The fickleness of data: Estimating the effects of different aspects of acupuncture treatment on heart rate variability (HRV). Initial findings from three pilot studies

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Background

Heart rate variability (HRV) is a measure of the interplay between sympathetic and parasympathetic influences on heart rate.
Higher HRV is usually associated with relaxation and health benefits, lower HRV with stress/pathology. HRV is used increasingly in acupuncture research.

Electroacupuncture (EA) and transcutaneous electrical acupoint stimulation (TEAS) are frequently used variants of manual acupuncture (MA).

Methods of assessing effect

HRV values
Changes in HRV values
Correlations between HRV values
Ratios of 'high' or 'low' HRV values relative to group median
Normalised percentage difference (Diff%) between values:

e.g. $$\frac{(\text{Value at 10 Hz}) - (\text{Value at 2.5 Hz})}{(\text{value at 2.5 Hz})} \times 100$$

Coefficient of variance (CV), a measure of dispersion
Cohen's *d* (effect size)
Correlation ratio *eta* (η)
Counts of significant differences *(N)*

Conclusions

There is excellent correlation between assessment methods.
The sum of η^2 for all factors (~ effect size) = 0.678, suggesting that >2/3 of factors responsible for variance in outcomes have been identified.

The analytical methods employed here are accessible even to those with little statistical expertise. They offer a simple way of assessing the contribution of several experimental factors to outcomes when statistical significance is elusive and sample size is small. They would thus be very appropriate in acupuncture research, which tends to involve a number of independent variables in small-scale studies.

Where next?

The next small-scale Pilot in this study will focus on individual participants, within individual sessions, and with stimulation at a single location (LI4[2] or ST36[2]) within each session, rather than attempting to compare the effects of several variables at once. Careful attention will be paid to the effects of baseline HRV (**B**) and stimulation **Amp**, as well as **Hz**. A mixed models approach and multivariate analysis will also be used to analyse new and existing results, with Bootstrap to ensure a sufficiently large sample size.

Treatment factors

- Frequency (**Hz**) [primary objective]
- Location (**Loc**, pair of points)
- Duration (**Dur**)
- Amplitude (**Amp**)
- Modality (**Mod**)
- Participant (**ID**)
- Visit (**V**)
- Baseline HRV (**B**)

HRV Measures

Domain	Measure	Description	In health
time domain	RR	Mean R-R interval (ms)	↑
time domain	SDNN	R-R standard deviation (ms)	↑
time domain	RMS SD	Root mean square of successive differences (ms)	↑
frequency domain	HFpwr	HF power (mA^2)	↑
frequency domain	LF/HF	LF/HF power ratio	↓
nonlinear	ApEn	Approximate entropy	↑
nonlinear	SampEn	Sample entropy	↑
nonlinear	D_2	Correlation dimension	↑

Objectives

To assess how treatment factors contribute to changes in HRV

Some RESULTS

Counts of significant differences in 8 HRV measures for main factors over (during or after) stimulation segments (total possible for each factor: 32)

	Hz	Loc	Dur	Amp	Mod	ID	V	Baseline	Total
Pilot 1	2 (3)	0 (0)	n/a	2 (6)	n/a	8 (8)	1 (4)	(6)	13 (27)
Pilot 2	0 (1)	0 (1)	0 (0)	5 (5)	n/a	8 (8)	1 (0)	(5)	14 (20)
Pilot 3 (EA)	1 (1)	0 (1)	n/a	5 (5)	0 (0)	5 (6)	0 (0)	(6)	11 (19)
Pilot 3 (TEAS)	0 (0)	0 (0)	n/a	1 (1)	0 (0)	5 (6)	0 (0)	(5)	6 (12)
All	3 (5)	0 (2)	0 (0)	13 (17)	0 (0)	26 (28)	2 (4)	(21)	46 (77)

T-tests or 1-way ANOVA were used, with Bootstrap (Mann-Whitney or Kruskal-Wallis test counts in parentheses).

