

# Psychophysical Outcomes From a Randomized Pilot Study of Manual, Electro, and Sham Acupuncture Treatment on Experimentally Induced Thermal Pain

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**Abstract:** In this pilot study comparing the analgesic effects of three acupuncture modes—manual, electro, and placebo (with Streitberger placebo needles)—in a cohort of healthy subjects, we found that verum acupuncture treatment, but not placebo, lowered pain ratings in response to calibrated noxious thermal stimuli. This finding was mainly the result of highly significant analgesia in 5 of the 11 subjects who completed the 5-session study. Of the 5 responders, 2 responded only to electroacupuncture and 3 only to manual acupuncture, suggesting that acupuncture's analgesic effects on experimental pain may be dependent on both subject and mode. We developed a simple quantitative assessment tool, the Subjective Acupuncture Sensation Scale (SASS), comprised of 9 descriptors and an anxiety measure to study the relationship between the *deqi* sensation induced by acupuncture and the putative therapeutic effects of acupuncture. The SASS results confirm that the *deqi* sensation is complex, with all subjects rating multiple descriptors during each mode. We found significant correlations of analgesia with SASS ratings of numbness and soreness, but not with ratings of stabbing, throbbing, tingling, burning, heaviness, fullness, or aching. This suggests that attributes of the *deqi* sensation may be useful clinical indicators of effective treatment.

**Perspective:** The results of this study indicate the existence of both individual subject and acupuncture mode variability in the analgesic effects of acupuncture. This suggests that switching acupuncture mode may be a treatment option for unresponsive patients.

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**Key words:** Acupuncture, acupuncture analgesia, acupuncture mode, *deqi* sensation, pain.

For more than 2000 years, acupuncture has been widely used in many cultures to relieve pain. Rigorous studies documenting the efficacy of acupuncture in reducing clinical pain is limited, with good evidence only for dental pain<sup>7</sup> and inconclusive or equivocal evidence for other pain disorders.<sup>3,8,9,15,16,22,26,34</sup> Basic science research investigating the salubrious effects of acupuncture treatment has produced results that have led to specific testable mechanistic hypotheses (eg, postulating roles for endogenous opioids<sup>13,14,25</sup>); however,

these have not been related directly to reputed clinical analgesic effects. Methodologic challenges that confound clinical trials of acupuncture analgesia are numerous and have been difficult to overcome.<sup>17-19,40</sup> Development of robust sham acupuncture methods is a critical step toward evaluating efficacy and potential therapeutic mechanisms.

Although acupuncturists traditionally have used manual needle manipulation to achieve therapeutic benefits, electro acupuncture is gaining popularity in clinical practice. Previous studies in healthy subjects suggest that different mechanisms may be involved in manual and electro acupuncture treatments.<sup>6,21,39,41,42</sup> Although treatment with both manual and electro acupuncture modalities has reduced subjective ratings of experimental pain,<sup>4,13,24,25</sup> none of these studies compared their analgesic efficacy in a single subject cohort. In addition, the response to acupuncture is believed to be a trait characteristic (ie, individuals can be good or poor responders), yet there is little evidence comparing the response to different acupuncture modalities within individuals.

The evocation of *deqi*, a sensation of numbness and fullness that develops at the site of stimulation, is believed to be important for acupuncture analgesia.<sup>1,31</sup>

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## Experimental procedures

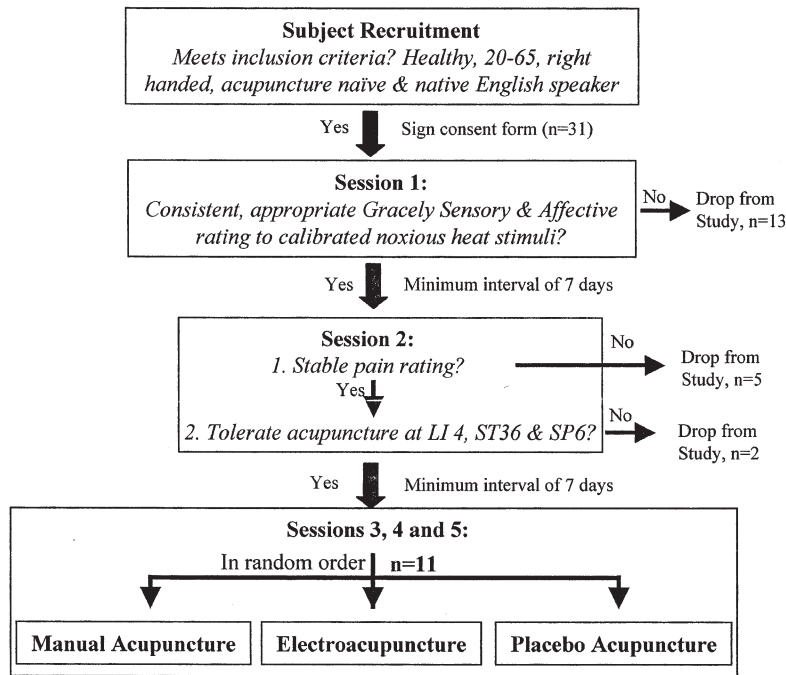


Figure 1. Flow chart of experiment.

