

IMPROVED NEUROMUSCULAR ACTIVITY OF HEMIPARETIC EXTREMITY
DUE TO HYPNOSIS

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Summary

In order to accelerate rehabilitation of hemiparetic patients hypnosis has been employed. The results of our research in a group of four patients of different age and different time after cerebrovascular insult are very promising. It can be seen a great influence of some hypnotic suggestions upon maximal and also electrically induced contraction of impaired muscle group. The effect of this method is shown with measured isometric torque and detected electromyographic signals of agonist and antagonist at dorsiflexion of paretic foot.

Discussed are some important details of neuromuscular mechanisms which were activated with hypnotic suggestion and which represent still unknown effects of hypnosis upon motor performance of impaired neuromuscular system. As the amplitude also the whole power and the frequency domain of voluntary EMG-activity of agonist was increased. On the other hand with the same electrical stimuli the M-response in EMG-activity of stimulated muscle was increased.

We can thus conclude that in hypnosis motor activation of paretic muscle is improved. As the effects of posthypnotic suggestions were also confirmed it is believed that hypnosis can be usefully implemented as a supplement to any other standard physiotherapeutic method in the rehabilitation of carefully selected hemiparetic patients.

Introduction

Various disturbances are present in the hemiparetic patient as a consequence of the reduced voluntary motor control on the affected half of the body. An increased muscle tone-spasticity and hyperactivity of spinal reflexes result in an ineffective movement of the upper and lower extremity. Different problems of psychological origin are often combined with abnormal motor functions. For that reason a successful rehabilitation program should be initiated by adequate psychological motivation treatment for the therapeutic program. Only in this way a better neuromuscular reeducation can be achieved during physiotherapy.

The main purpose of all recognised physical methods introduced in several rehabilitation centers is to prevent contractures, reduce spasticity, strengthen muscles and provide the paretic extremities with an improved function. Recently succeeded with many promising results the method called biofeedback therapy. This method tries to increase the patient's "awareness" for his own motor performance by different feedback informations /1/.

Our research has been directed to another way of modifying patient's cooperation which is known as hypnosis or hypersuggestion. The first results in a group of normal persons showed the possibility of applying this method in the rehabilitation of

paretic patients. Some neuromuscular mechanisms which were induced with a proper hypnotic suggestion caused increased electrically stimulated muscle contraction and reduced its fatigue/2/ /3/ /4/. These phenomena led to the hypothesis that by hypersuggestion possible neuromuscular and supraspinal reserves can be activated. As it was also assumed that hypnotherapy can offer its great advantages in overcoming the hemiparetic's psychological problems we wished to gain more insight into the use of hypnotic training in the physical rehabilitation /5/.

In our previous papers /6/ /7/ we already reported about some results of our research in a group of three hemiparetic patients. These preliminary reports showed that some hypnotic suggestions have a significant influence on motor response of paretic muscles.

In this paper we wish to discuss some further details of neuromuscular mechanisms which were activated with the hypnotic suggestion and which can give also a better explanation for the effects of hypnotic training with hemiparetic patients. We thus represent objective procedures which evaluate: (1) the effects of some forms of hypnotic suggestions upon maximal voluntary contraction of paretic dorsiflexors of the foot, (2) durability of these effects in both short and long time spans after hypnotic session and (3) the influence of some forms of hypnotic suggestions upon threshold and submaximal electrically stimulated motor response of the same muscle group.

We took into consideration the influence of hypnotic suggestions on natural and artificial motor control due to the well known fact that in the rehabilitation of the hemiparetic patients both active and passive exercises are used for many years. With active exercises we tried to combine the proper hypnotic suggestion with patient's conscious effort to contract paretic muscles. On the other hand we wished to improve with the hypnotic suggestion also the effect of functional electrical stimulation. With such a use of hypnosis we can ascertain some useful applications of this method in the rehabilitation for carefully selected and psychologically screened hemiparetic patients.

Experimental procedure and evaluation method

Our research has so far included four patients of different age with spastic hemiparesis at different time after cerebrovascular insult. Before starting with hypnotic training all four patients took part in standard physiotherapy for hemiparetics. However their whole therapeutic program as well as their progress was some months before hypnotherapy carefully inspected and evaluated. Before starting with the hypnotic program all selected patients were once more psychologically tested and given a neurological examination.

