# Does the cortical response to electroacupuncture depend on stimulation frequency?
# Results of a pilot EEG study first proposed at the AACP Conference in 2001[1]

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**Introduction.** EEG (electroencephalography) is a low-cost, accessible method of investigating electrical brain activity that is sensitive to rapid changes. Transcutaneous Electrical Acupoint Stimulation (TEAS), like electroacupuncture (EA), is an acupuncture-related method of stimulation.

**Objective.** To determine whether there is a central 'frequency following response' (FFR) to peripheral stimulation (i.e. if TEAS is applied at 2.5Hz, is that frequency more likely to appear in the EEG).

**Methods.** In each 2-hour session, TEAS was applied at 'strong but comfortable' intensity for 5 minutes at 6 different combinations of LI4 and ST36 (in balanced order). Five participants attended for 2 sessions (2.5Hz or 10Hz TEAS), two for one session each. EEG was monitored for 5 minutes before and after each 5-minute stimulation, recorded from scalp electrodes as electrical power or amplitude, and then analysed into frequency bands (0-45Hz), including Delta-related (c. 2.5Hz) and Alpha-related (c. 10Hz).

Changes in the following EEG measures in these bands might support the FFR hypothesis for TEAS:

- **Absolute spectral power**, ASP, the amount of electrical power, at a scalp measurement electrode in a particular EEG band (measured in $\mu V^2$)
- **Relative spectral power**, RSP, the ASP in a band divided by the total ASP for all ranges
- **Amplitude**, A (measured in $\mu V$)
- Derivations of spectral power, such as **Ratios** of spectral power in different bands, or left/right **Asymmetry**
- **Average frequency** within bands, AvHz, and its standard deviation (AvHz SD)
- Frequency with **maximum power** within bands, PkHz
- **Coherence**, Coh, a measure of phase synchronisation or coupling between signals at different electrodes
- **Cross-correlation**, XC, used to assess time delays between signals at different scalp electrodes
- **Phase delay**, PD, a measure of the temporal 'lead' or 'lag' of spectra between electrodes
- **Autocorrelation**, AC, a measure of the self-similarity of the EEG signal over time, or how often it repeats at a single electrode.

One method used to assess change in a measure was to subtract its value at 10Hz from that at 2.5Hz, and count the number of resulting (1) positive and (2) negative ('countertrend') differences. Subtracting the 2nd number from the 1st provided a 'plus – minus' (PmM) count, plotted against EEG band. Greater PmM in the EEG band centred on 2.5Hz (ctr2.5) than in that centred on 10Hz (ctr10) would support the FFR hypothesis.

## Possible confounding factors

- Stimulation amplitude (possible) – greater at 10Hz than 2.5Hz ($p<0.001$) (**Fig 1**)
- Visit order (unlikely) – e.g. comparing by visit rather than stimulation frequency results in a shift in RSP minimum from Alpha (ctr10) to Theta (ctr7.5) (**Fig 2**)
- Pre-existing baseline differences (very possible) (**Fig 3**)
- Individuality of response will obscure changes due to frequency (definite)

**Fig 1.** Amplitude & stimulation frequency

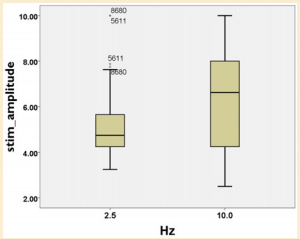



**Fig 2.** Differences in mean RSP for visit1–visit2 & 2.5Hz–10Hz

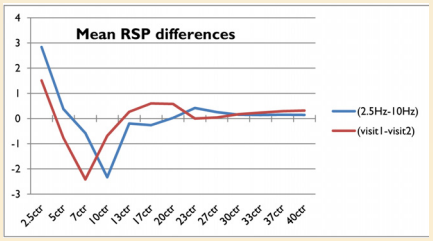
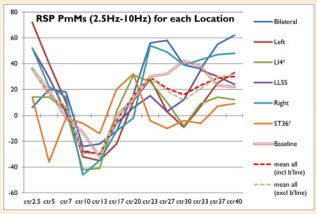



**Fig 3.** RSP PmMs, showing differential ctr2.5/ctr10 effect already at baseline, *before* stimulation.




However, RSP counts show that while proportion of positive to negative differences (2.5Hz–10Hz) was significant for all Locations (more *positive* differences for the Locations taken together), at baseline (Pre-EC), there were more *negative* differences.