Traditionally, patients are asked to remain aware of the sensation during treatment. Scientific evidence of the importance of the *deqi* sensation for treatment outcomes is limited, but one trial showed that *deqi* was the predictor of a positive outcome in osteoarthritis.<sup>32</sup> Thus, *deqi* may be an important variable in studies of the efficacy and mechanism of the action of acupuncture treatment.<sup>37</sup> However, there is no consensus for a method or instrument to quantify the *deqi* sensation despite efforts toward this goal.<sup>27,37,40</sup> Particularly, no studies to our knowledge have systemically investigated the relationship between different aspects of *deqi* and any treatment effects.

We hypothesized that individuals may respond differently to manual, electro, and placebo acupuncture and designed a study to investigate the influence of the two verum modes of acupuncture and placebo acupuncture on the psychophysical responses to noxious thermal stimuli in healthy subjects. We also administered an assessment tool to collect measures of subjective acupuncture-induced sensations to determine association of *deqi* traits with therapeutic effects.

## Material and Methods

### Subjects

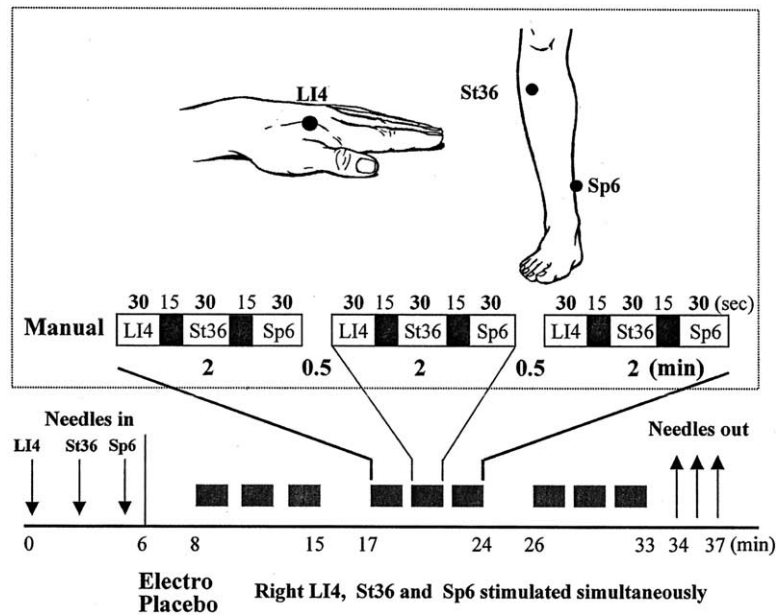
Thirty-one right-handed subjects (23 males, mean age  $25.1 \pm 3.5$  [SD] years) who were naïve to acupuncture participated in the study. All subjects were recruited by advertisement. A telephone screening was carried out to exclude subjects with medical disorders, including neu-

rologic and psychologic disorders. Experiments were conducted with the understanding and written consent of each subject and approval by the Human Subjects Committee at Massachusetts General Hospital.

### Procedures for the Delivery and Assessment of Noxious Thermal Stimuli

Thermal stimuli were delivered by a TSA-2001 thermal sensory analyzer with a  $3 \times 3$ -cm probe (Medoc Advanced Medical Systems, Rimat Yishai, Israel) running a proprietary computerized visual analog scale software (COVAS). Heat stimuli were 12 seconds in duration (including the  $\sim 3.5$ -second ramp up and down from baseline, the temperature ranged from  $41^\circ\text{C}$  to  $52^\circ\text{C}$ ) with a minimum interstimulus interval of 20 seconds. The probe was moved between each stimulus application by a research assistant. Each stimulus was separated by a minimum distance of 4 cm to minimize sensitization of the skin. Sequences of stimuli were applied on alternating sides and limbs. To ensure that stimuli were consistently applied, nonoverlapping sensory fields were labeled by grids drawn on the volar aspect of the forearms between the creases of the wrist and elbow and the medial aspect of the shins between the ankles and the knees in each session.

Each subject was studied in 5 sessions (Figure 1); the first 2 sessions were training sessions, and the 3 subsequent sessions were experimental sessions. Sessions were separated by at least 1 week to avoid sensitization to repeated application of the noxious stimuli and to allow for full recovery of the subject's skin. Subjects were asked



**Figure 2.** Schematic diagram of the acupuncture treatment procedures.

to hold common daily activities constant on experiment days (ie, duration of sleep, eating habits, caffeine intake). They also were asked not to shave their legs on the 2 days before a session.

In the first training sessions, subjects were trained to use Gracely Box 0-20 categorical scales with anchor words<sup>11,12</sup> to orally rate the sensation elicited by each pain stimulus. Three discrete temperatures were selected for each subject so that the subject consistently reported ratings in a target LOW, MEDIUM, and HIGH range (7-10, 11-14, and 15-18, respectively, on the Gracely Sensory Box Scale). Then, exactly the same 4 sequences of stimuli that were used during the rest of the sessions were administered. Thermal sequences consisted of 9 stimuli, 3 each of LOW, MEDIUM, and HIGH intensities administered in random order with different temperatures for arms and legs within the same individual. In the second training session, only these sequences were presented to establish the reliability of the subject's responses across sessions. At the end of Session 2, acupuncture was administered for 5 minutes. Subjects were then familiarized with our acupuncture sensation rating instrument (see below for further details) for both manual and electroacupuncture stimulation at each acupoint.