Finally we devoted more attention to the patient's voluntary activation of paretic dorsiflexors of the foot. For this purpose 3 to 4 testing measurements during 3 week period were made for each patient. For such a test the patient was asked to perform maximal contractions in equal time distances up to 15 times. With these results we got more insight into the magnitude and dispersion as well as the stationarity of contraction maximums for each patient. In this way the patient's starting motor condition of musculature was better known. Let us present some details from diagnosis for the selected patients important for our discussion:

- A. Z. - 18 years old boy, 3 months after injury in the left hemisphere, with weak dorsiflexion of the right foot. The im-

- paired motor functions were in spontaneous recovery phase. His psychological characteristic was rather depressed one.
- F.K. - 48 years old woman, 2,5 years after injury in the right hemisphere, with bad dorsiflexion together with an inversion of the left foot. She had rather unconstant motivation for treatment.
 - P.M. - 40 years old woman, 1,5 years after injury in the right hemisphere, with initial activity in dorsiflexors of the left foot and with pronounced spasticity in the flexors of the fingers of the left foot. Her motivation for rehabilitation was very strong.
 - Š.J. - 46 years old man, 2,5 years after injury in the right hemisphere, with very weak dorsal flexion of the left foot and with rather normal psychological characteristic.

Before presenting our further research program some words about our measuring system have to be said. As this system was already described /6/ /7/, we repeat here only the basic data.

During all hypnotic experiments and already during the beginning testing measurements the patient was seated in a comfortable armchair specially designed for our purpose. This measuring armchair enabled a precisely determined position of the subject in the course of repeated experiments. Also a firm fixation of the lower extremity was enabled and thus the movements of the body or leg did not affected the measured dorsiflexion of the foot. With a three coordinate measuring ankle brace the isometric torque of muscle force was measured. The brace being used registered the torque of the foot dorsiflexion as well as eversion- inversion and adduction- abduction torque of the foot.

Simultaneously with isometric torque the surface electromyographic activity of agonistic muscle (m. tibialis anterior) and antagonistic muscle (m.triceps surae) was detected. The position of detecting EMG-electrodes as well as the whole detecting procedure was held during all experiments for the same patient as constant as possible. Both EMG-signals together with foot dorsiflexion torque signals were then correspondingly amplified, recorded and tape-recorded for later evaluation and EMG-analysis with digital computer.

As the testing measurements were finished the patient was subjected to four hours of hypnotic sessions in order to be hypersuggestible. Then we began with our experimental program.

First we measured his maximal voluntary contractions of foot dorsiflexion in different states of consciousness (in awoken state, in hypnosis under suggestion of relaxation, in hypnotic age regression , in the immediate posthypnotic state and in the posthypnotic state after 15 minutes). The patient was performing contractions in time distances of 18 seconds which were given with short acoustic signals. We collected up to 10 contractions for every phase of the experiment. We repeated this procedure two or three times depending on the success of the first attempt.

The experimental program also included surface electrical stimulation of the peroneal nerve which resulted in foot dorsiflexion. We used two trains of electrical stimuli with the frequency and duration for tetanic contraction. The amplitude of the first train of impulses was selected for the threshold stimulation and for the second one for the submaximal stimulation. With the hypnotic suggestions of relaxation and hyperexcitability for electrical stimuli we tried to increase the effect of the same electrical stimulation. With another experiment we evaluated the

combination of voluntary motor control and electrical stimulation. Under the suggestion to the patient to help the electric stimuli as much as possible we measured resulting dorsiflexion of the foot in the awoken state, in hypnosis and in the posthypnotic state.

We made the control experiment after 3 to 4 months after the experimental program was finished. We registered the maximal voluntary contractions first in the awoken state. Thereafter we tried again to increase the motor response by hypnotic suggestions.

Results and discussion

The experimental results for the patients F.K., P.M. and S.J. showed similar effects. The values of maximal voluntary contractions during testing measurements were almost constant. It can be said that a stationary phase of paresis was characteristic for these three patients. As we review further results for the experiments at voluntary contractions it seems the activation of paretic muscles was improved in hypnosis. Already in the state after suggestion for complete relaxation of the entire body and still more after the suggestion of age regression in the years before injury the maximal muscle force increased.

To illustrate some of the effects we represent for two patients on Figure 1a) and Figure 2a) the histograms of all measured maximal voluntary contractions during the whole program of hypnotic training. On Figure 1a) the values of isometric dorsiflexion torque are represented, on Figure 2a) the proportion of the dorsiflexion torque to the inversion torque is considered. As it can be seen from both diagrams the values of dorsiflexion torque were significantly greater in hypnotic state as well as in the posthypnotic state in many of our sessions.

