

# Studies Supporting the Concept of Physiological Acupuncture

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## Summary

The rapidly increasing amount of scientific research now permits an explanation of acupuncture mechanisms on a physiological basis. Research has shown that many useful acupuncture points are motor points, trigger points, and locations of nerves. They can be located by the use of skin potential recordings. Such knowledge has permitted the development of a simplified, anatomically based practice of acupuncture. Research has shown that electrical stimulation of these points is an effective agent for reducing experimental pain. Electroacupuncture has also been effective in relieving chronic pain in patients with a variety of medical conditions. Hypnotic suggestibility does not account for this effectiveness. Cold pressor pain is a valuable and reliable research tool for measuring the effectiveness of analgesic agents. The analgesic effect of acupuncture was unrelated to anxiety level, patient selection, prior education, suggestion or distraction, which are generally implicated in the reduction of pain utilizing methods other than drugs.

## Introduction

Acupuncture has been practised in the Orient for many centuries. Its action is usually explained in terms of prescientific theories as expounded in the ancient text, *Nei Ching*. When acupuncture burst upon the scene of Western medicine in 1972, American physicians were skeptical of the meridian theory. They felt that acupuncture had no physical basis. The American Medical Association officially refused to accept acupuncture, and doctors who witnessed surgery with acupuncture as the analgesic agent labelled it as "Oriental hypnosis." The National Institutes of Health set up a committee to investigate acupuncture, and my group of investigators received the first grant given for such purposes. Initially, we sought to determine whether acupuncture points had a real existence. Later, these points were used to control both experimental and clinical pain. The effect of acupuncture and hypnosis as modifiers for pain control was studied.

Traditionally, acupuncture needles have been stimulated by twirling. In order to increase their effectiveness, moxibustion was added. The use of electricity for stimulation of acupuncture needles was first reported in Japan. Its application has spread widely so that at present it is a standard method for stimulation. Needling with and without electrical stimulation was compared and electroacupuncture,

hypnosis, and morphine sulfate were found to reduce pain between 40% and 50%. Needling without electrical stimulation was much less effective.

These studies began in the laboratory with an investigation of how to locate acupuncture points accurately. We then looked at the results of acupuncture stimulation, first upon the white cell count and body temperature and then its effectiveness in the control of experimental pain. This method of pain control was compared with that achieved by hypnosis. We then moved to the more difficult task of comparing acupuncture pain control and the control of pain by hypnosis in patients who had experienced acupuncture treatments for clinical conditions with chronic pain. The results of such studies were encouraging, so the techniques were brought into clinical practice. We have now had over 10 years of experience in the treatment of chronic pain by electroacupuncture. Recently some treatments have combined electroacupuncture with hypnosis.

The text, *Principles and Practice of Physiologic Acupuncture*, presents this method of simplified, anatomically based technique of acupuncture. It has been useful in the teaching of medical students.

### Location of Points

Traditionally, acupuncture points are located along hypothetical meridian channels as depicted on ancient charts [1]. They are described in relationship to external anatomical landmarks from which they are measured in terms of "cun". The cun or "Chinese inch" is described as the distance between the skin creases seen in the partially bent middle finger from the proximal end of the first phalanx and the distal end of the third phalanx. This, of course, varies with the size of each person's body, size of the hands, etc. Due to variations in bone length, muscle mass, etc., the several hundred points shown on acupuncture charts give, at best, only approximate locations. It is said that trained acupuncturists identify location through palpation techniques and the patient's objective responses to needling. To avoid such subjective variances emphasis was laid on a study of points with differing electrical characteristics located at random on the skin [2]. Devices (point finders) which measure changes in skin resistance are now commonly sold as a means for the location of acupuncture points. This method requires the application of electricity to the skin to measure its resistance to the passage of the current. The results of these brief efforts using the resistance technique suggest that with repeated application of a probe to a single skin site, the amplitude of the response (in millivolts) decreases with each trial until the site no longer gives a physical response. The implication is that the electrical resistance of the skin site had become elevated to the passage of the small currents. The currents were no longer effective in penetrating the skin at this site, thus there was no drop in skin resistance observed as compared to surrounding nonacupuncture points.

For these reasons the skin was explored using potential recording techniques for the identification and mapping of acupuncture loci. Such skin potentials depend solely on the electricity generated by the body itself. The outer skin surface is electrically negative with respect to the subcutaneous tissue, and the potential differences are measured in millivolts (mV).

### SIMILARITY OF POINTS ACROSS SUBJECTS

(LEFT ARM, REAR VIEW)

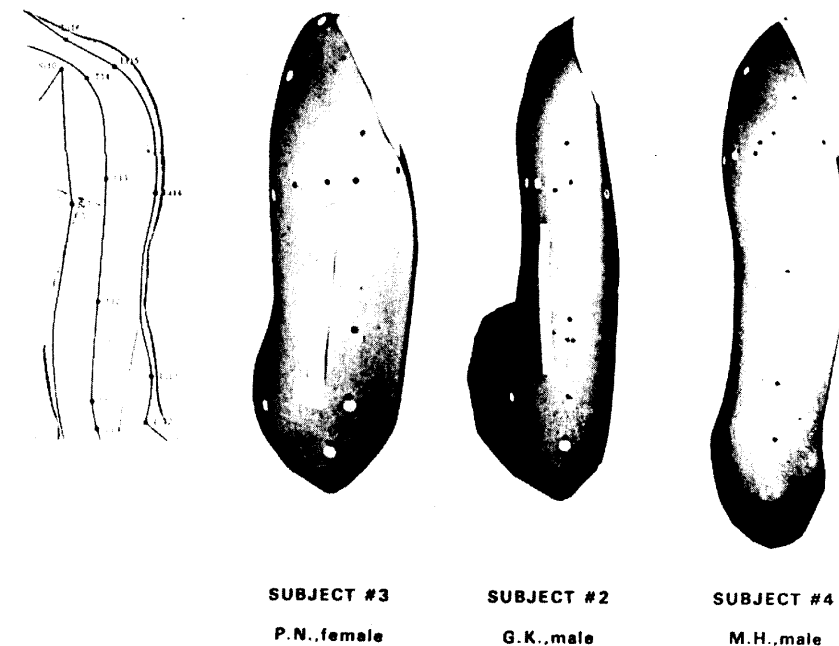


Fig. 1. The black circles on the subjects' arms indicate the points located by this method. As a guide, we used charts of traditional loci shown in the drawings at the extreme left of top and bottom rows [1]. These drawings show the meridional pathways on which the loci are said to be located. The outer line (LI) is the large intestine meridian; the center line (TB) is called triple burner meridian; the inner line is the small intestine (SI) meridian

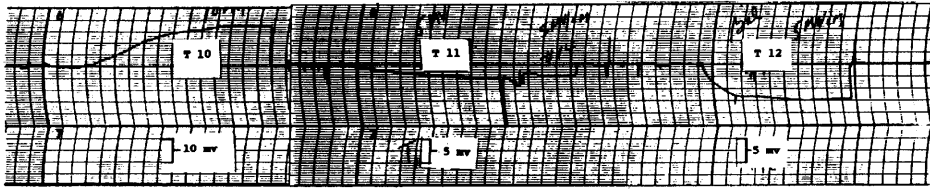
The upper arms of eight healthy volunteers were searched blindly for points from which large potential differences were elicited (Fig. 1). These points were then compared with the acupuncture points shown on the traditional charts.

