

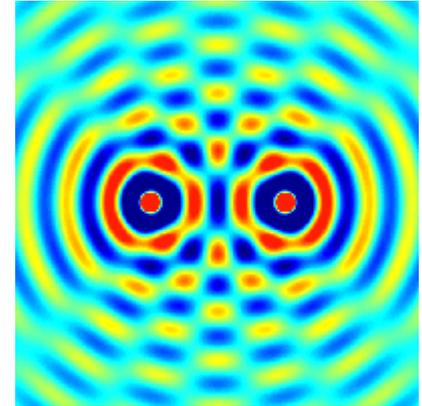


# TI stimulation - pros, cons, and future directions

Yu (Andy) Huang, Ph.D.  
Senior Scientist, Soterix Medical Inc.

What is Temporal Interference Stimulation (TI, tIS)?  
Interferential Stimulation (IFS)?

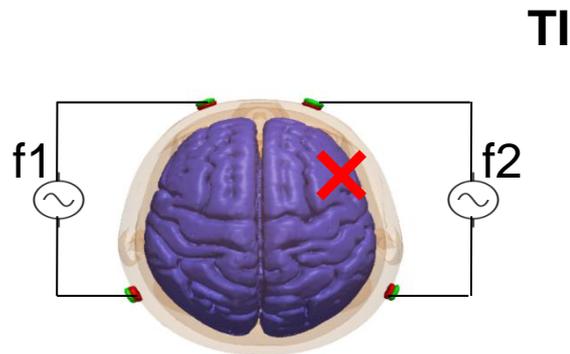
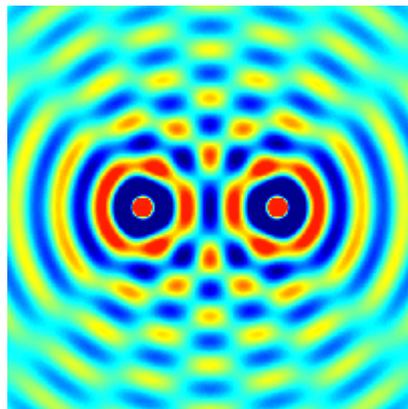
# An Analogy



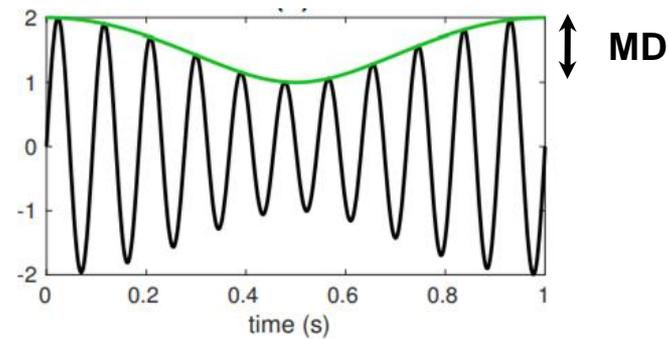
Source:  
[https://en.wikipedia.org/wiki/Wave\\_interference](https://en.wikipedia.org/wiki/Wave_interference)

# Modulation depth (MD) or intensity of TI

Cons



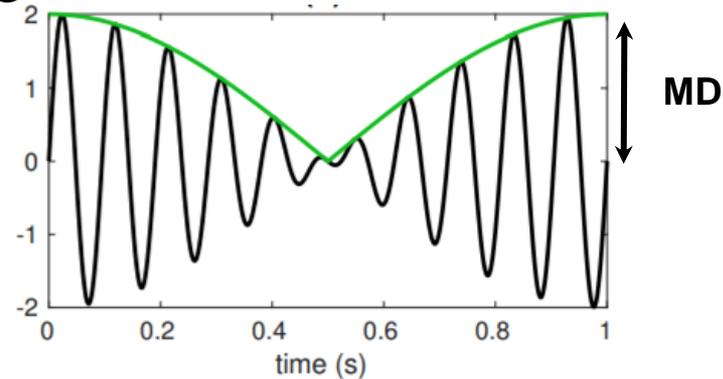
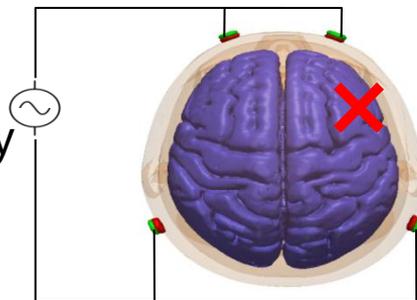
TI



