A multiphase study on the effects of electroacupuncture (EA) and transcutaneous electrical acupoint stimulation (TEAS) on the EEG and heart rate variability (HRV):

Some preliminary results

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(University of Hertfordshire)
Overview – clinical and research relevance

• What does electrical stimulation do to the brain and heart?
• Is it beneficial?
• Is it safe?
• Can particular states be induced?
• Do different treatment parameters change the effect? (stimulation frequency, acupoints, EA vs TEAS)

• EEG and HRV are both low-cost, relatively accessible research tools – why not use them?
Preliminary results

Part I. Encephalography (EEG)

Part II. Heart rate variability (HRV)

Part III. Expectation of feelings – a questionnaire

Part IV. Electrical potential measurements during EA/TEAS
## Protocol for Pilot1 (12 visits) – parameters

\[ N = 7 \text{ acupuncturists (5 crossover, + 2 individual visits)} \]

### Stimulation frequency

<table>
<thead>
<tr>
<th></th>
<th>Modality</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 2.5 Hz</td>
<td>TEAS</td>
</tr>
<tr>
<td>2. 10 Hz</td>
<td>TEAS</td>
</tr>
</tbody>
</table>

(for whole visit, in counterbalanced order)

### Locations used

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. LI4-ST36 (left)</td>
<td>4. LI4(^2) &amp; ST36(^2)</td>
<td></td>
</tr>
<tr>
<td>2. LI4-ST36 (right)</td>
<td>LRBilat</td>
<td>5. LI4(^2)</td>
</tr>
<tr>
<td>3. LI4-ST36 (bilateral)</td>
<td>UDBBoth</td>
<td>6. ST36(^2)</td>
</tr>
</tbody>
</table>

(each combination for 5 minutes, in counterbalanced order)
Electroencephalogram (EEG)

EEG is a rich and complex data stream with high temporal resolution that is a direct measure of the brain's electrical activity of the summation of the post-synaptic potentials of the Pyramidal neurons in the cortex.

It reflects the spontaneous self-regulation of the cortex and index of arousal of cortical areas.

The Human Brain weighs 2% of the body but consumes 20% of total body oxygen. It accounts for 25% of total body glucose utilization.

19 Channel Raw EEG - Eyes opened

Examples of different waves.
International Ten-Twenty system of Electrode placement

- **Fp** = Frontal pole
- **F** = Frontal
- **C** = Central (no central lobe)
- **T** = Temporal
- **O** = Occipital
- **P** = Parietal

Odd numbered on the left.

Even numbers on the right

“Z” (zero) refers to the electrode on the midline.

The smaller the number the closer to the midline

A is for ear lobe

---

EEG Spectrum

Looking down on the head
Nose at the top

The bottom “X” axis is Frequency from 0 to 30 Hz
The side “Y” axis represents Amplitude (*Absolute EEG power in μV²*)
or Power (*Relative EEG power in %*). Relative amplitude averaged over 3-30 Hz range.
This is the "POST" minus the "PRE" and makes the difference wave.

Where activity that is: Positive number means "More" activity in the "POST" that in the "PRE" Negative number means "More" activity in the "PRE" that in the "POST".

P=0.01261

The bins with statistically significant (t-test) differences are marked by bars at the bottom of each curve.

The smallest ones correspond to \( p<0.05 \) (z-score >2), the largest ones - to \( p<0.001 \) (z-score>3), the medium ones – to \( p<0.01 \) (z-score>2.6).
EEG – objectives

• To detect variations in the EEG following EA/TEAS at two different frequencies and 6 different acupoint locations

• To determine whether an EEG ‘frequency following response’ (FFR) occurs in different regions of the cortex, and whether this occurs preferentially at particular frequencies (2.5 or 10 Hz) or acupoints
EEG Recording timeline

VISITS 1 & 2

**Time**

- Capping up: 10 to 15 min
- Pre-EC: 5 min
- Pre-EO: 5 min
- Stim session 1: 5 min
- Recording slot 1: 5 min
- Stim session 2: 5 min
- Recording slot 2: 5 min
- Stim session 6: 5 min
- Recording slot 6: 5 min
- Post-EO: 5 min
- Decapping: 2 min