The device employed to locate the points on the skin consisted of a hand-held probe connected to a high input-impedance direct current amplifier. The probe was a solid (jewelers) silver bar, 10 cm long, 3 mm wide, and 1 mm thick, with its probe tip rounded to 2 mm in diameter while the opposite end of the bar was connected to the one megohm DC input of the polygraph with both the metal shield of the cable and the indifferent electrode connected to ground. The reference (inactive), electrode was placed on the contralateral arm to the one being searched. A reference area was located on the volar surface of the upper forearm about 5 cm below the elbow crease along its inner edge. The site was cleaned with alcohol and "skin drilled" according to the method of Shackel [3]. An Ag-AgCl electrode filled with electrode jelly was applied to the site with an adhesive collar.

The pen recorder was calibrated to give a pen deflection of 1 mV/cm; an upward pen deflection indicated a potential of increasing negativity. When the probe was lightly held on acupuncture loci, the pen deflected from the center line,

## ADJACENT POINTS ON MERIDIAN

### SHOWING DIFFERENT POLARITY AND DIFFERENT AMPLITUDE



R.S. (c)

Fig. 2. Different polarity and amplitude of DC voltage shown by adjacent 3 points on a meridian with respect to control skin. Down is positive, up is negative, T10 was  $-17$  mV; T11 was  $+3$  mV; and T12 was  $-8$  mV

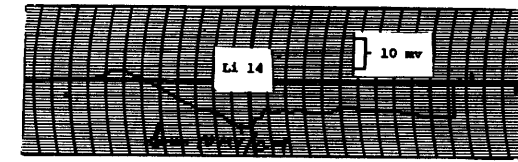
and when the asymptote (maximum amplitude) was approached the pen would remain at this amplitude until the probe was removed from the skin. Most of the potential recording reported in this study was obtained with a "dry active electrode," i.e., no electrode paste used between the skin and the roving electrode.

By this method eighteen discreet loci were located on the upper arm. These included all loci on the upper arm shown on the acupuncture charts as well as a few loci not listed on such charts. All of these loci produce responses of potential differences ranging from 2-42 mV. Symmetry of point location was observed between the right and left arms of the same subject. Differences between the two arms and the location of similar loci from common references range between 0 and 3.5 cm for all subjects. Wide variations in amplitude potential response for adjacent loci along single meridians were found (Fig. 2). A decrease in skin potential implied that the "active" site was less "negative" with respect to the reference electrode in the surrounding tissue. Increasing negativity produced an upward deflection, and decreasing negativity produced a downward deflection. A third type of response was bipolar in form (Fig. 3). The most common response observed was a decrease in negative potential (downward deflection). Some 80% of the responses from the left arm and 89% of the responses from the right arm were of this nature. Another 6% and 3%, respectively, demonstrated increases in negative potential, and the remaining trials showed mixed responses. The loci remained stable over a period of time with respect to location, and, equally important, there was little or no change in amplitude of potential response at each site during the 3-h time lapse.

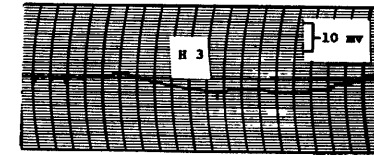
This study thus suggests that, at least for the upper arm, one can identify stable, electrically active loci, which are bilaterally symmetrical and include those points identified and utilized by acupuncturists. The skin potential procedure is a reliable technique for the precise location of acupuncture loci.

Although this method of location was used initially in our research work, we slowly came to the realization that useful acupuncture loci were simply points at which one could obtain access to the peripheral nervous system. The work of Liu [4] clearly suggests that many useful points are often the motor points used by electromyographers as the best place to elicit nerve stimulation (Fig. 4). Gun [5] added Golgi tendon organs to this concept. In clinical work needles were also often placed close to the point of nerve exit, as in the case of treating problems

### NEGATIVE-POSITIVE RESPONSE

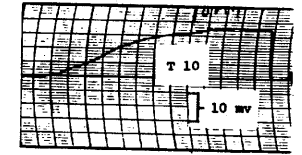


P.A. (E)



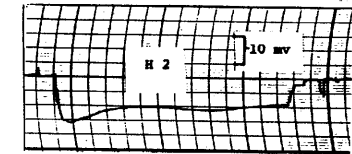
P.A. (E)

### PURE NEGATIVE RESPONSE



R.S. (f)

### PURE POSITIVE RESPONSE



R.S. (E)

Fig. 3. Types of resting skin potential at acupuncture loci *Upward deflections* are negative voltages and *downward* are positive

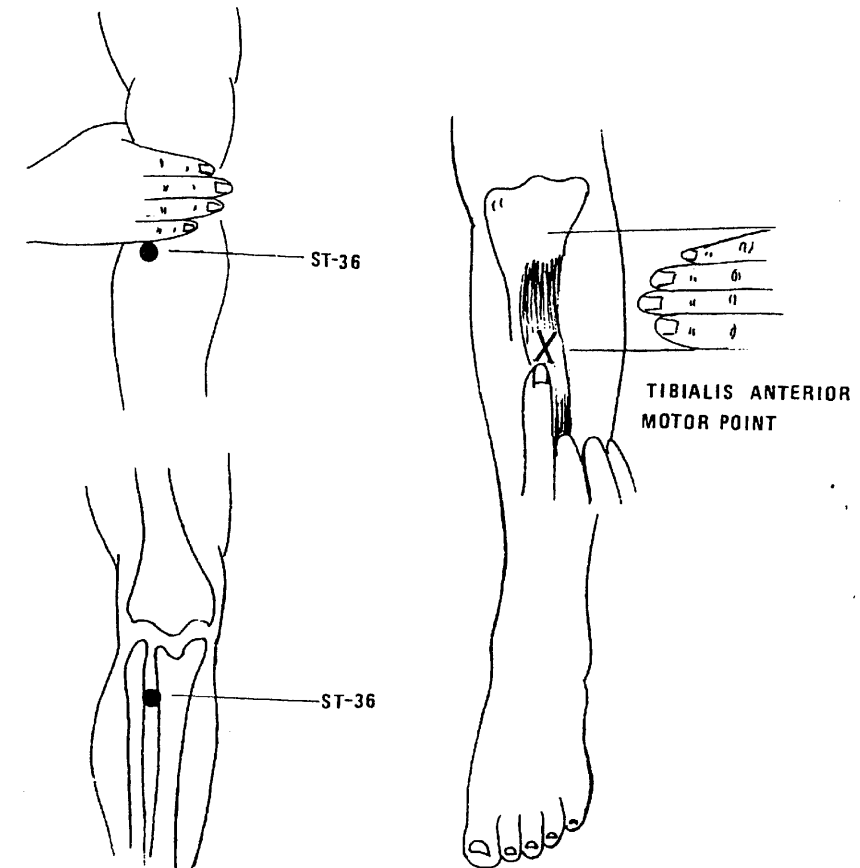


Fig. 4. Illustration of how an important acupuncture point is actually a motor point [35]

