# The Effect of Acupressure on the Bispectral Index and Entropy Parameters in Mentally Handicapped Humans: A Pilot Study

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**Citation**

G Schwarz, G Litscher, L Wang, A Schoepfer, I Roetzer. *The Effect of Acupressure on the Bispectral Index and Entropy Parameters in Mentally Handicapped Humans: A Pilot Study*. The Internet Journal of Neuromonitoring. 2004 Volume 4 Number 1.

**Abstract**

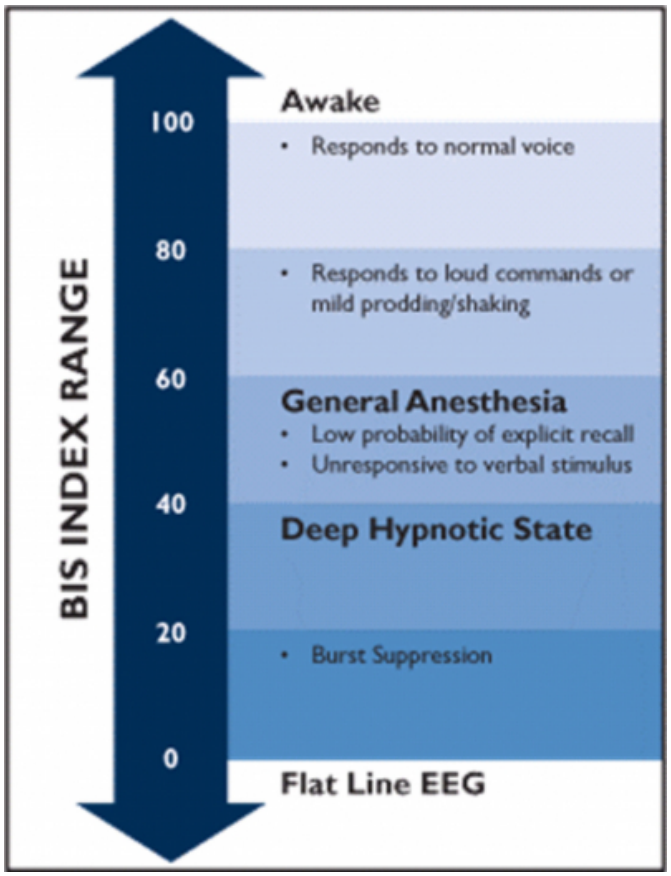
In the following pilot study, we give the first description of the effect of acupressure on the bispectral index (BIS), response entropy (RE), state entropy (SE), as well as on the emotional state of persons with congenital and acquired mental disabilities. A decrease in BIS readings (n=4) during acupressure was shown: the minimal decrease was 12%, the maximal decrease was 39%. The entropy readings (n=3) showed a minimal decrease of RE at 6% and of SE at 7%. The maximal decrease of RE was 76%, of SE 71%. After cessation of acupressure, all readings returned to almost the level that had been prior to the application of acupressure. All volunteers (n=5) found the effect of the acupressure to be comfortably relaxing; 3 volunteers experienced a feeling of tiredness, and 2 of these 3 entered intermittent short sleep phases. The results of the study presented here indicate that acupressure, when applied at appropriate pressure points, can aid in the peri-interventional phase a reduction of stress for mentally disabled humans. However, further development in the method is necessary for perioperative use, because the suppressive effect on bioelectrical activity remains limited to the active phase of acupressure.

## INTRODUCTION

Monitoring of the bispectral index (BIS) offers an infinite number of possibilities to better assess cerebral activity under the influence of narcotics and sedatives ([1]). BIS readings ranging from 100 to 90 reflect awareness; BIS readings between 90-60, respectively 65, a sedative state. BIS readings under 60 are adequate for anaesthesia during surgery. BIS values < 40 should indicate a deep state of anesthesia (see fig.1).

**Figure 1**

Figure 1: BIS – Index range.