EC = Eyes closed
EO = Eyes open
All Post Stim recording with Eyes closed

**Mitsar 202-DC**

- 19 Channels ECI Electrode Cap
- 24 Channels EEG
- 8 physiological Channels
  - DC to 150 Hz
  - 24 bit, 500 Hz/channel

**Nexus 4**

- 4 Channel Wireless physiological: EEG, EMG, ECG, EOG, BVP, SC/GSR, Skin Temperature and Respiration Sensor
EEG – statistically significant (t-test) differences

Grand Average changes in Percentage EEG power from Pre Stimulation to Post Stimulation in ALL visits (N = 12).

<table>
<thead>
<tr>
<th>Grand Average</th>
<th>Compared to Grand Average</th>
<th>p-Value</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALL subjects N.12</td>
<td>ALL Pre Eyes Closed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ALL Post Eyes Closed</td>
<td>INCREASE at 10 to 11 Hz</td>
<td>p=0.0126</td>
<td>C3</td>
</tr>
<tr>
<td></td>
<td>INCREASE at 10 to 11 Hz</td>
<td>p=0.0468</td>
<td>C4</td>
</tr>
<tr>
<td></td>
<td>DECREASE at 4.15 Hz</td>
<td>p=0.0343</td>
<td>T4</td>
</tr>
<tr>
<td></td>
<td>DECREASE at 14 Hz</td>
<td>p=0.0372</td>
<td>T4</td>
</tr>
<tr>
<td>ALL ST36 to ST36</td>
<td>INCREASE at 6.59 Hz</td>
<td>p=0.0385</td>
<td>O2</td>
</tr>
<tr>
<td>ALL Right LI4 to ST36</td>
<td>INCREASE at 10.50 Hz</td>
<td>p=0.0433</td>
<td>C3</td>
</tr>
<tr>
<td>ALL Bilateral LI4 to ST36</td>
<td>INCREASE at 10.25 Hz</td>
<td>p=0.0465</td>
<td>C3</td>
</tr>
</tbody>
</table>
Grand Average ALL Post EC minus Grand Average ALL Pre EC

A positive number means “More” activity in the “POST” that in the “PRE”
EEG – statistically significant (t-test) differences by **Stim Locations**

<table>
<thead>
<tr>
<th>Grand Average (N = 6)</th>
<th>Stim Freq</th>
<th>Compared to Grand Average (2.5 Hz Pre Eyes Closed)</th>
<th>p-Value</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post Eyes Closed</td>
<td>2.5 Hz</td>
<td>INCREASE at 7.08 Hz</td>
<td>p=0.0295</td>
<td>P4</td>
</tr>
<tr>
<td>ST36 to ST36</td>
<td>2.5 Hz</td>
<td>INCREASE at 7.08 Hz</td>
<td>p=0.0286</td>
<td>P4</td>
</tr>
<tr>
<td>LI4 to LI4</td>
<td>2.5 Hz</td>
<td>INCREASE at 7.08 Hz</td>
<td>p=0.0286</td>
<td>P4</td>
</tr>
<tr>
<td>Left LI4 to ST36</td>
<td>2.5 Hz</td>
<td>INCREASE at 7.08 Hz</td>
<td>p=0.0465</td>
<td>P4</td>
</tr>
<tr>
<td>Ditto</td>
<td>2.5 Hz</td>
<td>INCREASE at 10.01 Hz</td>
<td>p=0.0364</td>
<td>F7</td>
</tr>
<tr>
<td>Bilateral LI4 to ST36</td>
<td>2.5 Hz</td>
<td>INCREASE at 7.08 Hz</td>
<td>p=0.0124</td>
<td>P4</td>
</tr>
<tr>
<td>Post EO</td>
<td>10 Hz</td>
<td>INCREASE at 10.74 Hz</td>
<td>p=0.0231</td>
<td>Cz</td>
</tr>
</tbody>
</table>

**At 2.5 Hz** 4 out 6 Stim Locations show an increase of 7 Hz activity at P4
Grand Average 2.5 Hz Left LI4 to ST36 – Grand Average 2.5Hz Pre EC  \( N = 6 \) Percentage (%)
EEG – conclusions

• Group Pre-Post differences probably show a lowering of arousal over the duration of the session.