For the case on Figure 1a) for example the average value of maximal isometric dorsiflexion torques increased already in the first attempt in hypnosis 9-times with the suggestion of relaxation and 16-times in hypnotic age regression. The torque of muscle force remained 7-times greater also in the posthypnotic state with respect to the average value in the waking state or during testing measurements. A week after that the average value was still 5-times greater as it was confirmed with a short test. In the waking state of the next experiment with hypnosis the average muscle force was slightly higher and nearly the same as at the end of the first experiment. Again it can be noticed a greater contraction in hypnotic relaxation and an even greater in hypnotic regression when it was 23-times greater than during testing period. As the region of the values for maximal torque for this experiment was at higher magnitudes it seems also the therapeutic effect of hypnotic suggestions was present with this patient. Although the changes in muscle force between different phases of the third experiment were not significant, the torque was still 25-times greater than at the beginning of the research. The results of the control experiment performed 3,5 months after that confirmed that the muscle force remained nearly the same and even more that it increased with repeated hypnotic suggestions.

In the second case on the Figure 2a) some similar effects can be attributed to the hypnotic suggestion. Besides that it seems also that the functionality of the contraction of lifting the foot also improved with hypnotic training. Namely the dorsiflexion torque was increasing more than the inversion torque. As the inversion of the foot is unfunctional movement with respect to