^

HD-TES

$(f1+f2)/2$   
modulated by  
 $f1-f2$



**Why TI?**

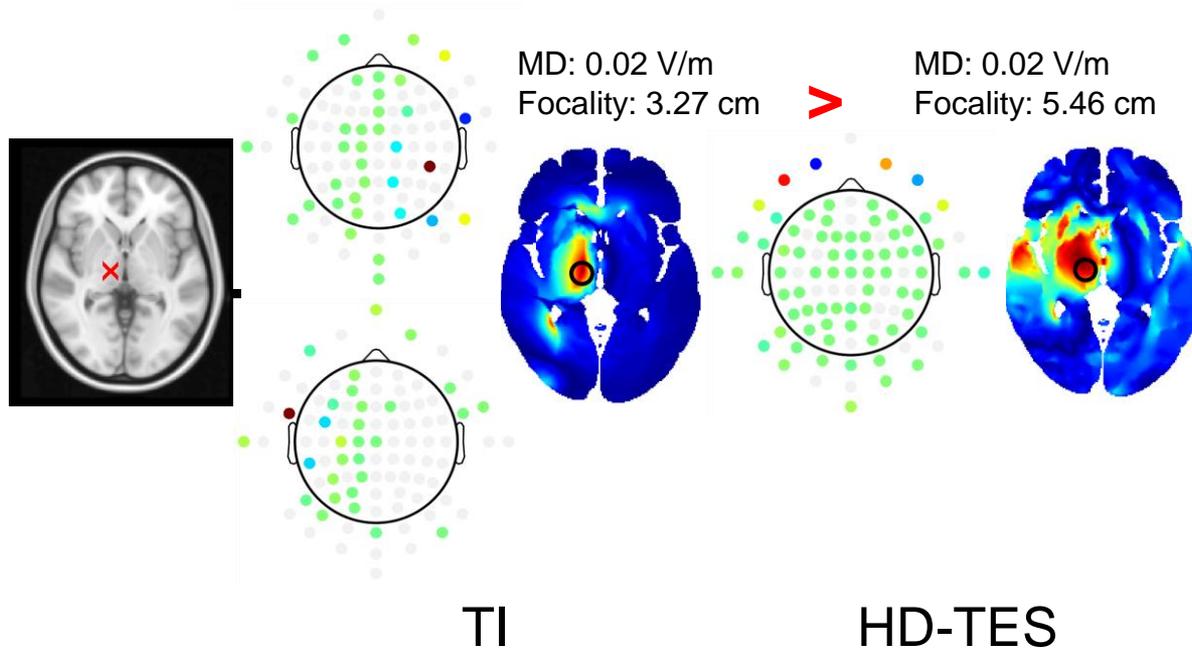
**Because of the focality**

# Optimizing TI focality

Pros

$$\begin{aligned} & \arg \max_{\mathbf{s}_1, \mathbf{s}_2} \\ & \text{s.t. } \mathbf{1}\mathbf{s}_1 = 0, \mathbf{1}\mathbf{s}_2 = 0, \\ & \|2 \min(|\mathbf{\Gamma}\mathbf{A}\mathbf{s}_1|, |\mathbf{\Gamma}\mathbf{A}\mathbf{s}_2|)\|^2 \leq P_{max}, \\ & \mathbf{1}\mathbf{s}_1^+ + \mathbf{1}\mathbf{s}_1^- \leq I_{max}, \mathbf{1}\mathbf{s}_2^+ + \mathbf{1}\mathbf{s}_2^- \leq I_{max}, \\ & 0 \leq \mathbf{s}_1^+, 0 \leq \mathbf{s}_1^-, 0 \leq \mathbf{s}_2^+, 0 \leq \mathbf{s}_2^-. \end{aligned}$$

$$2 \min(|\mathbf{e}^T \mathbf{A}\mathbf{s}_1|, |\mathbf{e}^T \mathbf{A}\mathbf{s}_2|)$$