• At 2.5 Hz Stim, 4 out 6 Stim Locations and the overall Pre-Post show an increase of 7 Hz activity at P4.

• At 10 Hz Stim NO pattern of change was seen.

• The hypothesis of a ‘frequency following response’ in the brain in response to peripheral stimulation was not supported.
Part II. Heart rate variability

“The hard and brittle will surely fall, and the soft and supple will overcome”

(Laozi – *Daodejing*)

“Complexity (like variability) is a sign of health”

(Bornas et al. 2007)
Heart rate variability (HRV) – background

- Variation of the RR interbeat interval
- Result of sympathetic and parasympathetic interplay
- Indicates autonomic flexibility
- Decreases in chronic stress and many conditions
- Shows relative rather than absolute reliability
- Results often contradictory in acupuncture studies.
Heart rate variability (HRV) – objectives

To investigate the effects on HRV of:

• 2.5 Hz and 10 Hz stimulation
• Different stimulation locations
• ‘Tincture of time’

and

• Whether such effects are ‘beneficial’ or not.
Protocol – equipment

<table>
<thead>
<tr>
<th>Hardware</th>
<th>Software</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mitsar 202 DC</td>
<td>Kubios 2.0</td>
</tr>
<tr>
<td>Nexus 4</td>
<td></td>
</tr>
</tbody>
</table>

ECG electrodes on right wrist: black negative, white ground (positive on left wrist)
## Heart rate variability (HRV) – methodology

<table>
<thead>
<tr>
<th>HRV measure</th>
<th>‘Beneficial’ change</th>
<th>Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>RR (mean &amp; SD)</td>
<td>+ (SD +)</td>
<td>** (SD –)</td>
</tr>
<tr>
<td>HR (mean &amp; SD)</td>
<td>– (SD +)</td>
<td>** (SD *)</td>
</tr>
<tr>
<td>RMS SD</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>Triangular index</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>HF absolute power</td>
<td>+</td>
<td>*</td>
</tr>
<tr>
<td>LF absolute power</td>
<td>+</td>
<td>*</td>
</tr>
<tr>
<td>LF/HF ratio</td>
<td>–</td>
<td>**</td>
</tr>
<tr>
<td>Poincaré SD1</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>Poincaré SD2</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>Sample Entropy</td>
<td>+</td>
<td>*</td>
</tr>
<tr>
<td>Correlation dimension D₂</td>
<td>+</td>
<td>–</td>
</tr>
</tbody>
</table>

(From 46 indices all based on the RR interbeat interval)

**Change**
- + Increase
- – Decrease

**Norms**
- ** Good
- * Average
- – Poor
HRV methodology – eight+ ways of assessing change

Slot-by-slot

[1] Slot value vs accepted normative data
[2] Slot $n-1$ to slot $n$ (‘relative difference’)
[3] Pre-EO to slot $n$ [EC] (‘overall difference’)
[3a] Pre-EC to slot $n$ [EC]

Whole visit

[4] Pre-EO to post-EO (global visit A)
[5] Pre-EO to post-slot 6 [EC] (global visit B)
[6] Pre-EC to post-slot 6 [EC] (global visit C)
[7] Pre-EC to post-EO (global visit D)
HRV results – comparisons

Whole group
Baseline data against literature (basic agreement)

Subgroups (factor levels)
1. 2.5 Hz vs 10 Hz (2)
2. Visit1 vs visit2 (2)
3. Acupoint location combinations (6)
4. Change over time, by slot (6), or split-half (2)
5. Participants (7)
## HRV results – 2.5 Hz vs 10 Hz