For entropy parameters it is also postulated to correlate with hypnotic depth of anesthesia, based on the extent of the irregularity of EEG signals ([2]). High entropy readings indicate a high irregularity of electrocerebral biosignals and correspond to the state of awareness. More consistent electrocerebral biosignals generate lower entropy readings and correspond to a state where consciousness is unlikely ([3]). The fast-reacting response entropy (RE) is calculated according to a measurement frequency range of up to 47 Hz and made up of EEG signals and frontal EMG signals (FEMG) ([4]); the reading range lies between 0-100. The more stable state entropy (SE) is calculated according to an EEG frequency range of up to 32 Hz, with a reading range between 0-91. The complete algorithm has been published by Viertiö-Oja et al. ([5]).

Investigations in awake volunteers ([6,7]) show that during acupressure at the Yintang acupoint, a significant drop in BIS occurs, accompanied by a subjective perception of suppression of stress.

The aim of this pilot study was to examine whether the effect of acupressure at Yintang on BIS and on entropy is demonstrable with mentally disabled patients, as well as whether a clinical correlation, in the sense of emotional relaxation, is subjectively felt.

## METHODS

Five volunteers with congenital or acquired mental disabilities were investigated (for further data see tab. 1). Volunteers were directly accompanied by either a parent/guardian or care person. The study was approved by the Ethics Committee of the Medical University of Graz. All parents/guardians or care persons gave written consent on behalf of the volunteers. All volunteers were able to answer questions correctly relating to status of their personality, time, situation, and place, as well as appropriately communicate. They were all active socially integrated and worked regularly at special sheltered workshops.

**Figure 2**

Table 1: Biometric data, etiology of disability and social integration.

| Volunteer | Age | Gender | Etiology | Regular occupational activity |
|---|---|---|---|---|
| 1 | 21 | f | peripartal asphyxia | + |
| 2 | 18 | m | chromosomal trisomy | + |
| 3 | 25 | m | chromosomal trisomy | + |
| 4 | 37 | f | chromosomal trisomy | + |
| 5 | 38 | m | meningoencephalitis | + |

## PARAMETERS

BIS: Two channels of spontaneous electrical activity were recorded from EEG electrodes (Zipprep® self prepping electrodes; Aspect Medical Systems Inc., Natick, MA, USA).

The skin-electrode impedances were < 2 k.

Low cut-off frequency was 2 Hz and high cut-off frequency was 30 Hz.

The EEG was measured continuously using an Aspect A-1000® System (version 3.12; Aspect Medical Systems Inc., Natick, MA, USA).

Entropy: The EEG signals were recorded from frontal and temporal areas via self-adhesive sensors (Entropy Sensor, Datex Ohmeda, Helsinki, Finland); the signal processing and display ran over the S/5 Entropy module (M-Entropy; Datex Ohmeda, Helsinki, Finland).

## STUDY DESIGN

After a period of steady state (control 1) > 3 minutes (min),

acupressure at the acupoint Yintang was started for a duration lasting from 6-10 min. Afterward, the EEG parameters were checked for a further 3 min period (control 2). During the control 1 phase, the highest reading of the electrophysiological parameters and the mean value of 3 measuring points (1-minute intervals) were calculated. For the acupressure phase, the lowest reading, as well as the mean value difference before acupressure and the lowest reading during acupressure (absolute and percentage) of BIS and entropy parameters were ascertained. For control phase 2, the highest readings were determined.

## ACUPRESSURE

Acupoint Yintang is located midway between the medial ends of the two eyebrows at the root of the nose. To assess the reliability and validity of acupressure, pressure on the acupoint was applied by the same medical doctor experienced in traditional Chinese medicine. The thumb pressure was estimated to be about 3x $10^5$ Pa ($_7$). Pressure was applied in alternating directions (clockwise and anti-clockwise) ($_7$). The patients were in a semi-lying position with eyes closed during the study.

## APPRAISAL OF SUBJECTIVE SENSITIVITY

In order to assess the subjective emotional sensitivity and perception regarding the effect of acupressure, 3 simply formulated questions were to be answered:

a) Does pressure at the acupoint cause pain? Yes – No
b) How do you feel during acupressure?
Uncomfortable – Comfortably-relaxed – Unchanged
c) Do you feel tired during acupressure? Yes – No

## RESULTS

The subjective appraisal of individual sensitivity during acupressure is listed below in table 2.