Screening criteria based on performance of the sensory rating task had to be met for a subject to proceed to the 3 experimental sessions. First, in the initial training session, subjects had to report subjective ratings that showed a clear correlation to the magnitude of the stimulus intensity during the administration of the stimuli on all 4 limbs. Second, subjects were required to report subjective ratings to their LOW, MEDIUM, and HIGH intensity noxious stimuli between the 2 training sessions that were within 15% as determined by the mean sensory scores. Only subjects who passed all screening criteria continued to the 3 experimental sessions.

The experimental sessions (Sessions 3-5) were identical for all subjects except for the acupuncture mode administered, the order of which was randomly assigned across subjects. Noxious thermal stimuli were presented approximately 5 minutes before and after administration of 1 of 3 modes of acupuncture (electro, manual, or placebo) by the same licensed acupuncturist. An identical series of 9 noxious stimuli in random order was applied to each limb with the order of right leg, left arm, left leg, and right arm before and after treatment.

To maintain uniform expectancy across treatments, subjects were told that they would receive 3 modalities of acupuncture, one in each of the 3 sessions, to investigate the efficacy of acupuncture analgesia. They were also told that the 3 modalities of acupuncture stimulation may produce distinct sensations and may work through different mechanisms, and the efficacy of one mode of acupuncture may not be associated with the efficacy of the other modes. At the end of Session 5, subjects were debriefed and asked to comment on their general experience of the pain stimuli, acupuncture modes, and testing conditions. They were also specifically asked if they thought any of the treatments had been a placebo.

### **Procedures for Acupuncture Administration**

Three acupoints on the right side of the body were used in this study. They were Large Intestine 4 (LI4), Stomach 36 (St36), and Spleen 6 (Sp6) (Figure 2). Each of these points has well-documented analgesic action.<sup>2,30</sup> After the acupuncturist located each acupoint and disinfected it with isopropyl alcohol, a small plastic ring was placed over the acupoint and then covered with a thin sterile plastic tape. This served to blind the subjects to

**Table 1A.** Mean sensory ratings before acupuncture treatment  $\pm$  SE for all subjects by session and temperature level

SESSION	LOW (7-10)	MEDIUM (11-14)	HIGH (16-18)
3	9.2 $\pm$ 0.6	12.8 $\pm$ 0.5	16.5 $\pm$ 0.2
4	8.5 $\pm$ 0.6	12.1 $\pm$ 0.4	16.0 $\pm$ 0.3
5	8.3 $\pm$ 0.5	11.6 $\pm$ 0.4	15.6 $\pm$ 0.4

Intended range indicated in parentheses (n = 11 in each cell).

whether verum or placebo needles were used. Next, a 38-gauge sterile disposable stainless steel acupuncture needle was inserted into LI4, followed by St36, and finally Sp6 and manually manipulated by the acupuncturist to achieve the subjective *deqi* sensation.

**Manual Acupuncture Procedure.** Manual acupuncture needle manipulation was performed by use of a balanced tonifying and reducing technique at the 3 acupoints on the right side of the body in three 7-minute blocks, each separated by a 2-minute rest period (see Figure 2). During the 7-minute stimulation period, the acupuncturist manually stimulated one point for 30 seconds, followed by a 15-second break before moving to the next acupoint. Rotation frequency was approximately 180 rotations per minute at an angle of 45 degrees from the perpendicular to the skin surface.

**Electro Acupuncture Procedure.** After the 3 acupuncture needles were inserted and the *deqi* sensation was evoked, a surface ground electrode was placed 2 inches from each acupoint (for LI4, the electrode was placed on the palm facing the acupoint of LI4; for St36 and Sp6, the electrode was placed on the meridian below and above the acupoint, respectively). Wire leads connected each needle and ground electrode to an electro acupuncture device (OMS Medical Supplies IC-1107). The electrical intensity was determined individually for each subject by manual adjustment of the device by the acupuncturist. At the beginning of each block, intensity was increased gradually until the subjects felt the intensity was around a moderate level. During each 7-minute stimulation block, the current was continuously passed through the electrodes, with the frequency alternating between 2 Hz and 15 Hz every 30 seconds. Electro acupuncture was performed simultaneously at the 3 points on the right side of the body in three 7-minute blocks each separated by a 2-minute rest period (see Figure 2).

**Placebo Acupuncture Procedure.** Specially designed sham acupuncture needles,<sup>20,29</sup> visually indistinguishable from verum needles, but with a blunt tip and retractable shaft, were used. The needle tip stood on the surface but did not penetrate into the skin. The procedure for the placebo mode was identical to that for the electro acupuncture except that no current was passed through the electrodes. The acupuncturist went through the same motions of eliciting *deqi*, turning equipment knobs, etc, to maintain subject blinding.