<table>
<thead>
<tr>
<th>Method</th>
<th>Result</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>[1] t-test, 1-way ANOVA (means)</td>
<td>More increases with 2.5</td>
<td>2.5 &gt; 10 Hz*</td>
</tr>
<tr>
<td></td>
<td>More beneficial with 2.5</td>
<td></td>
</tr>
<tr>
<td>[2] relative slot diffs</td>
<td>More change with 10**</td>
<td>10 &gt; 2.5 Hz</td>
</tr>
<tr>
<td>[3] overall slot diffs (counts)</td>
<td>More change with 10</td>
<td>10 &gt; 2.5 Hz</td>
</tr>
<tr>
<td></td>
<td>(More beneficial with 2.5)</td>
<td>(2.5 &gt; 10 Hz)</td>
</tr>
</tbody>
</table>

**Conclusion**

- Gather more data to enable better stats
- Use method [3a]; drop method [7]

* only 1 index significantly different at baseline  
** but less carry-over to post-EO
## HRV results – visit1 vs visit2

<table>
<thead>
<tr>
<th>Method</th>
<th>Result</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>[1] t-test, 1-way ANOVA (means and counts)</td>
<td>More increases with v2</td>
<td>v1 &gt; v2*</td>
</tr>
<tr>
<td></td>
<td>More beneficial with v1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Greater changes in v1</td>
<td></td>
</tr>
<tr>
<td>[2] relative slot diffs</td>
<td>More change with v1</td>
<td>v1 &gt; v2</td>
</tr>
<tr>
<td>[3] overall slot diffs</td>
<td>More change with v1</td>
<td>v1 &gt; v2</td>
</tr>
<tr>
<td>[6] global C</td>
<td>Greater changes in v1</td>
<td>v1 &gt; v2</td>
</tr>
<tr>
<td>[7] global D</td>
<td>More sig diffs with v2</td>
<td>v2 &gt; v1</td>
</tr>
</tbody>
</table>

## Conclusion
- Greater, more and more beneficial changes in v1
- Drop method [7]

* Only 2 indices significantly different at baseline
HRV results – 2.5 Hz vs 10 Hz and visit1 vs visit2

Differences between means of HRV indices

* p<0.05  ** p<0.01

<table>
<thead>
<tr>
<th>HRV index</th>
<th>Hz</th>
<th>Visit</th>
<th>HRV index</th>
<th>Hz</th>
<th>Visit</th>
</tr>
</thead>
<tbody>
<tr>
<td>RR (SD)</td>
<td>*</td>
<td>**</td>
<td>LF abs pwr</td>
<td>–</td>
<td>**</td>
</tr>
<tr>
<td>HR (SD)</td>
<td>**</td>
<td>**</td>
<td>Poinc SD1</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>RMS SD</td>
<td>**</td>
<td>**</td>
<td>Poinc SD2</td>
<td>*</td>
<td>**</td>
</tr>
<tr>
<td>Tri index</td>
<td>–</td>
<td>**</td>
<td>SampEn</td>
<td>**</td>
<td>**</td>
</tr>
</tbody>
</table>
## HRV results – acupoint locations

<table>
<thead>
<tr>
<th>Method</th>
<th>Result</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>[1a] repeated t-tests*</td>
<td>Sample entropy only</td>
<td>L &gt; R</td>
</tr>
<tr>
<td>[1b] (nonsig differences)</td>
<td>14 of 18 HRV indices greater (&amp; 3 of 6 resp)</td>
<td>L &gt; R</td>
</tr>
<tr>
<td>[1c] greatest means</td>
<td>L 5, 0 R, 3 Bilat; LI4² 6, 1 ST36², 8 Both</td>
<td>L &gt; Bilat &gt; R; LI4² &gt; ST36²</td>
</tr>
<tr>
<td>[1d] &gt;1 SD from gp mean</td>
<td>Most Bilat, least R</td>
<td>Bilat &gt; L &gt; R</td>
</tr>
<tr>
<td>[2] relative slot diffs</td>
<td>Greatest mean change, most indices &gt;1 SD from gp mean, &amp; most benefits</td>
<td>LI4² &gt; others (benefits: also L &gt; R)</td>
</tr>
<tr>
<td>[3] overall slot diffs</td>
<td>Greatest mean change (benefits)</td>
<td>R &gt; others (ST36² most)</td>
</tr>
</tbody>
</table>