### Figure 3

Table 2: Individual sensitivity appraisal during acupressure.

| | Pain | | Sensitivity | | | Tiredness | |
|---|---|---|---|---|---|---|---|
| Volunteer | yes | no | uncomfortable | comfortably-relaxed | unchanged | yes | no |
| 1 | - | + | - | + | - | - | + |
| 2 | - | + | - | + | - | - | + |
| 3 | - | + | - | + | - | + | - |
| 4 | - | + | - | + | - | +* | - |
| 5 | - | + | - | + | - | +* | - |

*intermittent short phases of sleep

The effects of acupressure on BIS and entropy parameters are summarized in table 3.

### Figure 4

Table 3: BIS and entropy (response entropy, state entropy) values before, during and after acupressure.

| | BIS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Control 1 | | Acupressure | | | Control 2 | | | | | | |
| Volunteer | x VBA | max VBA | min VDA | Δ abs | Δ % | max VAA | | | | | | |
| 1 | 92 | 94 | 56 | 36 | 39 | 90 | | | | | | |
| 2 | a | a | a | a | a | a | | | | | | |
| 3 | 98 | 100 | 80 | 18 | 18 | 95 | | | | | | |
| 4 | 83 | 86 | 50 | 33 | 39 | 83 | | | | | | |
| 5 | 97 | 98 | 85 | 12 | 12 | 97 | | | | | | |
| | RESPONSE ENTROPY (RE) | | | | | | STATE ENTROPY (SE) | | | | | |
| | Control 1 | | Acupressure | | | Control 2 | Control 1 | | Acupressure | | | Control 2 |
| Volunteer | x VBA | max VBA | min VDA | Δ abs | Δ % | max VAA | $\bar{x}$ VBA | max BAP | min VDA | Δ abs | Δ % | max VAA |
| 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| 2 | a | a | a | a | a | a | a | a | a | a | a | a |
| 3 | 90 | 91 | 85 | 5 | 6 | 91 | 97 | 100 | 90 | 7 | 7 | 96 |
| 4 | 86 | 91 | 64 | 22 | 25 | 83 | 79 | 80 | 60 | 19 | 24 | 92 |
| 5 | 99 | 100 | 29 | 70 | 71 | 100 | 89 | 90 | 21 | 68 | 76 | 91 |

| | |
|---|---|
| $\bar{x}$ VBA | mean of 3 measuring points (intervals of 60 s) before acupressure (baseline) |
| max VBA | maximal value before acupressure |
| min VDA | minimal value during acupressure |
| Δ abs | difference between $\bar{x}$ VBA and min VDA in absolute values |
| Δ % | percentile difference between $\bar{x}$ VBA and min VDA |
| max VAA | maximal value within 3 min after acupressure |
| a | artefact |

### Figure 5

Figure 2: BIS, RE and SE registration during acupressure.

### Figure 6

Figure 3: BIS values and trend graphs before (left) and during (right) acupressure.

In one volunteer (Nr 1), only the BIS was performed; in another volunteer (Nr. 2), an equivocal evaluation of the electrophysiological reading was impossible, due to contamination caused by movement artefacts. The average

BIS value before acupressure was 93 (range 83-97). Changes of BIS and entropy occurred in all volunteers where an interpretation of the reading was possible. The most noticeable difference between the mean baseline BIS-values before acupressure and the lowest BIS readings during acupressure was 12 (12%); the greatest difference was 33 (39%). The mean value of the control phase prior to acupressure was 92 for RE, and 88 for SE. For RE the greatest difference was 70 (71%) and for SE 68 (76%); for the lowest differences see table 3. Readings after acupressure returned to near baseline readings in all volunteers (see tab. 3).

## DISCUSSION

Preoperative stress and anxiety can influence intra-operative requirements and the recovery phase. In contrast, anxiolytic and sedative drugs can prolong the awakening time, and therefore - especially in mentally disabled patients - prolong the time until dismissal of the PACU. This fact becomes very obvious in ambulatory dental manipulation of mentally disabled patients under general anesthesia, because these patients have a prolonged recovery time in general.