with the trigeminal nerve. Using the principle of neurotomes, points were selected adjacent to the exit of spinal nerves on the posterior surface of the trunk. With electrical stimulation of needles, such a rule of thumb is sufficient for locating points for needle insertion because simply raising the amplitude of the electrical stimulus can overcome any slight inaccuracy of needle placement.

### Effect of Acupuncture on the White Cell Count

We next turned our attention to the effect of needling on the white blood cell count in normal healthy male volunteers [6]. Cheng [7] has shown that needling certain points of the body of a normal person or animal increased phagocytosis. This statement is also found in a book by P. Chan [8] and in studies conducted at the General Hospital of Kwang Chow, China [9]. Cracium et al. studied white cell counts before and after needling of the acupuncture point Du 14 Dazhui, below the 7th cervical vertebra, in groups of normal, healthy, volunteer students and reported increases in white cell counts of 59% in one study [10] and 44% in the other [11].

Twelve healthy, normal, male volunteers ranging in age from 19 to 29 years were used. The white blood cell count can increase up to 60% within 12 h of eating foods to which one has been found to be "allergic" by the Cytotoxic Food Test [12]. Thus, all subjects had to refrain from eating, drinking, or smoking for a minimum of 6 h prior to testing. The white blood cell count was examined the day before, during, and after the electrical stimulation of four well-known acupuncture sites as well as in four areas that showed no electrical evidence of containing acupuncture points. The method of locating the acupuncture sites on the skin surface was through the use of skin potential measurements as previously described. The stimuli used for all subjects were 20 min of sawtooth pulses of 100 Hz frequency, a duration of pulses of 0.02 ms, and voltages ranging from 1 to 30 V. Following the insertion of acupuncture needles the first blood sample was drawn from a fingertip on the subject's right hand. This blood was for the pre-stimulation baseline. After this the stimulation was begun on the needles of the left arm. The subject's task was to tell the experimenter the moment he felt any sensation at the site being stimulated. The intensity would then be slowly increased until a strong but not painful sensation was felt at the needle site. When all four needles were felt to be strongly but not painfully stimulated, the time was recorded for the start of a 20-min period of stimulation. After 5 min of stimulation the second blood sample was taken from the right hand, with a third sample taken immediately upon termination of the stimulation. At this time the stimulator was turned off, and the leads and the needles were removed. Fifteen minutes after the cessation of stimulation a fourth blood sample was taken, with a fifth and final sample taken 10 min later. Skin temperature was recorded at 5-min intervals throughout each investigation.

After needle insertion and while probing for the location of the acupuncture points, there was a slight increase in the white blood cell count. This suggested that Pavlov's "expectancy response" was operative here. Needle insertion had a negligible effect on blood cell count even with needles remaining in place for as long as 90-120 min (Fig. 5). The greatest response, however, was seen with electri-

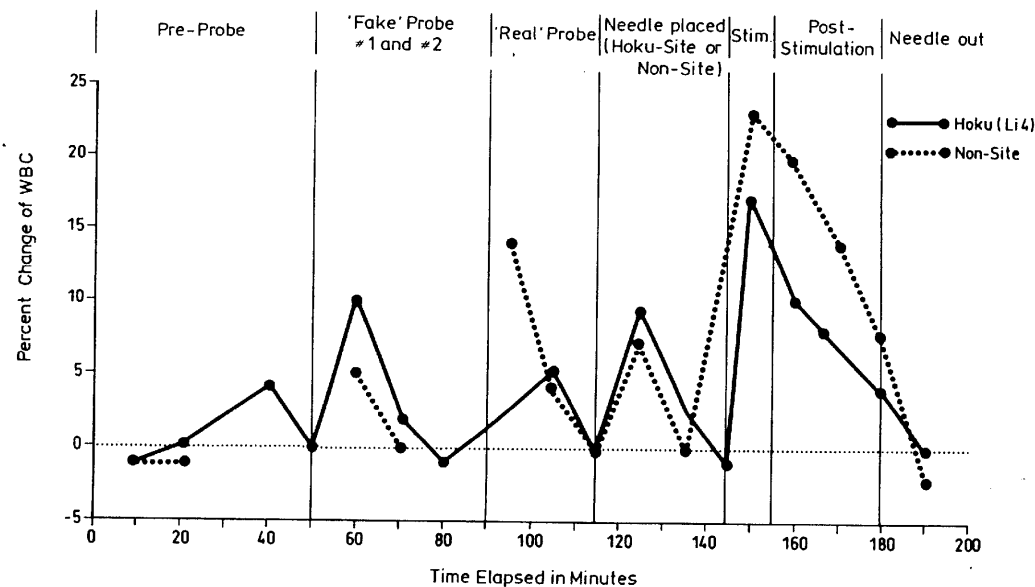


Fig. 5. Absolute changes in WBC count associated with specific events. WBC count was allowed to return to baseline before introducing the succeeding event. For one subject, the baseline for Hegu needling is 8150 cells/mm<sup>3</sup>; for another subject, single, "non-site" needling leads to 6650 cells/mm<sup>3</sup>.