### Conclusion
- Gather more data to enable better stats (*ANOVA*)
- Drop method [3] and replace with method [3a]
  - L > R
  - LI4² > ST36²
**HRV & ‘tincture of time’: two common patterns**

**A & B**
[1] directional changes over visit (slots 1-6)
[1] more indices >1 SD from gp mean in slot 1 than slots 2-6

**C & D**

**Conclusion:**
In general, effects tail off with time
HRV results – Participant (ID) characteristics

Case example 7032 (1 visit, 2.5 Hz)

Most response to Left LI4-ST36 stim (visit 1 slot 1)

7032 compared to group

[1] ‘most highest’ HRV indices at baseline and in 3 or more slots
[3,4,5] Greatest mean absolute changes

This patient has a heart condition

Conclusion

There is more variability in HRV indices and reactivity with ID than any other factor
HRV results – Poincaré plots (1&2: visits, A-D: cases)
HRV results – Poincaré plots (1&2: visits, E-G: cases)
Heart rate variability (HRV) – conclusions

**Data**
There is basic agreement between baseline and normative data

**Stimulation frequency**
10 > 2.5 Hz (or 2.5 > 10 Hz?)

**Location**
L > R & LI4² > ST36²

**Time**
Greater, more and more beneficial changes in visit 1
(in general, effects tail off with time)

**Participants**
There is more variability in HRV indices and reactivity with ID than any other factor

**Assessing changes**
Methods used have to be carefully researched and selected for their methodological soundness
Part III. Expectation of feelings – a questionnaire

Background

• Expectation & placebo
• Placebo & self-healing
• Self-healing & the flow of *qi*
• *Qi* and self-awareness
• Awareness of feelings & placebo
• Expectation of feelings
Expectation of feelings – objectives

• To develop and investigate the characteristics of an ‘expectation of feelings’ questionnaire (EXPre)
• To assess whether subjective changes experienced are in line with those expected (EXPost)
• To determine what acupuncture practitioners or students expect and experience from a nontraditional acupuncture intervention, in terms of changes in bodily sensations that are sometimes difficult to define in words
Expectation of feelings – methodology

Based on

- published reports
- undergraduate projects on awareness of qi
- standard (unrelated) questionnaires
- expert opinion
- a brief focus group

Administration

- EXPre (online) and EXPost (paper) questionnaires administered before and after EA/TEAS
- Further versions also completed (EXRep at visit2, EXDebr at online follow-up)
- EXPre and EXPost also piloted as an aid to the teaching of EA ($N=35$, ongoing)
Expectation of feelings – the questionnaire 1

EXPre
• “I expect to experience a change in the feeling of …”

EXPost
• “I experienced a change in the feeling of …”
  [Please asterisk (*) those changes you noticed most]

EXRep/EXDebr
• “… Have you experienced changes in any of the feelings listed below that you could attribute to taking part in this study?”

Scoring
• yes (1)
• no (-1)
• don’t know (0)
• most noticed changes (2)
(normalised scores also explored)
## Expectation of feelings – the questionnaire 2

<table>
<thead>
<tr>
<th>Feelings</th>
<th>Aliveness</th>
<th>Heaviness</th>
<th>Receptivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Being at ease</td>
<td>Hunger</td>
<td>Relaxation</td>
<td></td>
</tr>
<tr>
<td>Being blue or down in the dumps</td>
<td>Inner bodily awareness</td>
<td>Restlessness</td>
<td></td>
</tr>
<tr>
<td>Being in control</td>
<td>Inner bodily flow</td>
<td>Sensory acuteness</td>
<td></td>
</tr>
<tr>
<td>Being spaced-out</td>
<td>Intestinal rumblings</td>
<td>Sleepiness</td>
<td></td>
</tr>
<tr>
<td>Calmness</td>
<td>Mental energy</td>
<td>Suppleness</td>
<td></td>
</tr>
<tr>
<td>Cheerfulness</td>
<td>Mental focus</td>
<td>Tension</td>
<td></td>
</tr>
<tr>
<td>Clarity</td>
<td>Nervousness</td>
<td>Tingling</td>
<td></td>
</tr>
<tr>
<td>Connectedness with others</td>
<td>Pain</td>
<td>Warmth or coolness</td>
<td></td>
</tr>
<tr>
<td>Contentment</td>
<td>Peacefulness</td>
<td>Worry</td>
<td></td>
</tr>
<tr>
<td>Excitement</td>
<td>Physical vitality</td>
<td>(32 items)</td>
<td></td>
</tr>
</tbody>
</table>