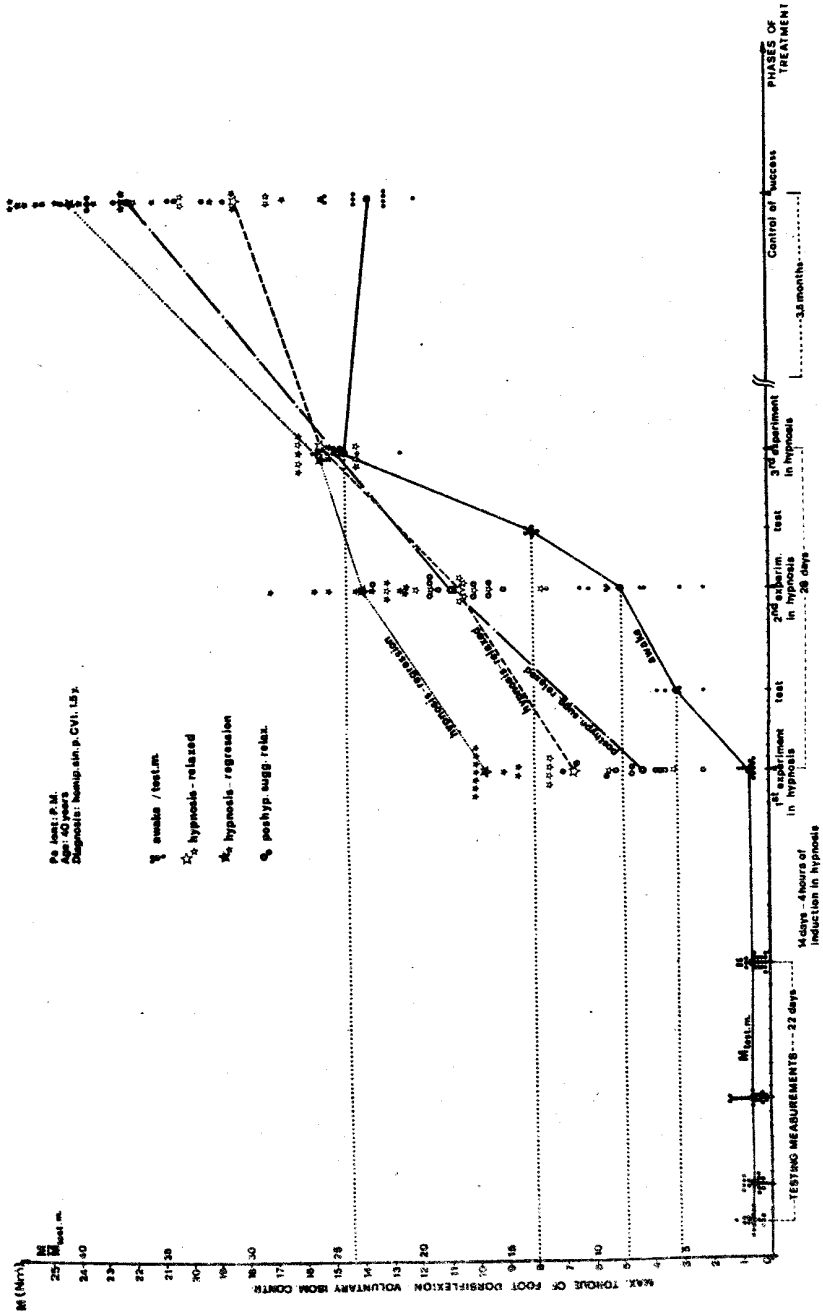


Figure 1a) : The results of measured dorsiflexion isometric torque during the whole program for the patient P.M.

● AWAKE
 ☆ IN HYPN.-RELAXED
 ★ HYPN. REGRESSION
 ☆ POSTHYPN. SUGG.

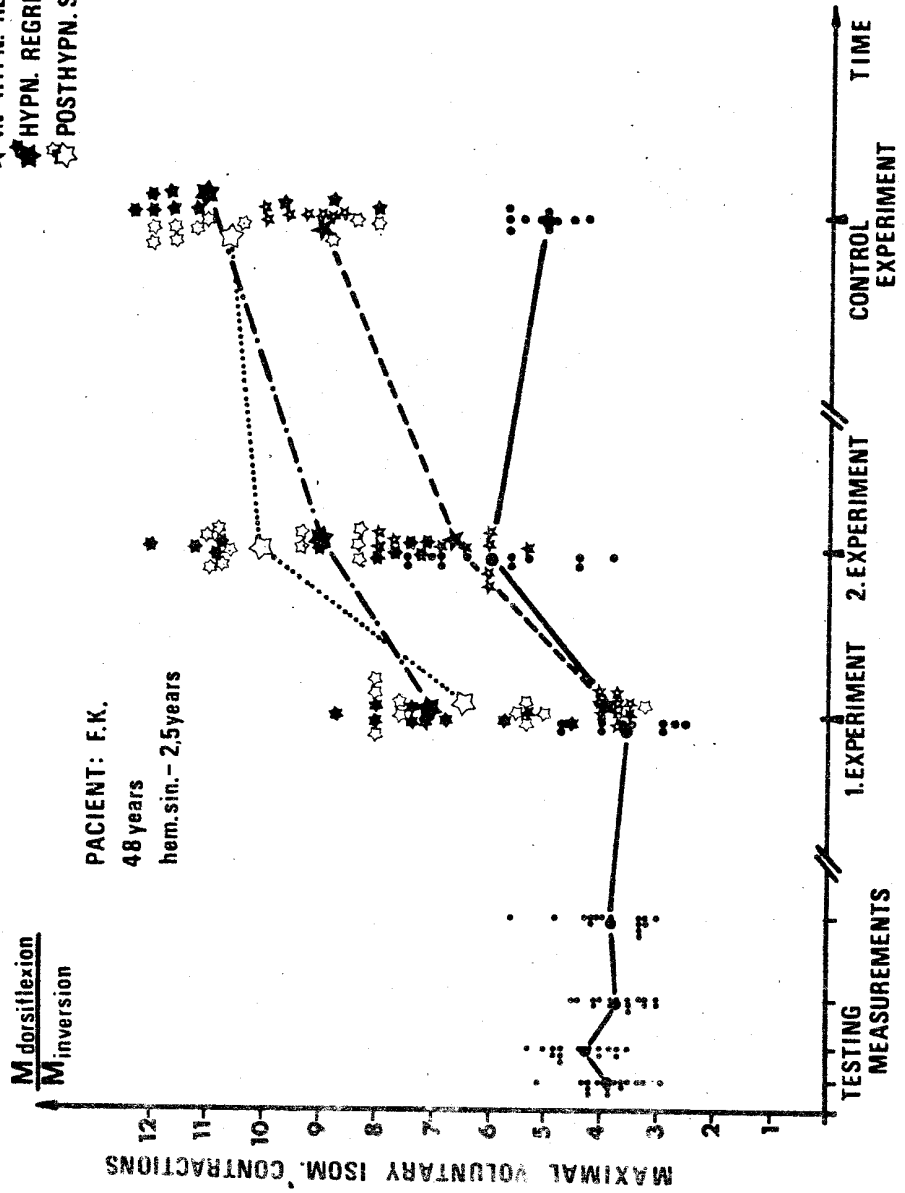


Figure 2a) : The results of the proportion of dorsiflexion to inversion torque during the whole program for F.K.

the normal movements during human gate its decrease is so much the wished one.