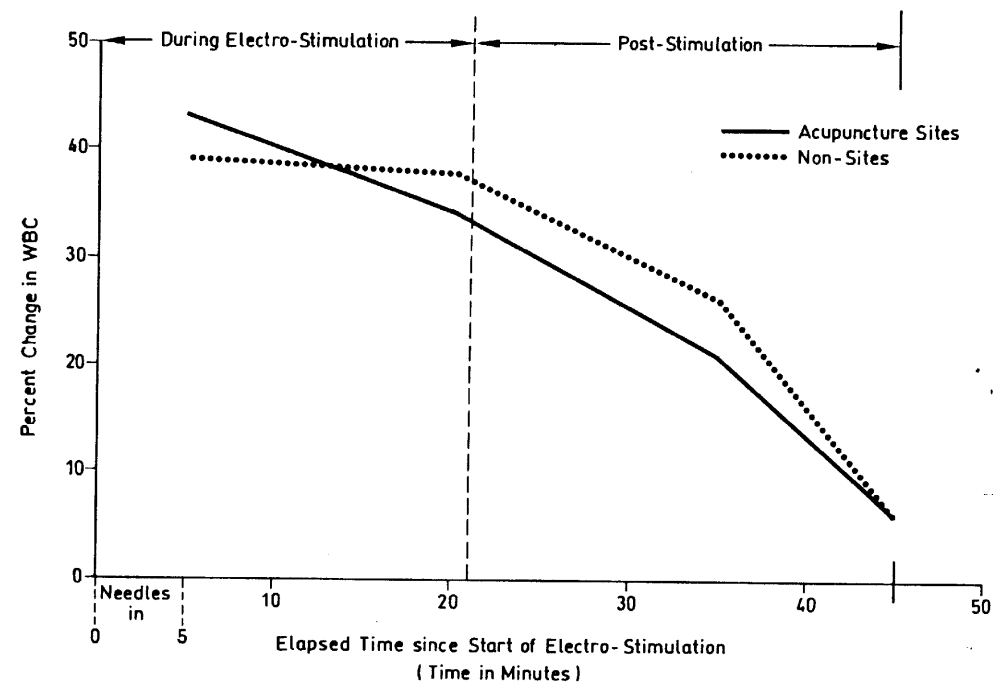


Fig. 6. Percentage change in mean WBC counts during electrostimulation and during poststimulation with needles removed. Post-needling mean WBC baseline was 7408 cells/mm<sup>3</sup> for nine subjects with acupuncture site placements and 8036 cells/mm<sup>3</sup> for seven subjects with "non-site" placements

cal stimulation whether it was or was not at an acupuncture site. This procedure evoked the largest increase in white blood cell count of all procedures measured. Regardless of the nature of the event, a decrease in white blood cell count then occurred over time. Even 35-45 min after stimulation the white blood cell count was still declining to the base level (Fig. 6).

The most significant finding from the verbal reports comparing site versus non-site data was that 69% of the subjects reported feeling pain from the needles, both on insertion and while the needle remained embedded in the tissue of non-site placements. Only 17% of subjects reported feeling pain from needles placed in acupuncture sites. Pain did not relate to the electrical stimulation.

As shown by these data, the effects of emotional or psychological factors in increasing white blood cell count are equally as important as needle insertion, and their effectiveness is exceeded only after 5-20 min of electrical stimulation of the needle. If such factors are not taken into account and their effect not cancelled by allowing time for the cell count to return to the baseline, an incorrect count is obtained by accumulating subsequent increases. This effect of psychological factors has been reported by others [13].

The white blood cell response as seen from these studies appears to be a nonspecific response as a result of the procedure of needling in acupuncture or non-acupuncture sites.

### Acupuncture, Hypnosis in Experimental Pain (Normal volunteers)

It has been suggested that acupuncture effects are mediated principally through suggestibility and/or hypnosis [14, 15]. Most of the anesthetic and analgesic effects claimed for acupuncture stimulation, both manual and electrical, can also be brought about with hypnosis [16]. This portion of the study was designed to explore the analgesic effects of electroacupuncture as compared with hypnosis and a number of pharmacological agents. The experiments were designed to answer the question of whether the analgesic effect of electroacupuncture on experimentally induced pain could be attributable entirely to suggestibility or hypnotizability.

This study employed 20 normal, healthy, Caucasian males, aged 18-30 years, who volunteered as paid subjects. Pain was produced by one of two methods. In the first, a cold bath was maintained by refrigeration at 0°C. A plastic sheet was placed across the surface of the water, thus permitting the subject's left forearm to remain dry while only the fingers were immersed the cold water. The intensity of the cold experience was, thus, considerably less than that found in standard cold pressor tests where the arm was fully immersed. The second type of pain, pressure pain, was produced by means of a sphygmomanometer attached to a blood pressure cuff placed around the subject's left arm at the level of the biceps with the cuff inflated to 300 mm Hg and held steady at that level by a clamp. The challenging agents employed to alter the experimentally induced pain were (a) hypnosis, (b) electrostimulation of acupuncture points, (c) electrostimulation of nonpoints, and (d) the drugs morphine, aspirin, diazepam, and placebo. In each session the subject was exposed twice to the painful stimulus, once under control without any

modifying agents such as drugs or acupuncture (herewith called "control pain") and once under the experimental conditions. The order of the challenging agents and the two pain induction procedures (cuff or cold) was randomized. Six physiological variables, EEG, EKG, EMG, skin temperature, peripheral vascular activity, and respiration, were sampled under the various conditions. Hypnosis induction was achieved by means of a standardized video tape recording viewed by the subject on a TV monitor. Stimulation was from a Grass model S-4 stimulator through the acupuncture needles. A common indifferent electrode (EKG plate) was placed with a rubber strap on the subject's left inner wrist. The electrical stimulation was at a frequency of 130 Hz. Current output was 10 mA maximum (pulse amplitude), and pulse wave forms were square. Pulse duration was 0.1 ms and biphasic in form. Duration of the stimulation through the needles was standardized to 50 min. Acupuncture true loci and random false loci were determined using the skin potential method previously described.

At each 15-s interval during the 5-min pain period for both cold and pressure pain, subjects were asked to signal intensity of the pain via a finger switch connected to the channel of the polygraph, their rating of the degree of pain experienced, and these were recorded using a 5-point scale: zero meaning no pain, 1 mild pain, 2 moderate pain, and 3 severe pain. Stimulus was stopped at the subjects' request when it was no longer tolerable, and a score of 4 was entered for each 15-s interval of the time remaining in the 5-min pain period.

All hypnosis subjects were screened using Form A of the Harvard Group Scale for Hypnotic Suggestibility prior to their first experimental session. Volunteers were administered this scale until a group of 20 subjects who completed all 14 of the experiments was gathered. Drug dosages used were: morphine sulfate, intramuscularly in the right arm, 10 mg/70 kg of body weight; diazepam, 10 mg in a 2-ml solution intravenously; aspirin, two tablets of 75 mg each given orally; and two small white capsules resembling Darvon (propoxyphene) but containing milk sugar were given orally as the placebo. Fig. 7 summarizes the results obtained.