This may indicate lack of a carry-over effect from baseline.

1. Mayor D.F. (2001) CNS resonances to peripheral stimulation: is frequency important? Journal of the AACP Nov, 29-63.

Detailed information available at www.qeeg.co.uk/electroacupuncture/eaffr.htm

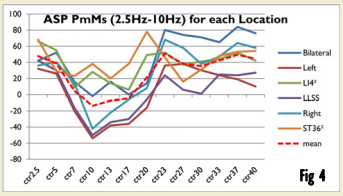
## Results.

Numbers of EEG measures findings: (a) similar for 2.5 & 10 Hz; (b) different; (c) supportive, or (d) contradictory, of the FFR hypothesis; (e) neither supportive nor contradictory of the hypothesis.

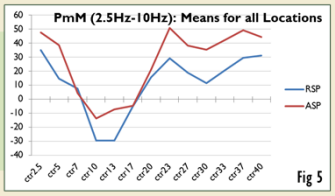
| Measure | (a) 2.5Hz≈10Hz | (b) 2.5Hz≠10Hz | (c) Supports FFR | (d) Contradicts FFR | (e) Neither |
|---|---|---|---|---|---|
| ASP | 6 | 14 | 5 | 1 | 8 |
| RSP | 9 | 19 | 4 | 1 | 14 |
| A | 5 | 8 | 2 | 1 | 5 |
| Asymmetry | 5 | 6 | 0 | 0 | 6 |
| Ratios of SP | 2 | 2 | 0 | 2 | 0 |
| AvHz & SD | 7 | 9 | 3 | 3 | 3 |
| PkHz | 2 | 3 | 2 | 1 | 0 |
| Coh | 2 | 5 | 1 | 0 | 4 |
| XC | 2 | 3 | 0 | 0 | 3 |
| PD | 1 | 5 | 2 | 2 | 1 |
| AC | 1 | 2 | 0 | 0 | 2 |
| **Totals** | **42** | **75** | **19** | **11** | **46** |

### Example findings

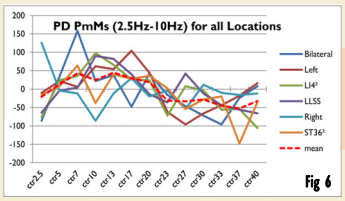
**Fig 4** ASP PmMs for all stimulation locations. **Fig 5.** Mean PmMs for ASP and RSP. Both are greater in the EEG band centred on 2.5Hz (ctr2.5) than in ctr10, supportive of the FFR hypothesis.



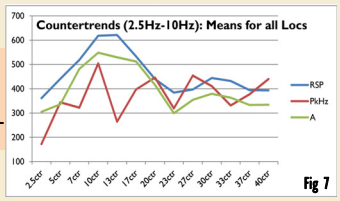

Supports FFR




However (**Fig 6**), summed (rather than averaged) PD counts show maxima and minima that do not support a FFR, although mean summed PmM is still lower in ctr2.5 than ctr10, supporting the hypothesis.




Equivocal




Summed minus ('countertrend') counts may also support the FFR hypothesis (**Fig 7**). Removing/replacing each Case in turn did not greatly change this pattern. However, such group mean patterns were not found for any individual Case (!).

Contradicts FFR

Some results did not support the hypothesis, such as changes in EEG Delta/Apha ratios.

## Conclusions

- At this stage, only ASP and RSP provide markedly more support than non-support for the FFR hypothesis.
- A central frequency following response to rhythmic electrical stimulation remains possible.
- However, individual response is very variable and may mask a FFR.
- Further research is justified, to clarify the possible role of confounding factors, and also explore issues such as whether a FFR occurs in response to some frequencies and not others, or in some individuals and not others.
- If evidence for a FFR is found, this would throw new light on the effects of different EA/TEAS stimulation frequencies on the brain and indeed different mental states, with potential for immediate clinical application.

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