Also some results of the analysis of the EMG-activity of contracting muscle can prove the progress in the activation of paretic muscles attained with the hypnotic training. On the photos on Figure 1b) and Figure 2b) the electrical signals of the dorsiflexion torque and EMG-activity of agonist are presented for the patients P.M. (as Figure 1a)) and F.K. (as the Figure 2a)). These photos were made for the one of the contractions which was the nearest one to the average value of maximal voluntary contractions in different phases of the first and the last - control hypnotic sessions. On the upper part of the Figure 1b) and Figure 2b) are also represented the power frequency spectra for the EMG-activity during maximum of the first experiment. These power frequency spectra were processed on a digital computer with a method already described in/8/. In the time interval of one second at maximum of the contraction the EMG-signal was sampled in one or two sequences with the frequency of 2000 Hz. Thus the power frequency spectra were made in the region from 10 Hz to 1000 Hz respectively. The EMG-activity during processing interval can be seen from the signal which is represented with the third oscilloscopic beam on the photos.

On the basis of these photos some interesting conclusions can be said. As it can be seen from the signals for EMG-activity of agonist an increase of the amplitude as well as in the frequency can be attributed to the effects of hypnotic suggestion of relaxation and even more to the hypnotic suggestion of age regression during both experiments. As we compare the intensity of EMG-activities for the first and the control experiment the progress in muscle activation is evident. The power frequency spectra still better demonstrate some mechanisms induced with hypnotic training. It can be seen that the whole power significantly increased as well as the main frequency domain of agonistic EMG-activity changed during the maximum of voluntary isometric contraction due to the hypnotic state and pertained hypnotic suggestions in both cases on Figure 1b) an Figure 2b). It is necessary to note that the power of the higher frequency range from 150 Hz to 400 Hz appeared in muscular activity only in hypnosis and in posthypnotic state.

Two possible neurophysiological mechanisms in motor control of skeletal muscles can be the reason for the effects observed. The first one can be that new motor units of paretic muscle became active during maximum of voluntary contraction, the second one that the frequency of recruitment of the motor units already active in awaken state increased under the influence of hypnotic and posthypnotic suggestions. Both mechanisms are determined according to the supraspinal motor control which can influence through different descendent motor pathways directly or indirectly through gamma neurons and reflex pathways upon alpha motor neurons and initiate the contraction of pertained muscle fibers. On the bases of the results obtained we can not estimate which of the two mechanisms caused the increased activity of paretic muscle in hypnosis. Still we can ascertain that new descendent pathways in motor control of this muscle were awakened up with the hypnotic suggestions already in the first attempt and that the success of the next attempt was still the better.

