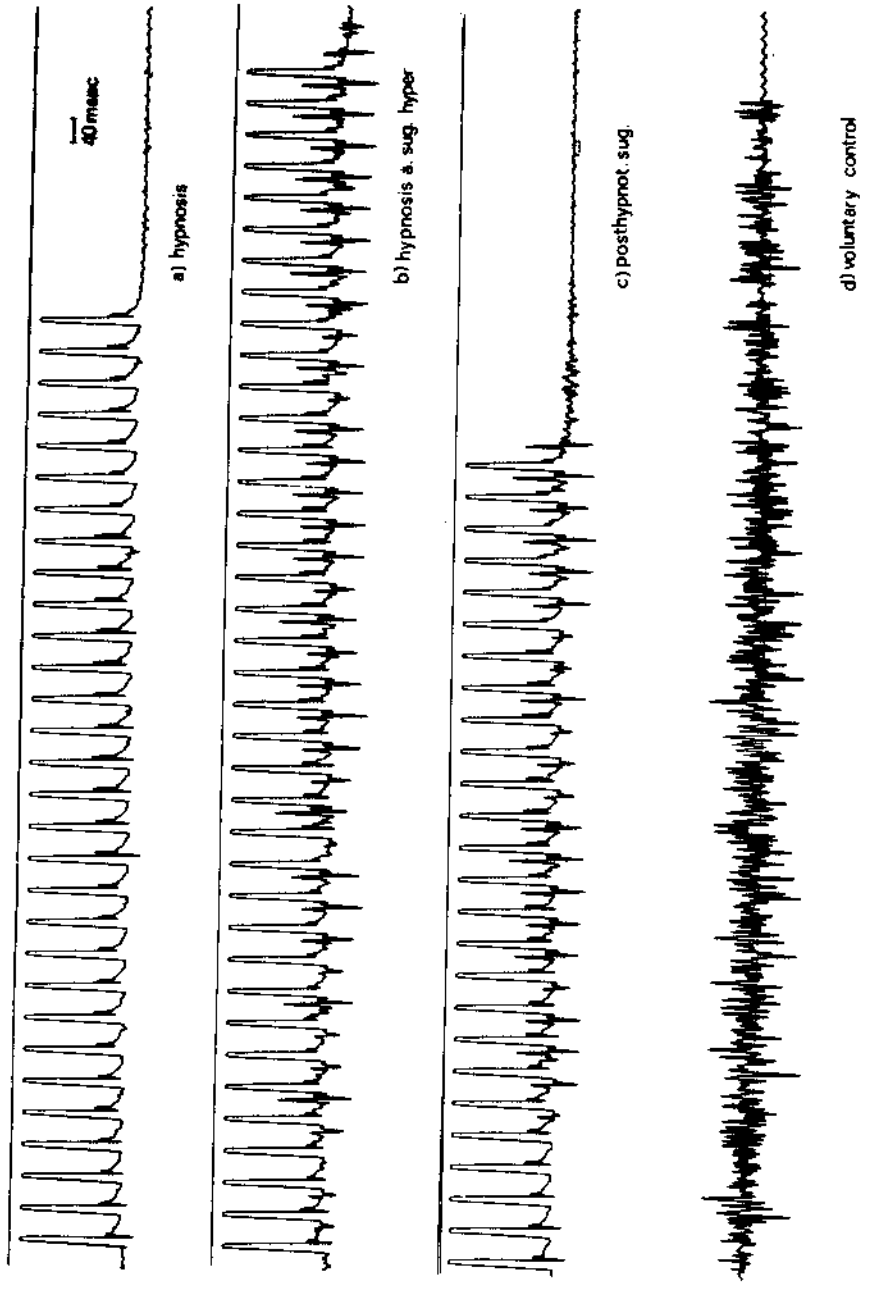



Fig. 3

Diagram of Changes of Motor Response at Hypnosis, Hypnotic Sug= gestion and Post-hypnotic Suggestion

temporal development of fatigue accompanied by the suggestion that the leg should not get tired.




EMG Records

Fig. 4

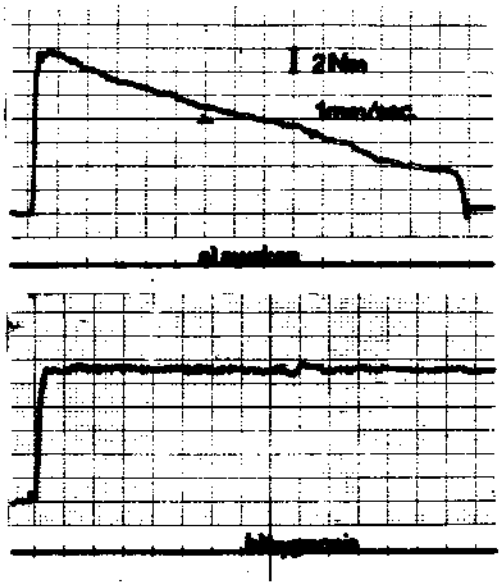



Fig. 5

Elimination of Fatigue Due to the Hypnotic Suggestion

## Conclusion

The present introductory study on normal subjects has shown interesting changes in muscle force during hypnosis. The major findings are :

- the maximal muscle force could not have been increased by hypnosis significantly, which is not in agreement with other reports (5). Therefore further investigations will be needed ;
- hyper- and hypo-excitability to FES were acheived with a low dispersion of results ;
- fatigue could be markedly reduced.

We believe that these results form a solid basis for further investigations on carefully selected patients.

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