**Table 1B.** Mean affective ratings before acupuncture treatment  $\pm$  SE for all subjects by session and temperature level (n = 11 in each cell)

SESSION	LOW	MEDIUM	HIGH
3	6.0 $\pm$ 0.9	9.3 $\pm$ 1.1	13.8 $\pm$ 1.3
4	5.4 $\pm$ 0.8	8.3 $\pm$ 1.0	12.8 $\pm$ 1.3
5	5.2 $\pm$ 0.7	8.1 $\pm$ 1.0	12.2 $\pm$ 1.4

### Subjective Acupuncture Sensation Scale

Immediately after each acupuncture treatment, subjects were asked to quantify their sensations at each acupoint by rating the intensity with which they experienced each of 9 descriptive sensations. The sensations were stabbing, throbbing, tingling, burning, heaviness, fullness, numbness, soreness, and aching. These verbal descriptors were selected on the basis of traditional Chinese medicine descriptions of the *deqi* sensation in previous literature<sup>1,31,37,39</sup> and our experience. Because the *deqi* sensation is a very complicated subjective feeling, we expected that each individual would give different description and endorse a unique set of descriptors. As an important supplement, one blank row at the end of the 9 descriptors was provided and subjects were specifically told that if the descriptors did not accurately or completely describe the sensation they experienced, they should add their own words. Finally, subjects were asked to rate their degrees of anxiety during the acupuncture treatment. Each of the 11 elements on the Subjective Acupuncture Symptom Scale (SASS) (9 descriptors, 1 blank row, and the anxiety measure) was presented with a 10-cm bar with the anchor words "none," "mild," "moderate," and "severe" spaced evenly on the continuum. Subjects were asked to indicate their sensations for each element for each of the 3 acupoints with a hash mark anywhere on the continuum.

### Data Analysis

**Sensory and Affective Ratings.** The analgesic effect of each of the 3 modes of acupuncture was determined by comparing the subjective ratings (sensory and affective) with identical noxious stimuli applied before and after acupuncture administration. We determined the difference between ratings for each preacupuncture and postacupuncture stimulus pair (matched for temperature, stimulus order, and limb). Analyses of variance (ANOVA) were conducted on this difference measure for the cohort. We fit full, fixed-effects ANOVA models separately for the sensory and affective ratings, including main effects and all interactions for the following factors: subject, acupuncture (verum vs sham), mode (manual vs electro), temperature level (low, medium, high), order of mode, limb (arm vs leg), laterality (treated/right vs untreated/left). We used fixed-effects models to understand the effects on this specific cohort. The significance level for the ANOVA models was  $P < .0013$ , Bonferroni corrected (.05/390).

**Table 2A. Mean sensory ratings before and after acupuncture treatment  $\pm$  SE for all subjects by mode across temperature levels (n = 11 in each cell)**

	Low (7-10)		MEDIUM (11-14)		HIGH (15-18)	
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
Electro	8.5 $\pm$ 0.5	7.9 $\pm$ 0.6	11.8 $\pm$ 0.5	11.3 $\pm$ 0.6	15.6 $\pm$ 0.4	15.1 $\pm$ 0.6
Manual	8.9 $\pm$ 0.6	7.8 $\pm$ 0.7	12.5 $\pm$ 0.4	11.9 $\pm$ 0.4	16.3 $\pm$ 0.3	15.7 $\pm$ 0.4
Placebo	8.6 $\pm$ 0.7	8.6 $\pm$ 0.7	12.3 $\pm$ 0.5	12.4 $\pm$ 0.6	16.2 $\pm$ 0.3	15.9 $\pm$ 0.5

**Table 2B. Mean affective ratings before and after acupuncture treatment  $\pm$  SE for all subjects by mode across temperature levels (n = 11 in each cell)**

	LOW		MEDIUM		HIGH	
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
Electro	5.5 $\pm$ 0.8	4.9 $\pm$ 0.7	8.3 $\pm$ 1.1	7.7 $\pm$ 0.9	12.4 $\pm$ 1.3	11.7 $\pm$ 1.3
Manual	5.7 $\pm$ 0.8	4.7 $\pm$ 0.9	8.8 $\pm$ 1.1	8.3 $\pm$ 1.0	13.3 $\pm$ 1.3	12.5 $\pm$ 1.3
Placebo	5.4 $\pm$ 0.8	5.5 $\pm$ 0.9	8.6 $\pm$ 1.0	8.8 $\pm$ 1.2	13.1 $\pm$ 1.4	12.6 $\pm$ 1.4

To investigate the specific individual subject contributions to the overall analgesic effect, two separate ANOVA analyses were performed, each using a model with temperature level and treatment mode as factors, on the sensory rating data from each of the subjects. The first analysis modeled the effect of verum acupuncture (manual and electro) compared with placebo; the second tested for the difference between the two modes of verum acupuncture (significant effects for both analyses reported at  $P < .05$ ).