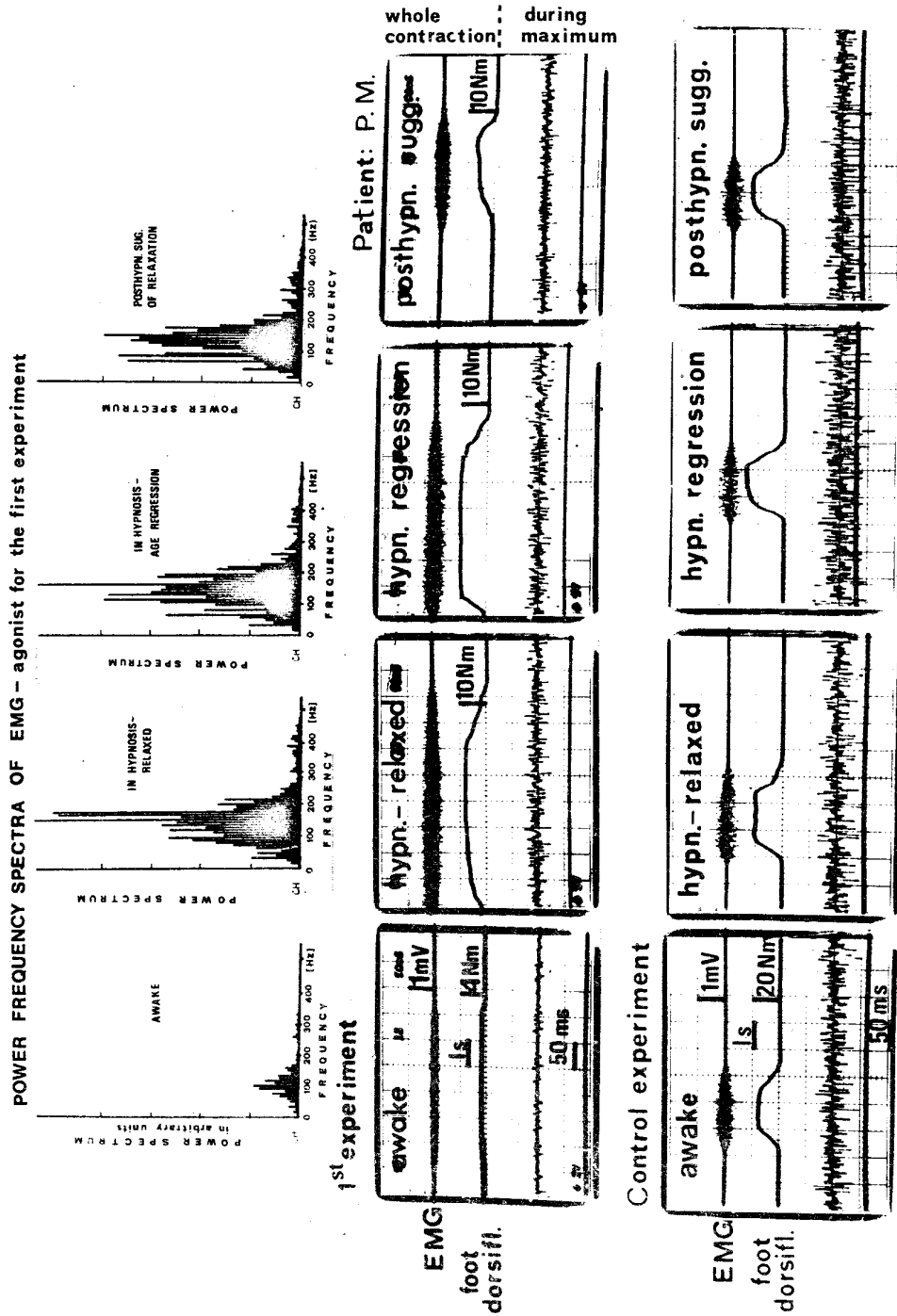


Figure 1b)