It was found from higher mean scores on both trials that the cold baths were a more painful experience than the inflating of the cuff. The difference between control and experimental pain scores was tested by *t*-tests. It was found that acupuncture with electrical stimulation at true loci was an effective pain reliever for cold bath pain ( $P < 0.01$ ). This failed to reach the 0.05 level of significance on cuff trials ( $P < 0.065$ ). Hypnosis provided the most effective analgesia for both types of pain, cold bath ( $P < 0.001$ ) and cuff ( $P < 0.001$ ). Morphine produced an analgesic effect similar to acupuncture on both types of pain, cold bath ( $P < 0.02$ ) and cuff ( $P < 0.001$ ). None of the other four challenges, acupuncture at false loci, diazepam, aspirin, or placebo, showed effectiveness as pain relievers.

Results on some of the physiological variables were as follows: For analgesia by both hypnosis and acupuncture at true sites, electrical stimulation produced the highest resting heart rates. The EMG showed a greater basal activity after both true and false electrical stimulation under the cold pressor conditions during control pain.

PAIN RATING (DIFFERENCE) COLD PRESSOR  
COMPARISON OF 'GOOD' & 'POOR' HYPNOTIC SUBJECTS (HARVARD SCALE)

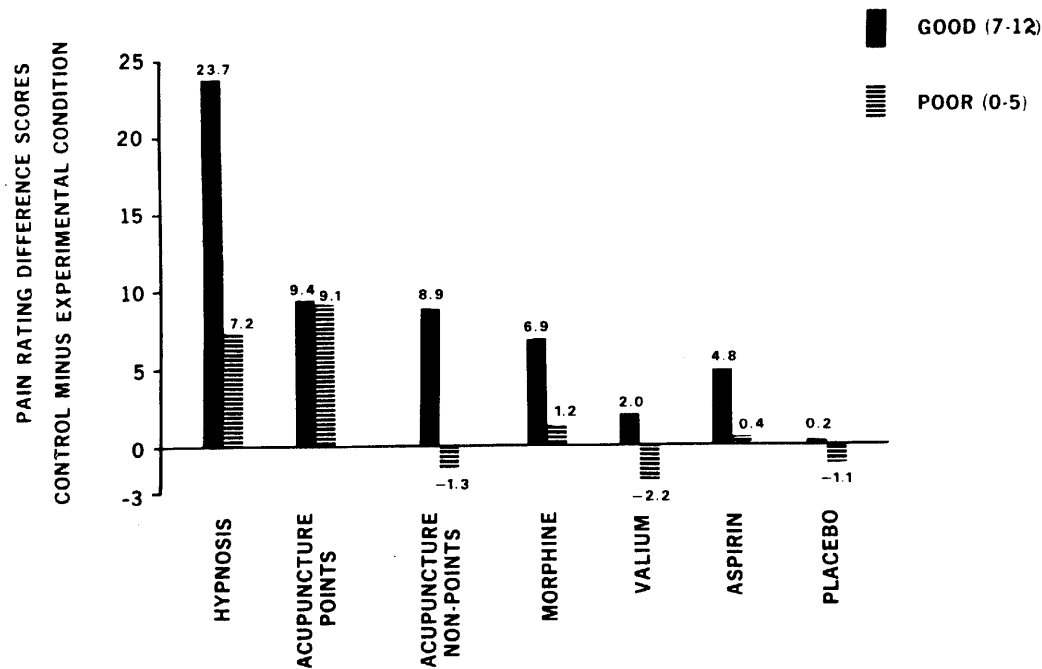


Fig. 7. Cold pressor results: 20 subjects were given 7 types of analgesic treatments in random order and were tested for cold pressor and cuff ischemic pain. This graph shows cold pressor results

### Conclusion

It was found that acupuncture with electrical stimulation of true sites specifically reduced experimental pain induced by a cold bath when compared with controlled trials without acupuncture. Electroacupuncture of true sites also caused some analgesia with cuff pain, but this did not reach significance, perhaps due to the low intensity of this type of pain (cold bath produced more severe pain than the cuff). Thus, it appears from both these data and those of other experiments that acupuncture is an effective challenger of experimentally induced pain.

No significant pain relief was derived from false site (sham) electrical stimulation as compared with controls for either cold pressor or ischemic pain. It has been suggested by some that analgesia could be a function of reduced anxiety. During these experiments it was noticed that the integrated EMG showed higher basal activity both during true and false site electrical stimulation during the cold pressor trials, suggesting that the analgesia produced by acupuncture is unrelated to the anxiety level of the subject. The increased heart beat after true site stimulation also strengthens this argument.

## Acupuncture, Hypnosis in Chronic Pain Patients (Reaction to Experimental Pain)

### Study Description

Twenty patients with a history of chronic pain were subjected to cold water-induced pain (cold pressor pain), and the data on the effect of 35 min of hypnotic suggestion and 20 min of acupuncture stimulation on the pain and other physiological variables were gathered in a controlled setting. These patients had previously had acupuncture treatment. Eleven had benefitted from acupuncture treatments in excess of 50% while nine had reported less than 50% improvement in their condition. This experiment was designed to determine retrospectively the predictability of outcome with acupuncture treatment. The subjects selected had been in active treatment by means of acupuncture for basically similar conditions using traditionally selected acupuncture points.

Patients with chronic low back pain and knee pain were chosen. These patients were selected from this clinic where a number of patients with these conditions have been treated over a 3-year period. From case records, all patients with back and knee pain were selected regardless of treatment outcome, of which 45 cases fitted these criteria. The first 20 patients accepting were recruited into the study. Patients were not paid, but all were offered an additional course of acupuncture treatment without cost. Patients ranged in age from 2 to 70 years. There were 9 females and 11 males with an average duration of pain of 8 years. All had been treated unsuccessfully by other physicians with tranquilizers and analgesics. After an initial examination, informed consent was obtained, and subjects were advised that they would undergo an experimental study in two sessions, one with hypnosis and one with acupuncture. The settings were to be determined on a random basis. Four acupuncture points on the arm which were used in previous experimental studies were selected. These were LI.4, LI.11, LI.14, and LI.15, all of which had been reliably noted to have produced analgesia in the hand. These points corresponded to commonly identified trigger points. They were stimulated by means of a Grass Model 4 stimulator. Stimulator intensity for each needle was monitored by a Tektronix differential oscilloscope. Stimulation was given at 130 Hz, 10 mA maximum (pulse amplitude), and with a pulse duration of 1 ms. Acupuncture points were located by the method of skin potential as previously described. With each 15-s interval during the 5-min period the subject was asked to signal the degree of pain by moving a finger switch which produced a recording on one channel of the polygraph. Pain was rated using a 5-point scale with 0 indicating no pain, 1 mild pain, 2 moderate pain, and 3 severe pain. If the pain became intolerable the pain stimulator was stopped at the request of the subject, the hand was removed from the bath, and the rating was recorded as 4.