**Deqi Ratings.** The subjective experience of each of the nine elements of the *deqi* sensation was quantified by measuring the distance in millimeters from the left end of the scale to the hatch mark indicated by each subject for each term. Quantified ratings (0.0-10.0) based on the 100-point scale were used to analyze the differences between acupuncture mode and acupoint. Ratings were averaged across subjects for each acupoint and for each treatment mode. In addition, an exploratory correlation analysis was performed between each of the SASS elements of the *deqi* sensation and the analgesic effect as determined by pain rating changes before and after treatment. The significance level for the correlation analysis was  $P < .006$ , Bonferroni corrected (.05/9).

## Results

### Subjects

Of the 31 volunteers who consented to the study, 11 (6 female) completed all five sessions. Subjects who did not demonstrate the psychophysical ability to reliably distinguish pain intensity were dropped from the study. Thirteen subjects did not meet criteria to proceed to Session 2; 5 did not meet criteria to proceed to Sessions 3 through 5 because of the unstable rating of calibrated pain stimuli, which was usually due to variability in the

ratings of stimuli applied to the legs. Two subjects were dropped from the study because they had mild adverse responses to acupuncture (dizziness during acupuncture manipulation) in Session 2.

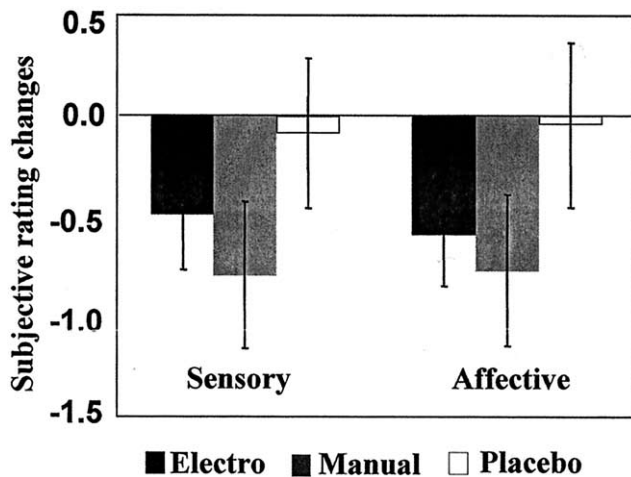
During the debriefing after Session 5, subjects were asked if they had noticed that any of the acupuncture treatments had been a placebo. None of the 11 subjects thought that they had received a placebo treatment, nor did any realize that the needles did not penetrate the skin in all treatments.

### Subjective Ratings of Pain and Acupuncture

**Stability of Subjective Ratings of Pain.** Subjects who completed the study consistently reported stable sensory and affective ratings that correlated with the intensity of the stimuli before treatment (Tables 1A and 1B). Although there was a small but significant decrease in the sensory ratings across Sessions 3, 4, and 5, the ratings remained within the intended ranges throughout the three sessions.

**Changes in Sensory and Affective Ratings Before and After Treatment.** The group-averaged sensory and affective rating for three modes of treatment are shown in Tables 2A and 2B. The changes in sensory and affective ratings of pain stimuli (POST-PRE) after acupuncture treatment, averaged across the three temperature levels and four limbs, are shown in Figure 3.

The ANOVA of sensory pain ratings indicated that there were main effects of subject ( $P < 1 \times 10^{-6}$ ), verum (manual or electro) acupuncture ( $P < 6.0 \times 10^{-4}$ ), and limb ( $P < 5.00 \times 10^{-4}$ ) (arms had greater analgesia than legs). Within the group, there was no difference between manual and electro acupuncture ( $P < .1$ ). There were significant interaction effects between subject and



**Figure 3.** Sensory and affective rating changes after treatment. Differences between sensory and affective pain ratings before and after acupuncture treatment averaged across the three temperature levels and four limbs ( $n = 11$ , values are mean  $\pm$  SE).

four other factors analyzed (acupuncture, mode, limb, and laterality) ( $P < 2.8 \times 10^{-4}$ ).

An identical ANOVA on the affective ratings showed that there were main effects of subject ( $P < 1 \times 10^{-6}$ ), verum (manual or electro) acupuncture ( $P = 6.2 \times 10^{-5}$ ), and limb ( $P < 3.2 \times 10^{-4}$ ) (arms had greater analgesia than legs). Within the group, there was no difference between manual and electro acupuncture ( $P < .3$ ). The affective ratings exhibited greater variability and, in addition to the four subject interaction effects found in the sensory ratings, also showed a significant three-way interaction among mode of acupuncture, side of pain application, and temperature level ( $P < 4.30 \times 10^{-4}$ ).

No effects were found for order of treatment mode, stimulus temperature level, or laterality (whether the pain was applied to the treated or untreated side) for either sensory or affective ratings.