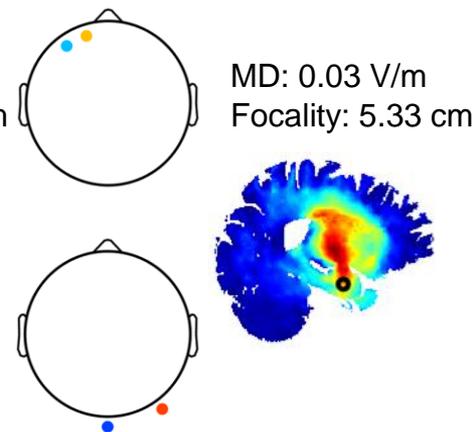
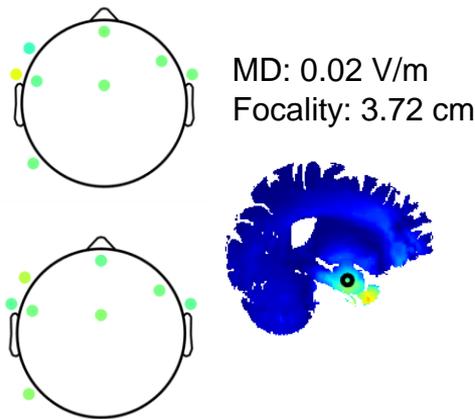
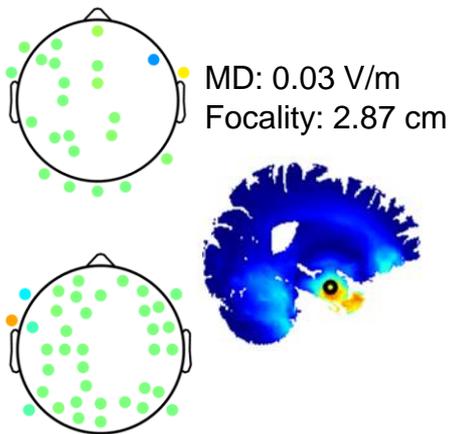
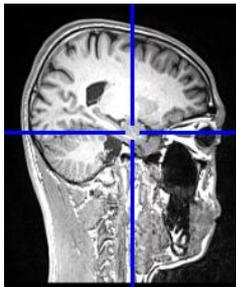


# Optimizing TI focality

Full array,  
More focal  
(sometimes);  
**Not practical**

Trade-off between  
focality/speed and practicality

Practical;  
**Less focal,**  
**Slow to compute**

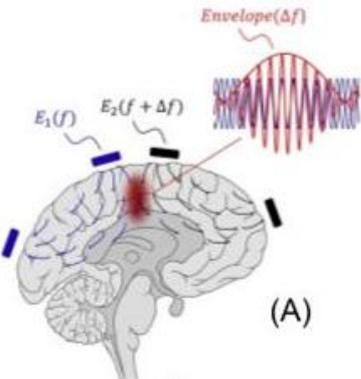


HD-Targets-IFS™  
1105 locations supported;  
more to come...

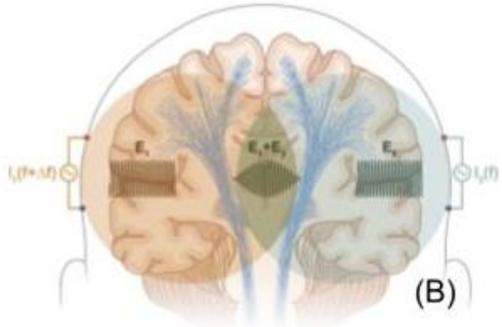
TI is special because of its ...

**Rotational  
E-field**

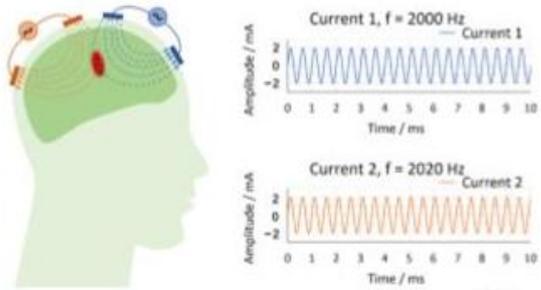
# Visualizing TI



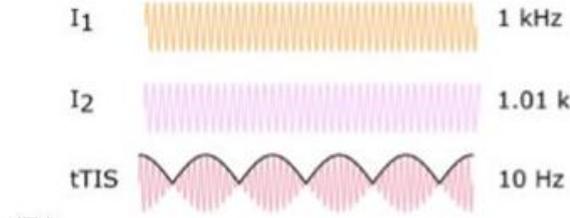
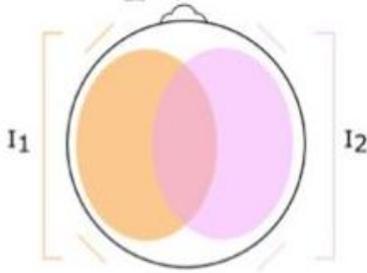
(A)