Acupressure is a nonpharmacological stimulation intervention and it has been shown to suppress postoperative nausea and vomiting ([8]) and to improve the quality of sleep ([9]). The report of Wang et al. ([10]) has shown that patients undergoing elective ambulatory surgery experienced less preoperative anxiety when auricular acupuncture was used. Further, there are reports that acupuncture can influence BIS readings ([11]). Recent studies have shown that acupressure of Yintang (extra 1 acupuncture point) reduces BIS readings and subjective stress indicators in volunteers ([6,7]). Similarly, acupressure at the same acupoint influences the readings of the A-line autoregressive index (AAI). The basis of this parameter are the middle latency auditory evoked potentials; this parameter is also used for measuring the depth of anaesthesia. Acupressure of the extra 1 acupuncture point leads to a decrease of AAI values and to a significant reduction of stress levels ([12]).

For mentally disabled patients, the encroachment on their personal integrity, caused by an imbalance in the relationship between stressful situations and the ability to cope with these implies an especially great emotional toll. Central effective sedative drugs can have a prolonged effect on the awaking and release time; additionally, the level of trust to the anesthesiologist team suffers long-term when acupuncture with needles is administered. For this reason acupressure before (but also after) ambulatory interventions requiring anesthesia (e.g. dental rehabilitation) appears to be a suitable alternative way of reducing preoperative stress for mentally disabled patients.

The parameters BIS and entropy were chosen to objectify the effects of acupressure on bioelectrical activity of the brain. These parameters are mainly used intraoperatively to monitor the hypnotic effect of anesthetic drugs. Comparative evaluation of BIS, RE and SE revealed similar information about the level of sedation ([13]). Varying influences can contaminate the readings, and, under certain conditions, paradoxical data can be recorded which do not correlate to the actual depth of anesthesia ([14]). Nonetheless, monitoring the depth of anesthesia based on EEG-activities significantly enriches the anesthesiological assessment. It is also reported that correlation exists between BIS readings and the different stages of physiological sleep ([15]). Conversely, a discrimination between pharmacologically-induced sleep and physiological sleep on the basis of this parameter is not possible. Likewise, when interpreting the readings, the wide range of possible values in various sleep phases must be scrutinised ([16]).

BIS and entropy readings of awake patients in comparison to the spectral edge frequency (SEF) point to a high intrapersonal stability and low interindividual deviation of the readings ([18]). Therefore BIS and entropy seem to be suitable parameters for our study.

The BIS values of volunteers 1, 3, 4 and 5, prior to acupressure were on average within a range of BIS > 90. In comparison to the measurement phase prior to acupressure, a reduction of BIS values occurred in all patients (at least 12%, maximum 39%) after onset of acupressure. After cessation of acupressure BIS readings rose back to the range of baseline readings.

The smallest changes for RE and SE of volunteers 3, 4, 5 were 6%, resp. 7%; the greatest change was 71%, resp. 76%. The entropy readings after acupressure also returned near to baseline levels.

Of course, it was also of great interest whether the acupressure-related changes of numerical EEG descriptors were accompanied by the similar emotional stress lowering effects as described in healthy volunteers ([6,7]). In order to ensure the patients' cooperation in regards to their own

estimation of sensitivity during acupressure, a differentiated scale - a verbal stress scale (VSS) - based on 10 different stress levels, was waived. Instead, three simple questions were to be answered (see methods). The state of all volunteers was categorised as comfortably relaxed; in 3 of these patients this sensation was accompanied by tiredness (see tab. 2); in 2 of them intermittent short phases of sleep appeared. Regarding the sensation of pressure at the Yintang stimulation point none of the volunteers in our study reported discomfort due to acupressure. This could be caused by the method of application of the pressure stimulus.

The results presented here are encouraging. However, our data as well as the data presented in the literature show that the suppressive effects of acupressure on the readings of EEG-indices ([6,7]) and AAI ([12]) are recordable only during the stimulation phase. For becoming an effective perioperative clinical application, further suitable methods for a continuous application of the local pressure for prolonging the effect of the applied acupressure need to be developed. Additional comprehensive studies with major patient cohorts are necessary.

## ACKNOWLEDGEMENTS

The authors thank the Styrian Government FA8B and FA11B (Projects 22.0-616/03-1ad and 34-812/03-e) and Prof. H. Kärcher, MD (Head of Department for Oral, Craniomaxillar and Facial Surgery, Medical University of Graz) for the support of this study.

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