The experiment proceeded as follows: (a) rest periods of 10 min after location of acupuncture sites, (b) control pain induction and rating for 5 min, (c) needle insertion with stimulation for 20 min, (d) experimental pain induction and rating for 5 min, and (e) rest for 10 min.

The effects of suggestibility and its possible predictive value in terms of the usefulness of hypnosis in preventing noxious perception were of interest in this inves-

tigation. A short version of instructions for the Harvard Group Scale [17] was used to evaluate hypnotic suggestibility. The instructions were recorded on magnetic tape, and subjects listened to the tape prior to filling out the scale. The scheme for the hypnosis experiment was as follows: (a) 10-min rest period, (b) 5-min controlled pain rating, and (c) 35 min of videotaped induction and hypnosis using task motivation and instructions by Barber and Halverly [18] (a videotaped hypnosis induction procedure was used to ensure uniformity; this procedure is well tested and appears to be as good as direct therapists' instruction [4, 19]), (d) 5-min experimental pain rating, (e) 20 min deepening of trace and evaluation of trace using Barber Suggestibility Scale (both d and e were done with video instructions), and (f) 10 min of rest. The patients who participated in this study had been treated with acupuncture therapy and as part of their progress notes had been asked at the end of each treatment period to evaluate the degree of improvement in their condition over the treatment period. Seventeen of the 20 patients were seen by different acupuncture therapists. If a patient or the therapist at either period rated the patient as improved by 50%, 75%, or 100%, then they were classified as acupuncture therapy responsive. If improvement was rated 25% or 0% they were classified as nonresponsive. On this basis, 11 patients were responsive and 9 were nonresponsive.

The various data were then analyzed according to the four different conditions of research: (1) suggestible and nonsuggestible populations, (2) acupuncture responsive and nonresponsive populations, (3) suggestible acupuncture responsive and suggestible acupuncture nonresponsive populations, and (4) nonsuggestible acupuncture responsive and nonsuggestible acupuncture nonresponsive populations.

All patients were exposed to the pain four times on two occasions, including a control period required of each hypnosis and acupuncture experiment. The data were analyzed using analysis of variance techniques with four dependent variables: (1) groups (acupuncture responsive and nonresponsive patients), (2) treatment (hypnosis and acupuncture), (3) manipulation (cold pressor technique under control and cold pressor technique during the two treatment conditions), and (4) the interaction between treatment and manipulation of the patient (i.e., during cold pressor application).

## Results

The results demonstrate a significant group effect, with acupuncture responsive patients demonstrating less pain under all conditions and a significant treatment by manipulation effect. It also appeared that there were differences in age between the two groups. The average age of responsive patients was 54.09 years, while that for the poor responders was 66.89 years. Differences between these groups were significant.

The correlation between performance on the Harvard Group Hypnotizability Scale and the pain reduction by hypnosis was high indicating that those who had the highest scores on measured hypnotic suggestibility obtained the greatest relief from pain when exposed to it under hypnosis.

The data suggest that acupuncture and hypnosis are distinct and independent treatment modes; that since hypnotic susceptibility does not predict success with acupuncture treatment. Our results show that acupuncture responsive patients have higher thresholds of pain and perceive it less than the average population and that acupuncture may be useful in younger populations.

## Electrophysiological Changes

### *Sensory Evoked Potential*

Twenty mentally and physically healthy male volunteers with an age range of 19–34 years (mean 35 years) and a weight range of 58–89 kg (mean 72 kg) participated in the study [20]. Pain was induced by somatic sensory stimuli designed for eliciting somatosensory evoked potentials (SEP), consisting of brief electrical stimuli applied at 2-s intervals over the median nerve with a pulse duration of 0.1 ms. Actually, the stimuli were not really painful since their intensity ranged from 35–80 V depending upon the subject's threshold (threshold plus 50%). Stimuli were produced by an especially designed constant voltage stimulator triggered by a Tektronix 162 wave form generator and Tektronix 161 pulse generator. Their output was fed into a Grass stimulus isolation unit (model SIU-4B) connected to the subject's right wrist by means of two, 8-mm diameter, silver electrodes which were 3 cm apart (anode distal). A ground electrode was placed proximal to the cathode. Twice in each session (before and during analgesia) 250 stimuli were applied (each session lasting approximately 9 min).

The pain challengers included hypnosis, acupuncture, and analgesic drugs. In two sessions, "hypno-analgesia" was induced by videotape [19]. The principal difference was the identity of the hypnotist. There were four acupuncture sessions. In the first the needles were inserted at specific loci as recommended by Chinese medicine for analgesia of the wrist, LI.4 and LI.7, and in the second session needles were placed at nonspecific sites near the specific loci. In the third session the subject filled out a self-rating scale.

Neurophysiological parameters included: quantitatively analyzed 5-min resting EEG recordings (RR) and 9-min SEP and concomitant EEG (SEP/EEG) recordings. The specific recording SEP leads were placed in a parasagittal plane 7 cm to the left and right of the midline. The posterior electrode was placed 2 cm behind the line from the vertex to the external auditory meatus and the anterior was placed 7 cm in front of the posterior electrode. In addition, a reading from the right and left occipital leads with reference electrodes at the ears was recorded. A ground electrode was placed on the forehead. SEPs and EEGs were recorded and amplified by a Grass polygraph model 79 and Ampex FR 1300 tape recorder. SEPs were fed into a CAT 400 B for summation. Analysis time was 500 ms. Each average SEP to 250 stimuli was plotted on a Moseley XY plotter. The EEG was analyzed off-line utilizing EEG digital computer analysis programs [21, 22]. This method permits analysis of 22 EEG parameters (including average frequency, frequency deviation, and eight different frequency bands of each of the primary and first derivative waves), as well as the average absolute amplitude and the

amplitude variability (Drohocki measurements) at a sampling rate of 320 points per second. Any 10-s epoch demonstrating movement or muscle artifacts was excluded from statistical analysis.

The temporal ordering was constant for each session starting with a 5-min resting record and a 9-min SEP/EEG recording. Then the pain challenger was applied. Nineteen minutes after the start of hypnosis, acupuncture, or saline injection, a 5-min "analgesia" resting record was obtained. An 8-min pause followed, and subsequently, the "analgesia" SEP/EEG was recorded for 9 min (32 min after application of the pain challenger). In the morphine session the "analgesia" resting record was not started until 27 min after injection because the drug effect peaks 1 h after IM administration while the SEP/EEG record was started as usual, at 32 min after the injection. In the ketamine trials the time sequence was changed because of the rapid onset of drug action. The "analgesia" resting record was started at 4 min after the injection, and the SEP/EEG recording followed immediately thereafter.