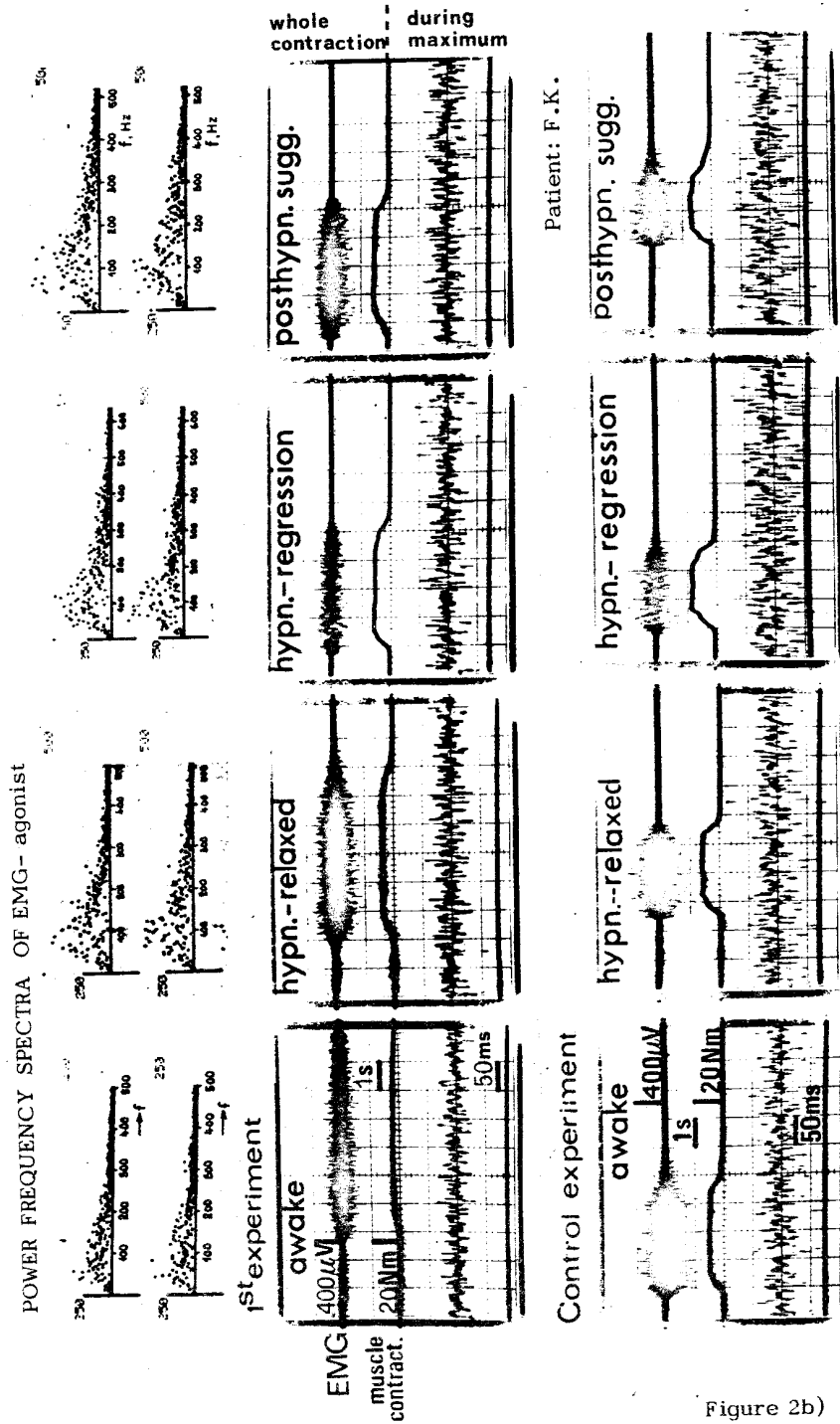


Figure 2b)

To give a complete report of our research for voluntary contraction we have to mention that the results for the fourth patient A.Z. were not so good as those with the three patients cited above. The magnitude of his maximal voluntary contractions spontaneously improved by 40 % already during test measurement period. In the first attempt with hypnotic suggestions the magnitude of maximal voluntary contraction was only slightly better than in the awoken state, so it would be difficult to attribute the resultant increase in this case to the hypnotic suggestion.

Let us illustrate at the end some results about the influence of hypnotic and posthypnotic suggestion of relaxation and hyperexcitability at an electrically induced isometric dorsiflexion of the foot. In the middle part of the Figure 3 the records of dorsiflexion torque signal are represented for four successive electrically induced contractions in some phases of the experiment. The first part of the curve at each contraction was recorded during threshold stimulation and the second one during submaximal stimulation. On the photos in the upper and the lower part of the Figure 3 the EMG-activity of agonist and pertained dorsiflexion torque can be seen during one of the four contractions in each phase of the experiment and that for both amplitudes of electrical stimuli. It is seen that the amplitude of direct M-response was increasing and its wave shape was changing more and more due to the hypnotic suggestions. So it can be concluded that the number of stimulated motor units increased in hypnosis though the electrical stimuli remained unchanged. The reason for increased number of excited motor units at the same parameters of electrical stimuli may be attributed to the increased excitability of motor nerve fibers or to the contribution of supraspinal facilitatory inflow as the result of hypnotic suggestions. Further investigations with more precise methods of detection of the EMG-activity of the stimulated muscle will attempt to elucidate the neurophysiological mechanisms important for these effects of hypnotic suggestions. As we have already the similar results for the hypnotic suggestion which asked the patient to help consciously the electrical stimuli we are more inclined to the second neurophysiological mechanism cited above.