Thus ID, Baseline HRV and stimulation Amp contribute most to changes in HRV.
This is confirmed by further analysis:

Effects of the main factors: a summary

Comparison	*N*	CV	Cohen's *d*	*eta* (η)	Diff%
Hz	5	0.149	0.217	0.133	11.481
Loc	2	0.193	0.225	0.205	10.438
Visit	4	0.293	0.376	0.237	12.150
Amp	17	0.826	0.562	0.240	n/a
Dur	0	1.165)	0.113	0.051	n/a
Baseline	21	n/a	n/a	0.355	n/a
ID	28	1.030	4.156	0.613	45.217

Means are shown, except for *N*

Results for all impact assessment methods are greatest for ID, and (apart from Diff%) least for Hz.
This suggests that the effects of Hz may be masked by those of other factors.

Protocol

Pilots 1-3
Points: LI4 to LI4 (**LI4**[2]), **ST36**[2], **Left** or **Right** LI4 to ST36
Parameters: 2.5 Hz or 10 Hz (256 µs), 'strong but comfortable'
Modalities: manual (**MA**), electro (**EA**), transcutaneous (**TEAS**)

In Pilot 1 (2 visits), all Locs were used, in each visit (including 2 additional Locs).
In Pilot 2 (4 visits), one Loc was used in each visit. In Pilot 3 (4 visits), two Locs were used in each visit. Order of Locs was balanced in each Pilot.

Pilot 1. EC | EO1 | TEAS1 | TEAS2 | TEAS3 | TEAS4 | TEAS5 | TEAS6 | EO2

9 5-min time segments, all eyes closed (EC) except for EO1 and EO2 (eyes open)

Pilot 2. EO1 | MA1 | EA1 | EA2 | EA3 | EA4 | MA2 | EO2

Pilot 3. EO1 | MA1 | EA1 | EO2 | MA2 | EA2 | EO3 | TEAS1 | EO4 | TEAS2 | EO5

or

EO1 | TEAS1 | EO2 | TEAS2 | EO3 | MA1 | EA1 | EO4 | MA2 | EA2 | EO5

Pilots 2-3. All 5-min segments EO. Pilot 2: 4 x 5 mins **Dur**

In Pilot 1, HRV recorded *after* each stimulation segment; In Pilots 2 &3, recorded *during* stimulation.

Does fickleness account for the effects of frequency (Hz)?

Several methods suggest a small, non-significant difference in favour of 2.5 Hz (e.g. Fig 1). Most of these can be explained by intrinsic variation. For instance, greatest Diff% for Hz was found for SDNN, RMS SD and HFpwr. However (Fig 2), both at baseline (horizontal bars) and during stimulation (histogram), these were among HRV measures that showed greatest CV:

Fig 1

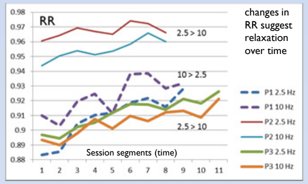
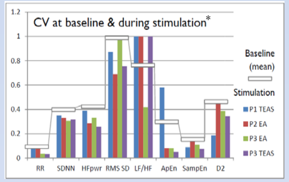


Fig 2



(*Values normalised separately)

In Pilot 2, over the 20 minutes of EA stimulation, changes in value of 7 out of 8 HRV measures were in opposite directions for the two frequencies. At 2.5 Hz, 7 measures increased, but at 10 Hz only 3 measures (e.g. Fig 3). However, plotting Diff% against CV for the 8 measures (Fig 4), it is clear that such changes are very closely associated with inherent variability (CV):

Fig 3

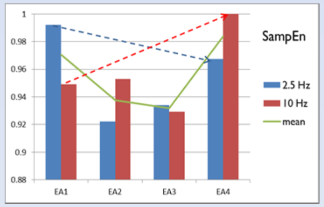
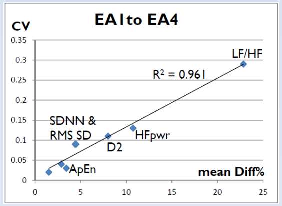


Fig 4



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Further information available at www.qeeg.co.uk/electroacupuncture/hrv1.htm, also accessible through the QR code at the head of this poster.

16th International Acupuncture Research Symposium, King's College London, 29 March 2014