Statistical analysis of the stimulus intensity ratings demonstrated a significant decrease in the subjective experience of pain after the application of several pain challengers. In each subject the SEP stimulus intensity was kept the same during both the prerecordings as well as the analgesia recordings.

With insertion of acupuncture needles in specific loci, only a slight and insignificant decrease was noted (from 1.7 to 1.5). However, electroacupuncture of the same specific sites resulted in a significant ( $P < 0.01$ ) decrease of pain (from 1.7 to 1.3). When the needles were inserted at nonacupuncture points, no change in the pain experience occurred. Electroacupuncture in unspecific loci did not result in any particular change (from 1.5 to 1.4). Morphine sulfate administered IM produced a significant ( $P < 0.01$ ) decrease in the perceived stimulus intensity. Ketamine was administered at two different doses due to the fact that despite an intensive literature search no data could be obtained indicating which dosage would be analgesic in adults and which would be anesthetic. Thus, nine subjects received 5 mg per kg. It turned out that this dosage was anesthetic as the subjects did not respond to external stimuli. Anesthesia was reached approximately 6 min after injection and lasted for 20 min.

The decrease in the perceived stimulus intensity with hypnosis I and hypnosis II was significant ( $P < 0.01$ ) as compared with the control session, during which the pain experience did not change. Over four acupuncture sessions only electroacupuncture at specific (real) loci elicited a significant response ( $P < 0.01$ ) or attenuation of feeling the stimulus intensity. This attenuation was only slightly below that experienced with hypnosis and morphine. Morphine was significantly different from the control session ( $P < 0.05$ ). Hypnosis I and hypnosis II were significantly more effective in reducing pain than acupuncture at specific loci with and without electrical stimulation. Morphine was only significantly superior to acupuncture at unspecific loci in the control session. No comparison between ketamine and other conditions was made due to its anesthetic effect which precluded any of the subjects giving a response during the period of stimulation.

Examination of the SEP findings revealed 12 peaks identified within the first 500 ms following the stimulus. Peaks 1 and 2 can be regarded as the primary evoked response ("sensory response"), while the subsequent peaks can be looked

upon as secondary response ("cognitive response"). The primary response is seen in the contralateral hemisphere (left side). Over the ipsilateral hemisphere (right side), the first two peaks were absent. The latency of each peak from the stimulus artifact and the peak-to-peak amplitudes were measured for statistical analysis.

During the control session no statistically significant alterations occurred with the exception of the amplitude increase in peaks 9-10. In contrast, during hypnotic analgesia there occurred a latency increase in the early second response that was significant ( $P < 0.05$ ) in peak 4 on the left side and a significant latency decrease in the late response in the peak on the right side. The amplitude of the late components was attenuated and reached the level of statistical significance in peaks 7 and 8 (left side) and peaks 10 and 11 on both sides.

Acupuncture in specific loci resulted in a latency decrease in the early secondary response (significant in right-sided peaks 5 and 6), and a latency decrease in the late response (significant in right-sided peaks 8-11). In terms of amplitude, a significant decrease was observed in peaks 7 and 8 of the left side, while on the right side a significant augmentation of peaks 4 and 5 occurred. Electroacupuncture in specific loci produced a significant latency decrease in left-sided peaks 3 and 8 as well as an amplitude augmentation of peaks 3 and 4. Insertion of the needles in nonspecific loci resulted similarly in a latency increase in the early portion and a latency decrease in the late portion of the response which, however, only reached the level of statistical significance in the left-sided peak 3. There were no significant changes with electroacupuncture in nonspecific loci.

### EEG Results

Computer analyzed EEG from period analysis of the resting record during the control session demonstrated no significant changes as compared with the pre-resting record. During both hypnosis sessions a significant increase of delta and theta activity as well as a significant decrease of alpha and slow beta waves (average frequency and frequency deviations) were observed. Acupuncture, with needle insertion alone at specific sites, produced only one significant effect, i.e., an increase in very high frequency activity (90 cps and above). Electroacupuncture at the same specific loci resulted in a significant attenuation of delta and beta waves ( $P < 0.05$ ).

Acupuncture at nonspecific loci did not induce any significant alterations, while electroacupuncture at nonspecific sites produced a decrease of slow activity (significant in the delta band), an increase in the 13-20 cps beta band, and an increase in average frequency.

Acupuncture was an effective pain challenger when needles were inserted at specific loci and electrically stimulated. Insertion of the needles alone at nonspecific sites or acupuncture in specific loci without electrical stimulation did not affect pain perception nor did it affect the quantitatively analyzed EEG. Significant changes in the quantitatively analyzed EEG occurred only with electroacupuncture at specific points and were characterized by a decrease in delta and beta waves, 16-26 CPS activity, and amplitude variability as well as by an increase in average frequency for absolute amplitude alpha, slow beta waves, and very fast

beta activity. Our findings are in agreement with those of the Peking Acupuncture and Anesthesia Coordinating Group [23], who found that during needling the alpha wave predominated and its amplitude increased. In our study acupuncture-induced changes were significantly different and generally opposite from the hypnosis-induced alterations. These indicated a stimulatory effect of electroacupuncture regardless of the site of stimulation.

### *Conclusions: Electrophysiological Changes*

Interestingly, SEP changes are almost exclusively statistically significant when acupuncture needles are inserted in specific loci with and without current stimulation. After these changes a latency decrease in the early peaks 2 and 3 and very late peaks 8 and 12 and an increase in the middle portion of SEP in peaks 5 and 6 occurred. Thus, we were able to support the findings of the Peking Acupuncture Anesthesia Coordinating Group [23] who showed that needling the points LI.4 Hegu and Pe.6 Neiguan suppressed or weakened the potential evoked by painful stimulation of the nervi cutaneus colli in animals.

Neurophysiological findings, both EEG and SEP, demonstrated that electrical stimulation of acupuncture at specific loci does have a significant influence on brain activity. This is in agreement with the view of Chang Hsiang-Tung [24]. It is thus suggested that the efficacy of acupuncture analgesia may be affected by the state of brain excitability and is due to the inhibited interaction between afferent impulses arriving from the needle points and those from the sites of pain impulses in the brain, especially in the thalamus.

During both of the hypnosis sessions a significant increase in slow EEG activity occurred together with some decrease in the alpha band. In some cases there was also an increase in delta together with a decrease in beta activity. Acupuncture with needle insertion of specific sites produced a significant increase in high frequency beta activity [20].

### **Acupuncture Versus Hypnosis**

Pronouncements were made on by two leading hypotherapists, Speigel [14] and Kroger [15], that acupuncture was a kind of Oriental hypnosis induction therapy. This opinion derived from a vast experience with hypnosis but little with acupuncture and had the "halo" effect of strengthening the widespread belief that acupuncture was merely a form of hypnosis. Increasing familiarity with acupuncture, however, led to a change of opinion. Patrick Wall, for example, stated that, "in 1972, my own belief is that acupuncture is an effective use of hypnosis" [25]. In 1974, after a tour of China, he retracted that statement [26].