Conclusions

Explaining the success described we are well convinced that in hypnosis certain functions in neuromuscular structures are manifested which are latent in the waking state. By a proper suggestion the relaxation and concentration of the patient performing a certain muscular contraction are improved, whereas their conscious effort would not suffice. It is also well known that the increased effectiveness of neuromuscular reeducation can be achieved in hypnosis. As we have been successful with the patients more than a year and a half after cerebrovascular insult the possibilities of applying this method are the more promising. We think that the hypnotic suggestion of relaxation was so successful with these patients since during relaxation process they were capable to release many other spastic muscle groups, even those which function antagonistically to the dorsiflexors of the foot. In hypnotic age regression the patients were able to experience the motor activity prior to the injury. This fact also had a determining influ-

1000 Hz (1000 cycles/min)

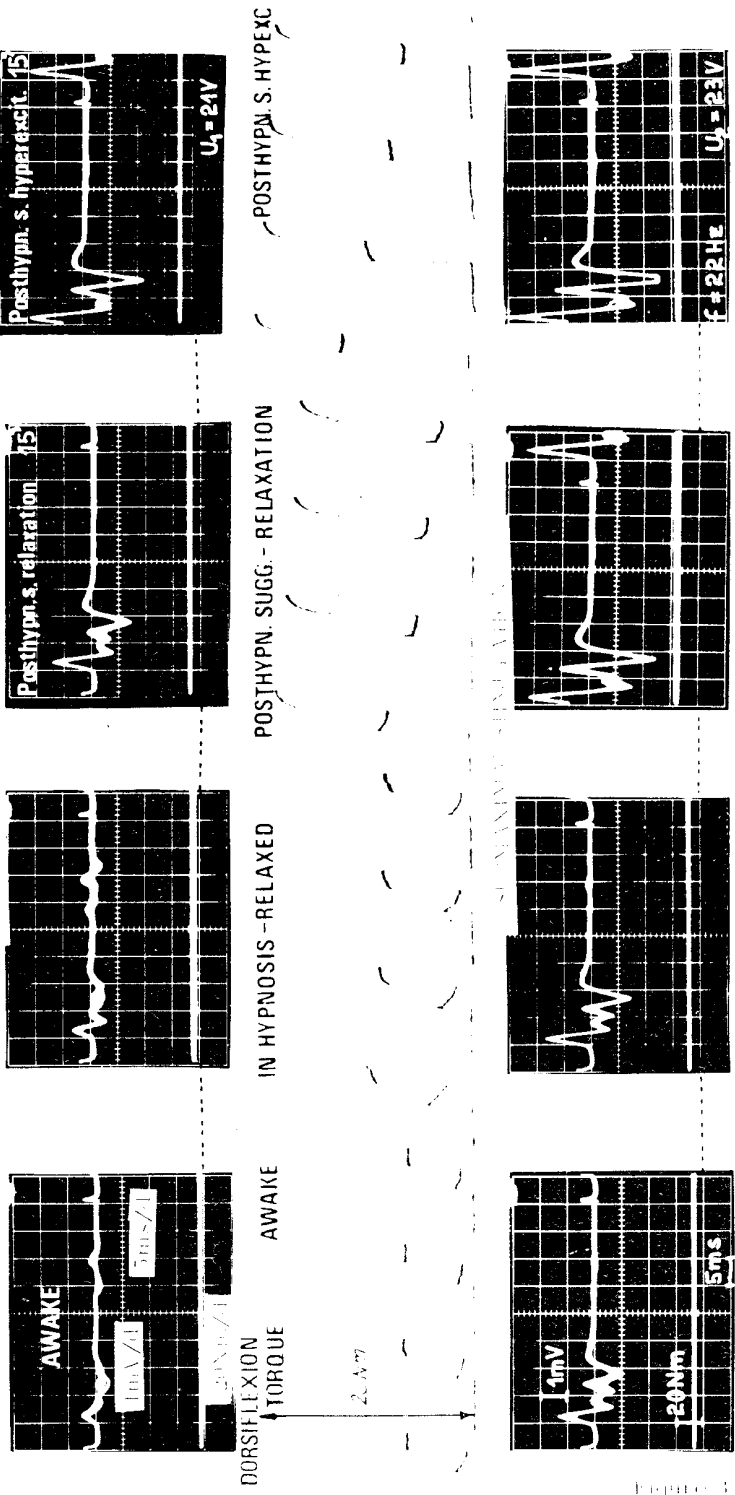


Figure 1

ence on improved neuromuscular activity of paretic extremity. Even though we came to these realisations through many of experiments with the hypnotic suggestions we are still limited in our generalisations due to the small number of individuals included in our research till now. However the results obtained are very stimulating and prove that in hypnosis we can mobilize in hemiparetic patients some neuromuscular reserves which remain active in great amount also in the posthypnotic state and even do not decrease after some months after hypnotic training.

It is hoped that these conclusions will contribute to the idea that hypnotic suggestion can be very helpfull in improving and accelerating the rehabilitation of hemiparetic patients.

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