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## Expectation of feelings – results

<table>
<thead>
<tr>
<th>Feelings most expected (≥3&lt;sup&gt;rd&lt;/sup&gt; q)</th>
<th>Feelings most experienced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aliveness</td>
<td>X</td>
</tr>
<tr>
<td>Being at ease</td>
<td>Being at ease</td>
</tr>
<tr>
<td>X</td>
<td>Being in control</td>
</tr>
<tr>
<td>Calmness</td>
<td>Calmness&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>X</td>
<td>Clarity&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Inner bodily awareness&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Inner bodily awareness* (v1)</td>
</tr>
<tr>
<td>Inner bodily flow&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Inner bodily flow</td>
</tr>
<tr>
<td>Mental energy</td>
<td>Intestinal rumblings</td>
</tr>
<tr>
<td>Mental focus</td>
<td>Mental energy</td>
</tr>
<tr>
<td>Relaxation&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Mental focus&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Physical vitality (v1)</td>
<td>Relaxation*(v1)</td>
</tr>
<tr>
<td>X</td>
<td>Sensory acuteness&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>X</td>
<td>Tingling</td>
</tr>
</tbody>
</table>

a. Most experienced only in visit2

b. Only these items showed significant pre/post differences in χ² test

* ‘Most noticed’
### Expectation of feelings – results (2.5 Hz vs 10 Hz TEAS)

<table>
<thead>
<tr>
<th>Most ‘yes’ scores – 2.5 Hz (≥3rd quartile)</th>
<th>Most ‘yes’ scores – 10 Hz (≥3rd quartile)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Being at ease&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Aliveness&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Being spaced-out&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Being at ease&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Calmness&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Calmness&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>Clarity&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Cheerfulness&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>Inner bodily awareness&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Inner bodily awareness&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>Inner bodily flow&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Inner bodily flow&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>Intestinal rumblings&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>Mental energy&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>Tingling</td>
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- **a. Expected**
- **b. Not expected**

**Bold**: items in one column only
Expectation of feelings – results (2.5 Hz vs 10 Hz TEAS)

- Mean total scores increased following 2.5 Hz, but decreased after 10 Hz.
- Neither pre/post difference was significant, nor was the difference between them (Wilcoxon p>0.05)
- The largest number of ‘greatest changes’ in ‘yes’, ‘no’ and ‘don’t know’ scores occurred following 2.5 Hz
- Participants agreed more that some change had been experienced after 10 Hz than after 2.5 Hz
Mean total scores increased following visit 1, but decreased after visit 2.

Pre-post differences were significant for visit 2 only (Wilcoxon p=0.043).

The difference between pre/post differences for visit 1 and visit 2 was also significant.

The largest number of ‘greatest changes’ in ‘yes’, ‘no’ and ‘don’t know’ scores occurred following visit 1.

Mean differences between 2.5 Hz/10 Hz scores > those between visit 1/visit 2 scores.
Expectation of feelings – reliability, sensitivity, specificity

Reliability

*Test-retest reliability*
better for 10 Hz than 2.5 Hz (EXPost/EXDebr)

*Split-half reliability*
EXPre reasonably stable, EXPost least stable, EXDebr most stable

*Cronbach’s alpha*
$\alpha >0.8$ for all 4 questionnaires

Sensitivity and specificity

A ‘receiver operating characteristic’ (ROC) curve analysis of sensitivity and specificity was conducted

Validity

Validity of a measure of subjective feelings is problematic
Expectation of feelings – cluster analysis

