Transcranial ultrasound ('TUS') – an optimal non-invasive brain-machine interface via microtubules?

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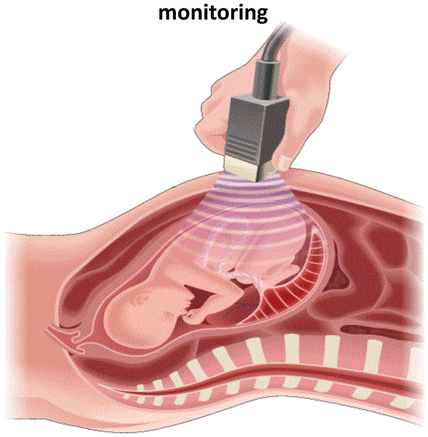
Introduction

Ultrasound (US) consists of mechanical vibrations e.g. in megahertz. Low intensity (non-thermal) ultrasound is generally considered safe when used for imaging, including fetal ultrasound.

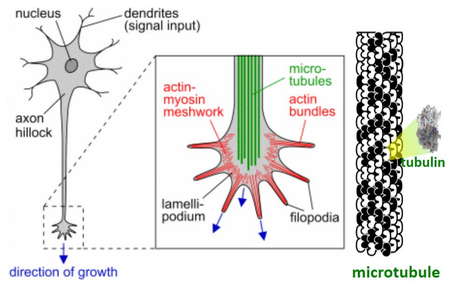
At the cellular level, ultrasound alters neuronal migration[1] and accelerates cell growth mediated by microtubules[2] which guide and regulate neuronal axon and dendrite extension. Microtubules also have resonances in megahertz.[3,4]

Can transcranial ultrasound (TUS) applied to the brain affect neuronal growth, mental states and cognitive function?

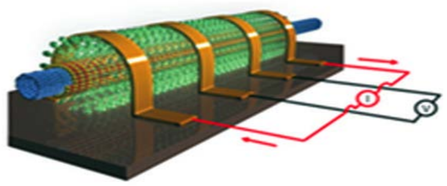
Ultrasound consists of megahertz mechanical vibrations which propagate through living tissue and reflect off surfaces, e.g. in fetal monitoring

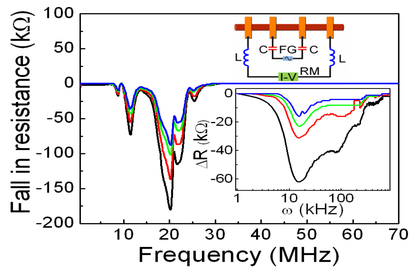


Neuronal growth and development is regulated by cytoskeletal microtubules

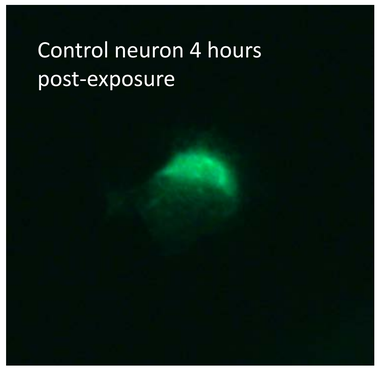


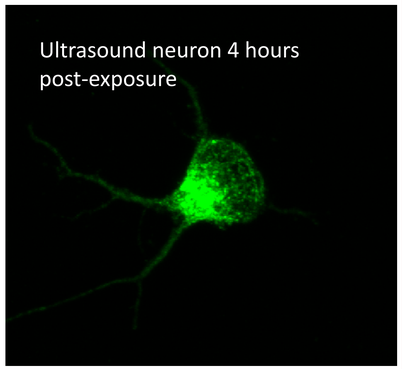
Microtubules have electronic resonances in megahertz, in ultrasound range[3,4]





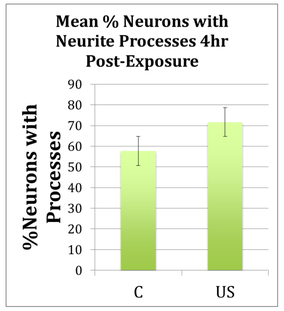
Ultrasound can accelerate neuronal development





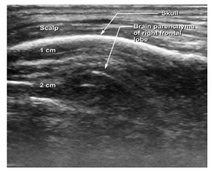
Low-intensity ultrasound promotes neurite outgrowth in cultured cortical neurons[2]

Low-intensity ultrasound promotes neurite outgrowth in cultured cortical neurons[8]



Trial	Percent Difference	p-value
1	15.3	0.002
2	14.2	0.004
3	12.4	0.007
Mean	14.0	0.002

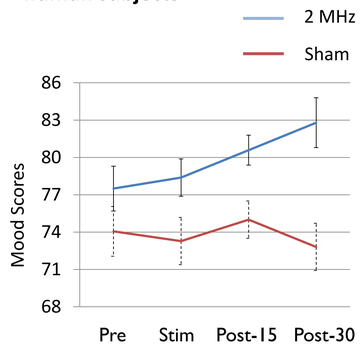
Ultrasound to the mature brain can improve mood.[5,6] (by resonating microtubules?)



Ultrasound image of brain through the skull.

Transcranial ultrasound improves mood in human subjects

- 2 Experiments
- 62 Healthy undergraduates
- Mood surveys
- 2 MHz increased positive affect
- 2 MHz increased global vigor
- No effects for sham



Low-intensity ultrasound can modulate/enhance mental states.[5,6]

Conclusions

- Ultrasound accelerates microtubule-related neuronal development
- Low/moderate transcranial ultrasound (TUS) to frontal cortex in adult humans improves mood and vigor, and is suggested for depression, TBI, Alzheimers and other disorders.
- Transcranial ultrasound (TUS) could benefit autistic subjects by promoting microtubule resonance and remapping brain circuits

References

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