Analysis of data from each individual showed that, of the 11 subjects who completed the study, 5 showed significant analgesic effects of verum acupuncture, with 3 subjects significantly responding to manual acupuncture and 2 subjects to electro acupuncture. Each of these 5 subjects had a small but highly significant analgesic effect ( $P$  values for the 5 subjects: .028, .022, .013, .002,  $3 \times 10^{-7}$ ) to only one verum mode of treatment. The mean changes in sensory rating for these 5 responders averaged across temperature levels and limbs was  $1.6 \pm 0.5$  and did not differ between the two verum modes. The magnitude of this suppression in ratings did not differ between arm and legs but showed a trend toward stronger analgesia on the right side than on the left side ( $P < .09$ ). There was also a trend for the subjects to be the most sensitive to the analgesia effect in response to the lowest of the three temperature levels; however, because of individual variability, this was not significant ( $P < .08$ ). Further, no subject had a statistically significant increase in pain ratings after any acupuncture treat-

ment. There were no significant interactions between treatment mode and temperature level in any of the individual analyses.

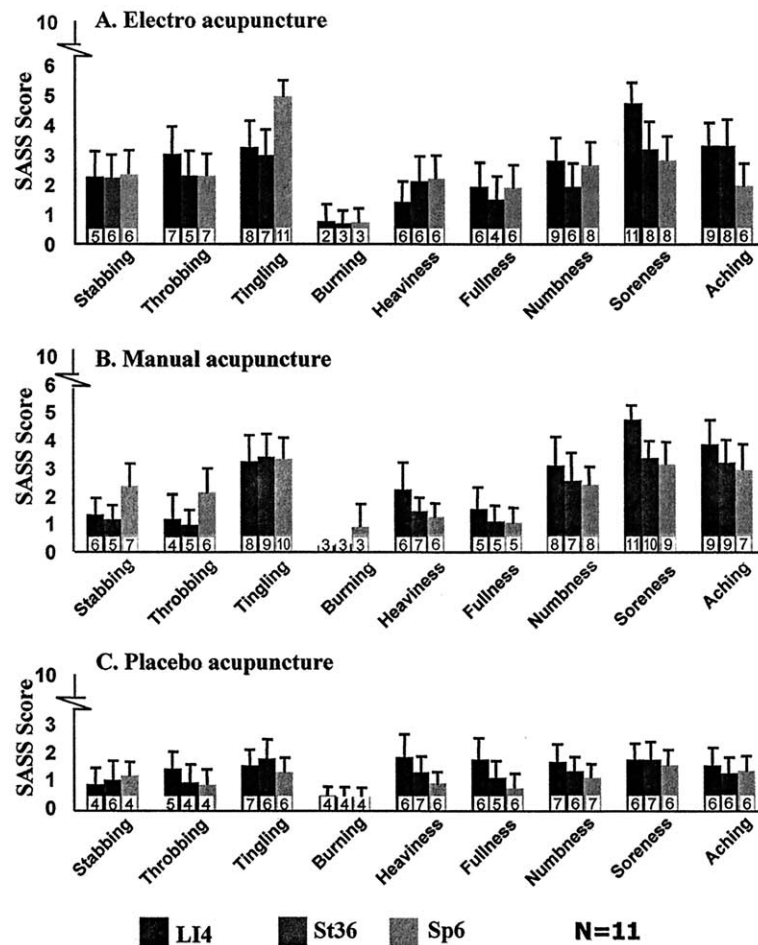
**SASS.** Figure 4 presents the summary of the ratings for each of the nine descriptors on the SASS by mode and acupoint. Average ratings of each of the nine elements of the *deqi* sensation for each acupoint fell between 0.0 and 6.0 on the 10.0-point scale for all three modes of treatment. Individual ratings for the sensations spanned the 10.0-point scale (with highest score reported 9.1), but most ratings fell in the mild to moderate range ( $< 5.0$ ). We found relatively consistent ratings across the three acupuncture points within each mode, with highest ratings for tingling, numbness, soreness, and aching. Across all modes and acupoints, subjects reported a constellation of sensations, selecting an average of  $5.17 \pm 0.43$  (mean  $\pm$  SD) sensations out of the nine possible descriptors. The two verum modes of acupuncture produced approximately equivalent ratings for all three acupoints. The average ratings for the placebo mode (1.3) were less than those for either the electro (2.4) or manual (2.2) verum modes. All subjects reported their experience of the *deqi* sensation using the nine terms presented in the SASS; no subject opted to add a term in the blank row provided.

Exploratory correlation analysis between the analgesic effect (difference in sensory pain ratings between post-treatment and pretreatment pain epochs) and each of the nine sensations quantified on the SASS revealed significant correlations with two scales: the numbness sensation ratings ( $P < 9.0 \times 10^{-4}$ ) and the soreness sensation ratings ( $P < .002$ ) (Figure 5). The same results were noted when the analysis was performed for each mode separately.

**Anxiety Ratings.** The average subjective ratings of anxiety during treatment for each of the three acupoints across the three modes ranged from 0.4 to 1.5 on the 10.0 scale. Six of the 11 subjects reported anxiety ratings of 0 over all acupuncture points and modes. The ratings were consistent across points for each mode with average anxiety ratings of 1.3 for electro, 0.7 for manual, and 0.5 for placebo. There were no significant differences between the acupuncture modes.