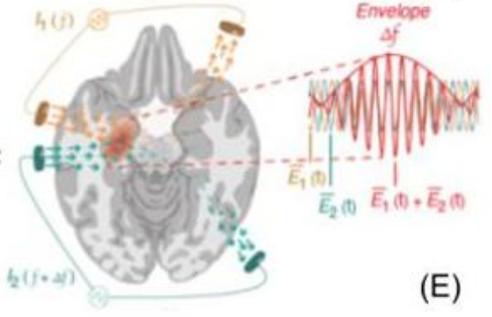
(B)



(C)



(D)



(E)

These are misleading...



S1A

S1C

S1E

S1G

S1J

S1B

S1D

S1F

S1H

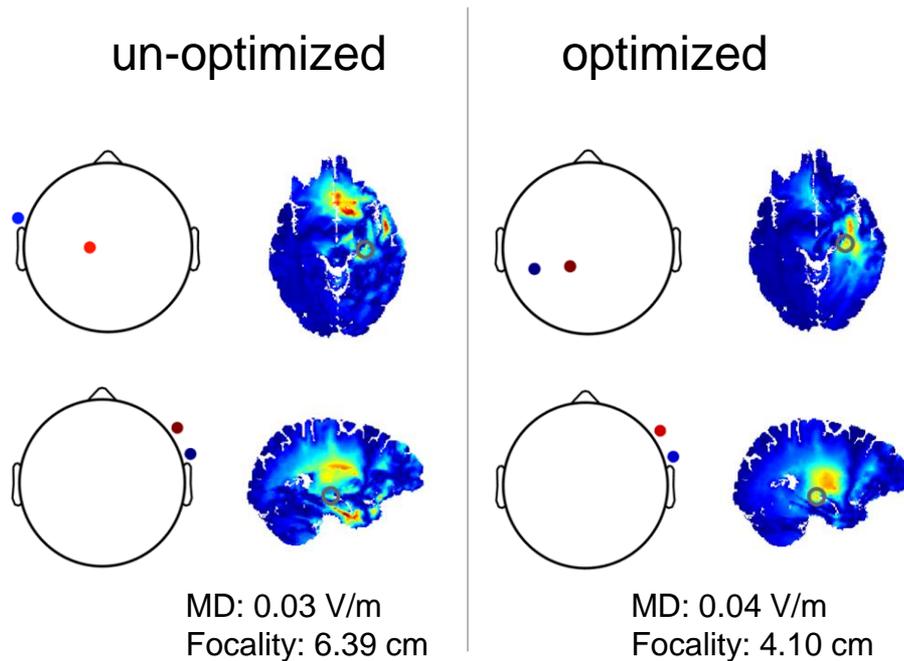
S1I

TI is special because of its ...