‘Positive’, ‘negative’ and ‘neutral’ feelings

• Participants did not expect to feel a change in ‘negative’ feelings,
• Participants did expect to feel a change in ‘positive’ feelings
• Certain participants tended to have more positive or negative expectations in general than others (‘yea’ and ‘nay’ sayers), and others were more consistently uncertain.
Expectation of feelings – provisional conclusions

- Expectations of change were slightly cautious compared to changes experienced
- Experiences were different for 2.5 Hz and 10 Hz (and in visit1 and visit2)
- Participants agreed more that some change was experienced after 10 Hz than after 2.5 Hz
- However, mean total scores (and numbers of ‘yes’, ‘no’ and ‘don’t know’ scores increased more after 2.5 Hz
  —
- Participant response characteristics should be taken into account
Part IV. Electrical potential measurements during EA/TEAS

Background

In our pilot study, EEG and ECG were recorded after each session of stimulation.

If simultaneous stimulation and recording is possible, this will reduce visit time and allow us to streamline the study.
Electrical potential measurements – objectives

• To investigate electrical potentials at various sites on the body in response to EA and TEAS at fixed acupoints LI4 and ST36 in different combinations

• To assess whether such stimulation is likely to interfere with EEG and ECG recording if carried out at the same time

• To design equipment and software to enable simultaneous stimulation/recording
**Electrical potential measurements – methodology**

\[ N = 1 \text{ (1 visit)} \]

**Stimulation frequency**
- 2.5 Hz

**Stimulation locations**
- 1. LI4-ST36 (left)
- 4. LI4
- 5. LI4²
- 6. ST36²

**Measurement locations**
- 1. Left P4, P6, KI24, ST16, yintang
- 2. Left P4*-P6*, KI24-ST16, P6*-KI24*

**Modalities**
- TEAS, then EA

Potentials between points were measured using an oscilloscope.

(Acupuncture needles as well as ECG electrodes were used at the asterisked measurement points)
Electrical potential measurements – some initial results

• Voltage tolerated: TEAS ~ 10 X EA
• TEAS/EA at LI4\(^2\) – greater potentials detected at:
  Nose to left chest, nose to right ear, left chest points
• TEAS/EA at left LI4-ST36 – greater potentials detected at:
  Nose to left arm, nose to yintang, left arm to chest, left arm points
• Stimulation at ST36\(^2\) did not result in measurements at any points on the chest, arms or head greater than background noise levels.
Electrical potential measurements – conclusions

• Left-sided stimulation may affect ECG recording more than stimulation at LI4²

• EEG recording may be affected by both stimulation configurations

• ST36² is less likely to affect either EEG or ECG recording

• More rigorous study is necessary before firm conclusions can be reached
Final conclusions

**Stimulation frequency**

EEG: 2.5 Hz ≠ 10 Hz. Possibly 2.5 Hz > 10 Hz  
HRV: 2.5 Hz ≠ 10 Hz. Possibly 10 Hz > 2.5 Hz  
EXP: 2.5 Hz ≠ 10 Hz. Possibly 10 Hz > 2.5 Hz

**Location**

EEG: Effects vary with frequency. Only Both (LI4/ST36) showed no effect  
HRV: L > R & LI4² > ST36²  
POT: L ≈ LI4² > ST36²

More research is required to clarify these results.
What have we learned?

- Approach the right ethics committee!
- Find the right people to collaborate
- Sell anything you don’t need for your research funds
- Don’t be afraid to ask for help
- Discuss minutiae first
- Run a test session before you start
- Read software instructions
- Ensure participants can attend as required
- Ask the right research questions
- Learn about data analysis and statistics
- Never forget ‘tincture of time’ (allow plenty ...)
- Be prepared for frustration and a lot of hard work
What lies ahead?

**Ongoing**

Refining questionnaires

**Potential measurements study 2** \((N = 3-4)\)

A small pilot to determine if we can stimulate and measure simultaneously.

**Phase 2** \((N = 4-8)\)

A second pilot to refine methods (looking at EA vs TEAS and duration of stimulation)

Research is a serious business

**Final study** \((N = 12-16)\)

Integrating the results of previous pilots.
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Please note: The information presented here is preliminary and provisional, and should not be referenced without permission.

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