## Discussion

Our randomized pilot study in 11 healthy subjects showed that verum acupuncture (both manual and electro), but not placebo, lowered pain ratings to calibrated noxious thermal stimuli. There were significant interaction effects between subject and four other factors analyzed (acupuncture, mode, limb, and laterality), consistent with the interpretation that there was individual variability in response to acupuncture-induced analgesia. For example, some subjects showed a greater analgesic laterality effect ipsilaterally and others contralaterally, but averaging over the cohort, there was no significant laterality effect. Although we did not find a significant difference between the two verum modes in the group, individual ANOVA revealed that manual acu-

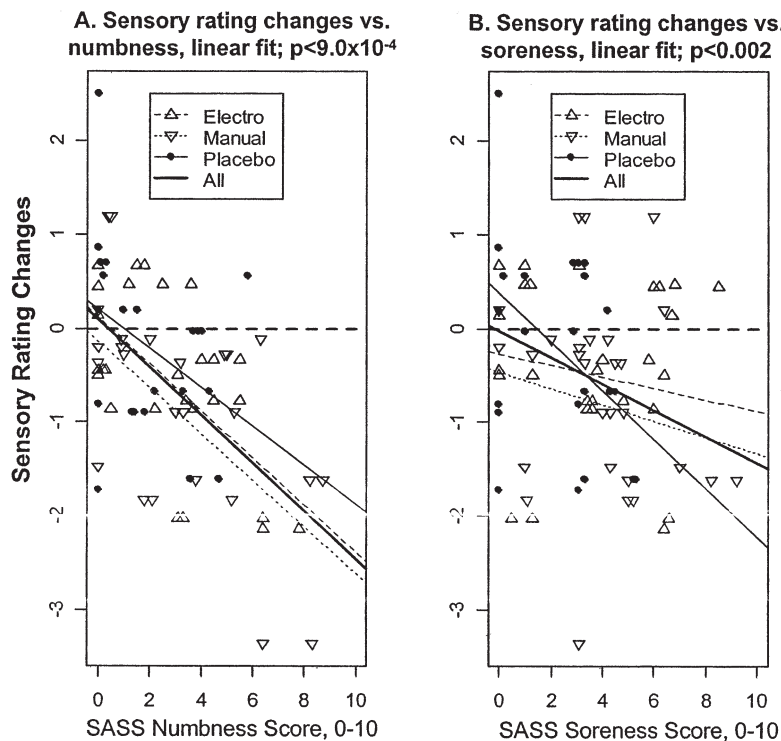


**Figure 4.** Acupuncture treatment is associated with a complex sensory experience. Group average results of the SASS show mild to moderate ratings (mean  $\pm$  SD) for each acupoint and mode (electro [A], manual [B], placebo [C]). The numeral on each bar indicates the number of subjects out of 11 who rated that term above 0.

puncture resulted in significant analgesia in 3 subjects, whereas electro acupuncture resulted in significant analgesia in 2 others compared with placebo acupuncture treatment. These results are consistent with previous studies showing that verum acupuncture can produce detectable analgesia to experimental pain in healthy subjects as measured by sensory and affective ratings.<sup>13,25</sup>

Subjects reported equivalent average ratings of the *deqi* sensations evoked by the two verum modes of acupuncture. Although most subjects reported sensations during placebo treatment, the average ratings were lower than for the two verum modes. Importantly, subjects reported that they had either no or very low anxiety during any of the treatments, suggesting that stress is not likely to have contributed to the analgesia. Significant correlations between analgesia (difference in sensory pain ratings between posttreatment and pretreatment pain) and the SASS ratings of (1) numbness and (2) soreness, but not with the ratings of stabbing, throbbing, tingling, burning, heaviness, fullness, or aching, were found. This suggests that some attributes of the *deqi* sensation may be useful clinical indicators of effective treatment.

The question of whether certain individuals are “good” responders to acupuncture is important when clinical outcomes of acupuncture treatment are investigated. An equally important question is whether an individual’s response to one modality of acupuncture will predict the response to another modality. In a previous study comparing treatment efficacy of different acupuncture modes (manual acupuncture and electro acupuncture at 2 Hz and 80 Hz) for chronic low back pain, Thomas and Lundberg<sup>33</sup> found that only electro acupuncture at 2 Hz produced significant improvement. However, their experimental design precludes within-subject comparisons of treatment mode efficacy. Although ours was not a clinical study, individual ANOVA results show that 5 of the 11 subjects had significant analgesia compared with placebo treatment after verum acupuncture, whereas the remaining 6 showed no measurable effect, suggesting that there were five “good” responders in our cohort. There were no systematic differences in the temperatures used during heat pain administration between these “good” responders and the rest of the cohort. Of the 5 responders in our study, 3 only showed significant analgesia after manual acupuncture, whereas 2 others only showed the effect after elec-



**Figure 5.** Treatment efficacy is correlated with ratings of numbness and soreness. Each graph shows the results of the correlation analysis of one element of the SASS (numbness [A], soreness [B]) with the difference in sensory pain ratings before and after treatment.

tro acupuncture. It is important to note that there is no evidence that responses to different modalities are mutually exclusive. The interpretation of these results is limited by our small sample size; however, the results demonstrate for the first time the existence of both individual and acupuncture mode variability, suggesting that acupuncture's analgesic effect on experimental pain may be dependent on both subject and mode.