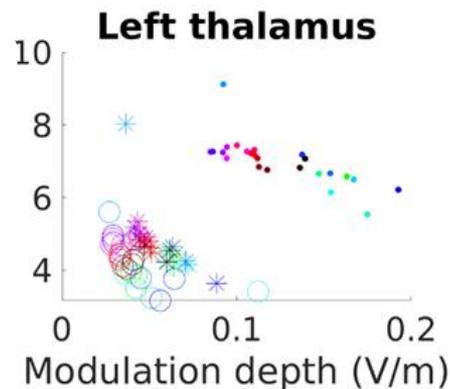
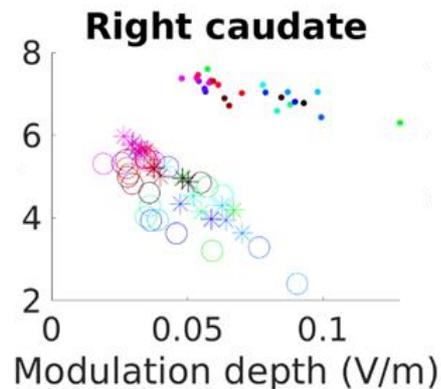
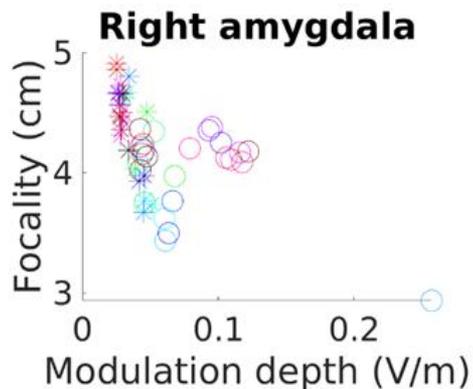
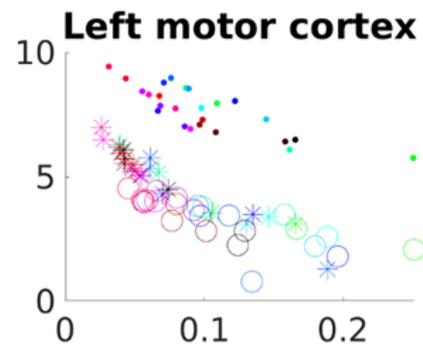
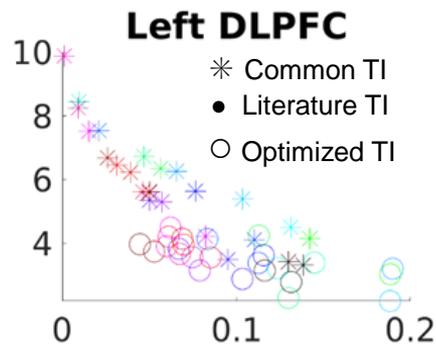
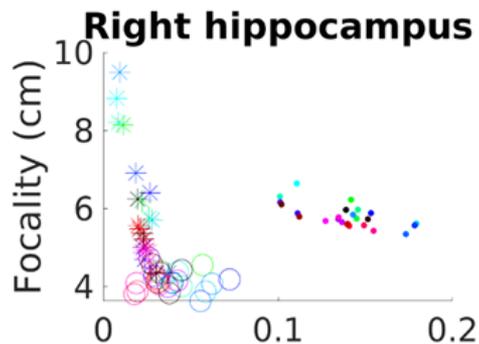
**Rotational  
E-field**