Ronald Katz, who reported that a positive response to acupuncture was closely related to a high score on hypnosis susceptibility testing [27] later stated, "I have assisted in four operations under acupuncture anesthesia and many more than that under hypnosis. The patients behave differently. Those under hypnosis are in a tight self-controlled world, seemingly unaware of what is going on about them.

Patients under acupuncture were part of the team, joking, laughing and commenting freely" [28].

From an extensive review of the literature, Lu and Needham [29] stated that one cannot deny the importance of a certain measure of suggestion and suggestibility such as occurs in all treatments but that it is a gross misuse of the term hypnosis to cover all aspects of acupuncture treatment.

Omura [30] mentions his study of 300 patients using the Speigel Eye-Roll Hypnotizability Test. He found that those persons with hypnotizability scores above three had a slightly better response to acupuncture. Yet more than 50% of his subjects with hypnotizability scores of 0 showed beneficial effects of acupuncture treatment.

Matsumoto [31], using acupuncture both clinically and experimentally, concludes "... our clinical experience mitigates against the concept that acupuncture is a form of hypnosis." Our own experiences have been similar [32]. We did, however, observe that clinical and experimental pain are different phenomena and respond differently to acupuncture. Cold pressor pain, such as we and others have utilized in the experimental laboratory, certainly has different characteristics from the chronic pain syndromes that make up the bulk of clinical acupuncture practice. Today there is sufficient neuroanatomical and neurochemical knowledge of pain mechanisms to suggest the basis for such differences and thus to, account for some of the differing results reported.

Goldstein and Hilgard [33] in 1975 pointed out that while naloxone inhibits the analgesia of morphine and acupuncture, it does not inhibit hypnoanalgesia. Related to this in the important finding of Levine et al. [34] that naloxone blocks the placebo analgesic response that curbs the pain of electrical stimulation of tooth pulp. Thus, one must apparently differentiate between the term suggestibility as applied to placebo responders and suggestibility implying hypnotizability.

The psychological response does not predict acupuncture response. It has become increasingly clear from these investigations that hypnosis and acupuncture act in different ways upon the complex pain mechanisms within the central nervous system. Accordingly, in our clinical work with patients for whom acupuncture has failed, we have sometimes turned to hypnosis with good results. These two methods then seem complementary to each other.

In order to avoid the use of analgesic drugs with their propensity for unwanted side effects and potential for addiction, the optimal nondrug approach for the modulation of pain might well include three techniques, each with a different action component within the central nervous system: maximization of the placebo response (psychological/physiological) which is abolished by naloxone; electroacupuncture (physiological), also abolished by naloxone; and hypnosis (psychological/physiological), not abolished by naloxone.

In our study of 20 healthy volunteers using cold pressor (water bath pain), ischemic (tourniquet cuff pain) and electrical stimulation pain to elicit the SEP response, we found the protective effects of both 35 min of hypnotic suggestion and electroacupuncture stimulation at specific points to be effective methods of pain relief and at least as potent as the administration of 10 mg of morphine sulfate. Our studies found that hypnosis, electroacupuncture, and morphine sulfate were all nearly equally effective in reducing experimental pain (Fig. 8). While our

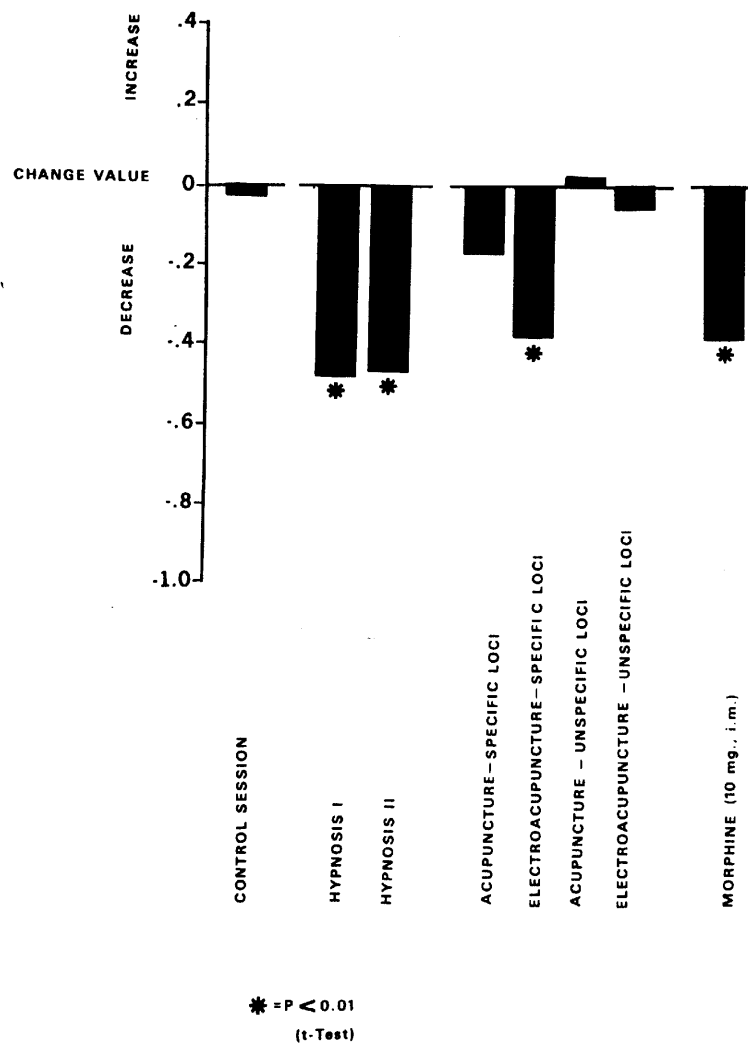


Fig. 8. Changes in the subjects' experience of experimental pain with different pain challengers (analgesics) ( $n = 20$ )

good hypnotic subjects did respond better to both hypnosis and electroacupuncture, we found that the poor hypnotic subjects also responded well to electroacupuncture. It was our conclusion, therefore, that electroacupuncture given at specific acupuncture points was an effective agent for reducing experimental pain and that hypnotic susceptibility does not account for this effectiveness.

In a study of 20 patients who had received clinical acupuncture treatments for the relief of chronic low back or knee pain we found that those who had done well in treatment, i.e., good acupuncture responders, felt less pain with the experimental cold pressor pain stimulus than did those who had a poor clinical result. That is, those who had less clinical pain reduction felt the experimental pain more keenly. In this study hypnotic susceptibility and response to acupuncture were independent variables.

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