This finding supports evidence that different mechanisms may underlie these two treatment modalities. For instance, recent functional brain mapping studies conducted during administration of manual and electro acupuncture in healthy subjects demonstrate distinct patterns of brain activation.<sup>21,41,42</sup> This was observed even when the same acupoint, LI4, was used in the same cohort of subjects.<sup>21</sup> As another example, manual and electro acupuncture treatment at a series of acupoints, including LI4, St36, and Sp6, had different effects on rates of resting and stimulated salivary flow in healthy subjects.<sup>6</sup> This differential effect on salivary flow rates has been associated with differential release of neuropeptides.<sup>5</sup> These results, together with the observations in this study, suggest that manual and electro acupuncture may work through different mechanisms and, thus, may affect the same individual differentially.

Design of an adequate control condition is a major challenge in acupuncture research.<sup>23,28,35,36,40</sup> An appropriate control condition should be physiologically inert in that it must not activate any of the proposed mechanisms of acupuncture. The sham needle with the retract-

able shaft does not puncture the skin but provides a sensation on placement that is reported to be indistinguishable from the matched verum acupuncture needles.<sup>20,29,40</sup> This is a crucial development in acupuncture research because it fully controls for subject expectancy without puncturing the skin and potentially activating any of the hypothesized neural, endocrine, immune, or metabolic signaling pathways.<sup>10,13,14,39</sup> Previous studies of placebo acupuncture using a sham needle included manual manipulation of the sham needle to maintain subject blinding. Our novel method of administration addresses the argument that even manual manipulation without insertion at an acupoint can produce some treatment effect. Further, we had no need to manually manipulate the sham needle to protect subject blinding because our placebo mode was designed to mimic electro acupuncture in which minimal manual manipulation only occurs at the time of insertion.

Our simple assessment tool, the SASS, was useful in investigating the *deqi* sensation evoked by acupuncture needle manipulation. The SASS results confirm that the *deqi* sensation is complex, with all subjects using multiple descriptors for each acupoint during each mode. This fits with results reported by Vincent et al<sup>37</sup> in a large cohort of patients, further supporting the clinical observation that *deqi* is a complex sensory experience. In our study, because of the individual variability, no clear gender differences were noted in the SASS ratings. Further, there were no clear patterns in rating for "good" responders. The three acupuncture points tested, LI4, St36,

and Sp6, are all located deep (approximately 1 cm) in comparable tissue planes.<sup>44</sup> These three acupuncture points had comparable SASS profiles within and across subjects. Further investigation could verify what sensations would be reported on the SASS for acupoints with different tissue characteristics. Of note, no subject wrote in an additional sensation descriptor, suggesting that the SASS is effective in evaluating the *deqi* sensation in healthy, acupuncture-naïve subjects. Since we completed our data collection, reports of another assessment tool that quantifies four aspects of the *deqi* sensation (dull/heavy, radiating, stinging, and electric) have been published.<sup>27,40</sup> It is notable that this assessment tool aggregates the term “numbness” with “heaviness” and, hence, might not have shown the correlation with analgesia.

We found a significant correlation between the analgesic effect and the ratings on numbness and soreness evoked by acupuncture treatment. With use of action potential recordings to categorize the nerve fibers involved in aspects of the *deqi* sensation, Wang et al<sup>38</sup> showed that numbness was conveyed mainly by Aβ/γ fibers, distention and heaviness by Aα fibers, and soreness by C fibers. Our findings suggest that multiple fiber types may participate in the analgesic effects of acupuncture, and further, that the experience of numbness or soreness during acupuncture treatment may be an important clinical correlate of analgesia irrespective of treatment modality. These observations must be interpreted with appropriate caution because they were made in a relatively small cohort of healthy subjects. Further testing in clinical populations is warranted.

Despite the small cohort, our study design afforded us sufficient statistical power to test our hypothesis, and this result is in line with previous reports and expectations, given the cohort and the nature of the experimen-

tal pain stimuli. First, we conducted a within-subjects comparison, allowing us to compare analgesic responses directly with the three modes of treatment within each individual. Second, we used experimental pain, which has been used in previous acupuncture analgesia studies and is more reliably comparable and controllable across subjects and sessions compared with chronic pain. Finally, we included pretreatment training sessions and established strict criteria to exclude subjects who were not able to rate the experimental pain stimuli reliably. This last element significantly reduced noise in the data that would have resulted from unstable pain ratings had we not included such rigorous training and screening in our study. These three aspects of our study design allowed us to detect significant analgesic effects of acupuncture in response to calibrated noxious stimuli.

This pilot study is limited by the small cohort size, which consisted only of healthy subjects able to reliably sense and report nonclinical pain. We want to emphasize here that the positive finding was clearly exploratory and that additional studies to examine the effect of acupuncture treatment on pain in clinical populations in larger sample sizes are necessary. This preliminary result may be of importance for the design of further confirmative studies. Improvements in study design for future clinical trials of acupuncture, such as validated tools for the subjective assessment of the *deqi* sensation and better sham control conditions, may confer greater sensitivity to detect true therapeutic effects of acupuncture.<sup>43</sup>

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