Inter-individual variability of optimized TI

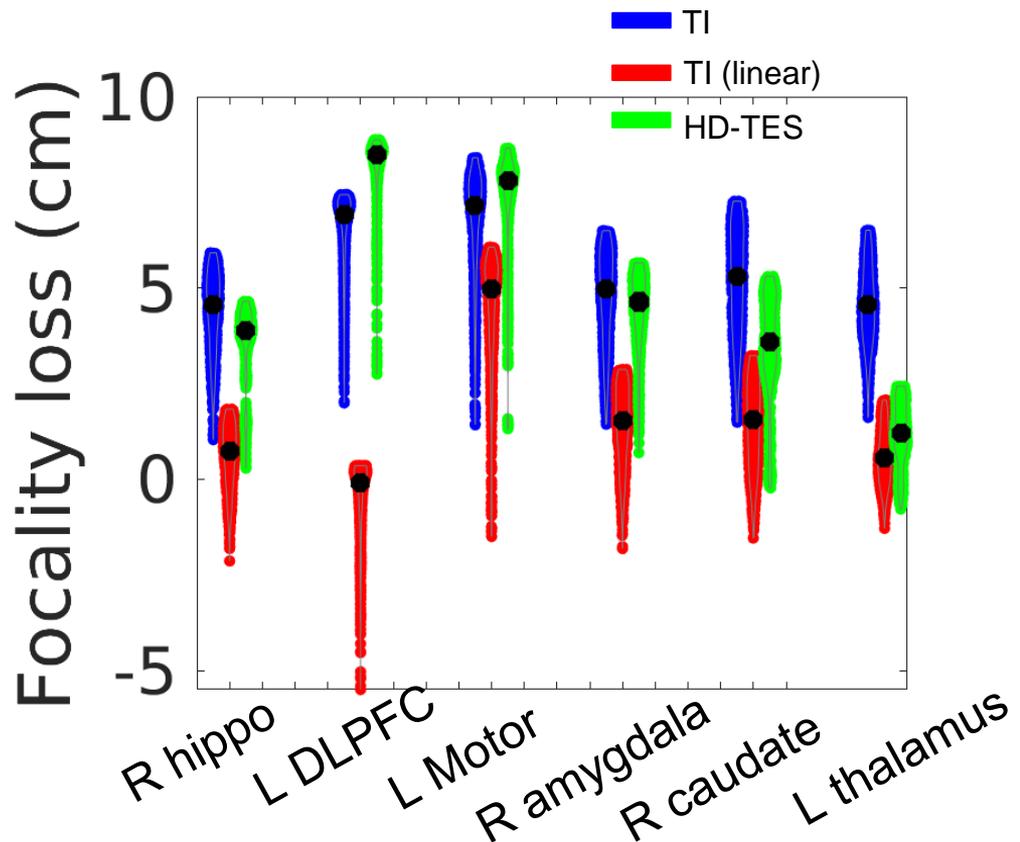
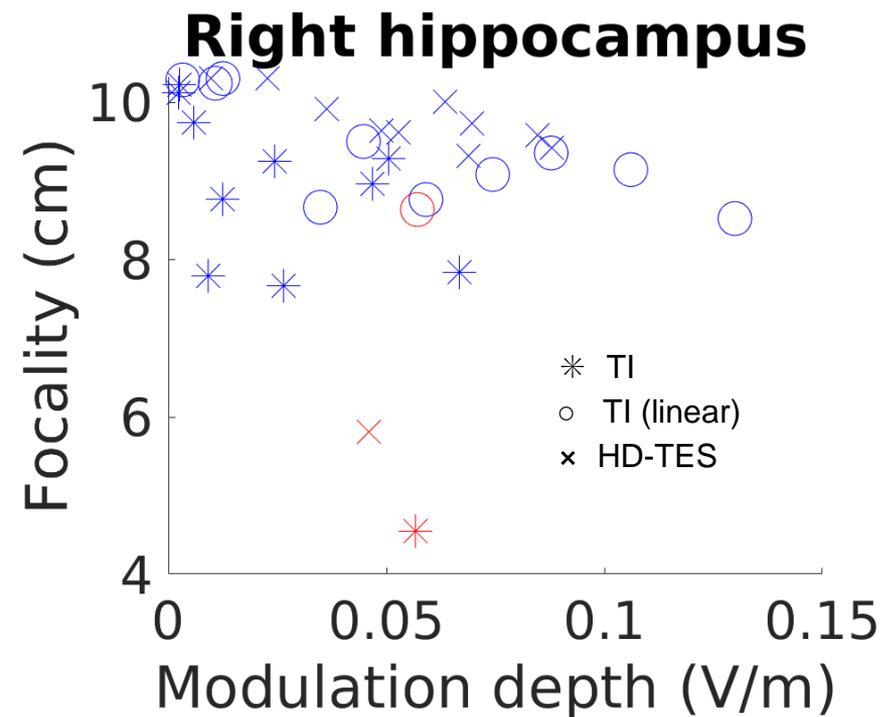
# Focality loss when not optimized



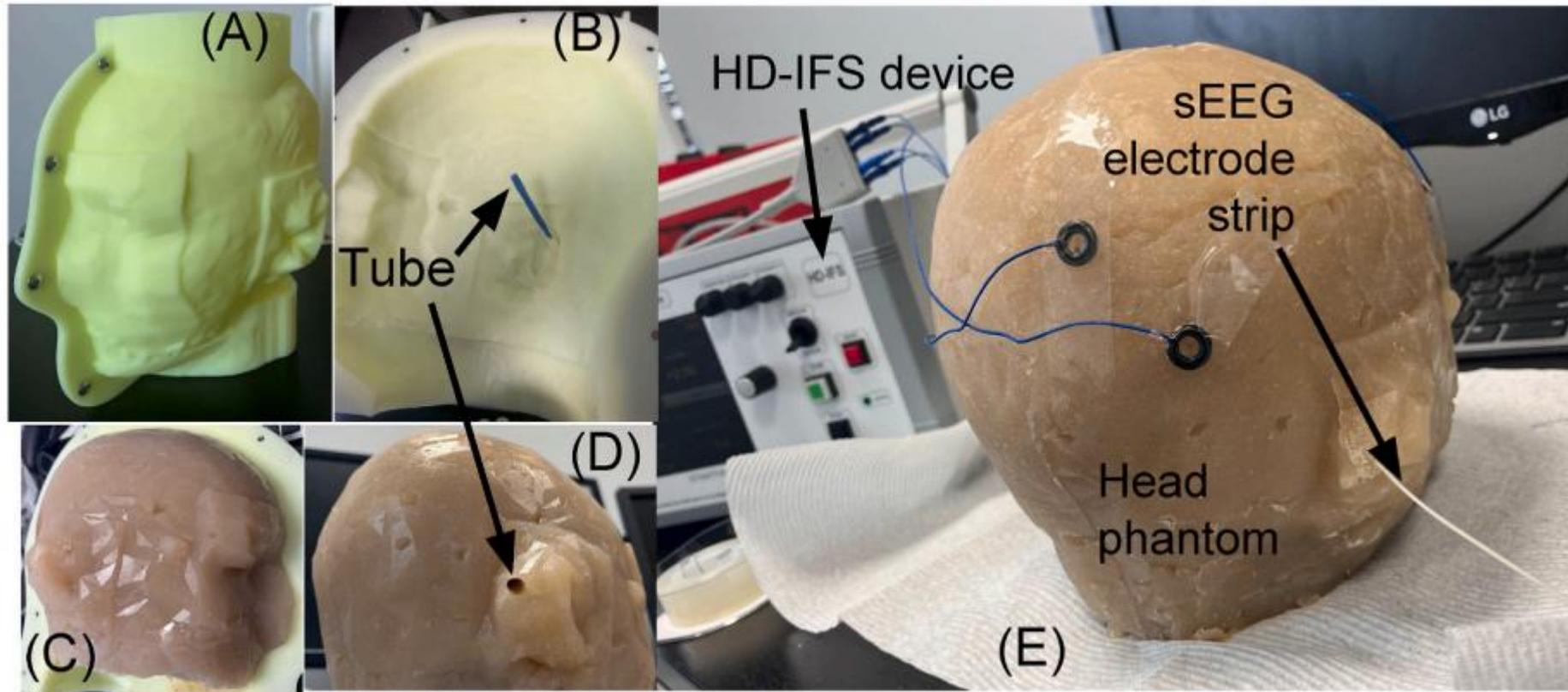
# Scale up in more data



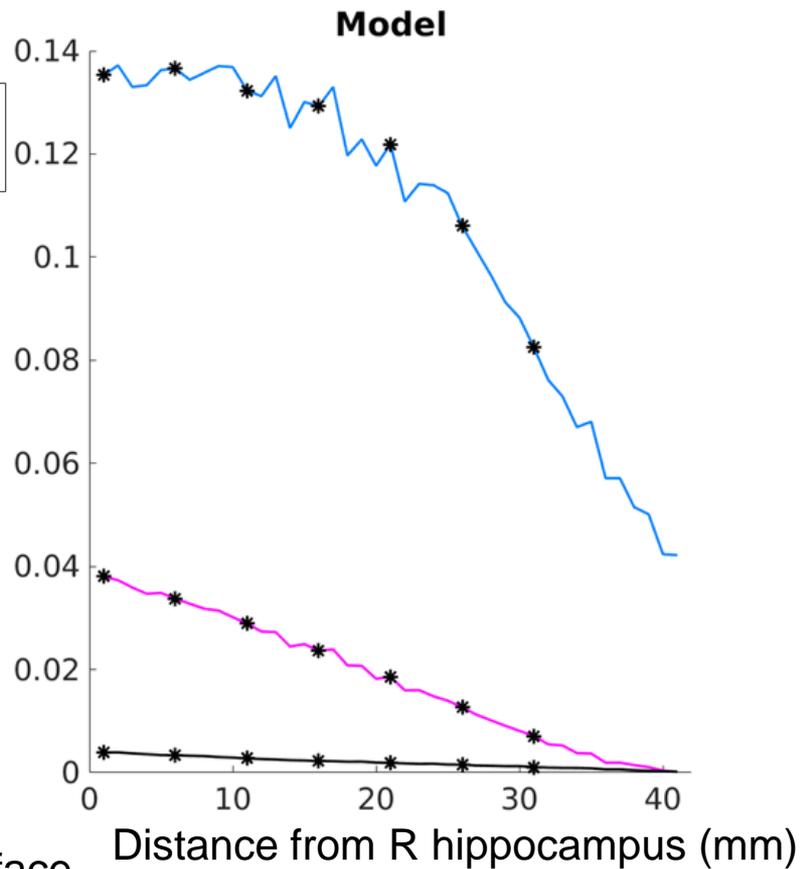
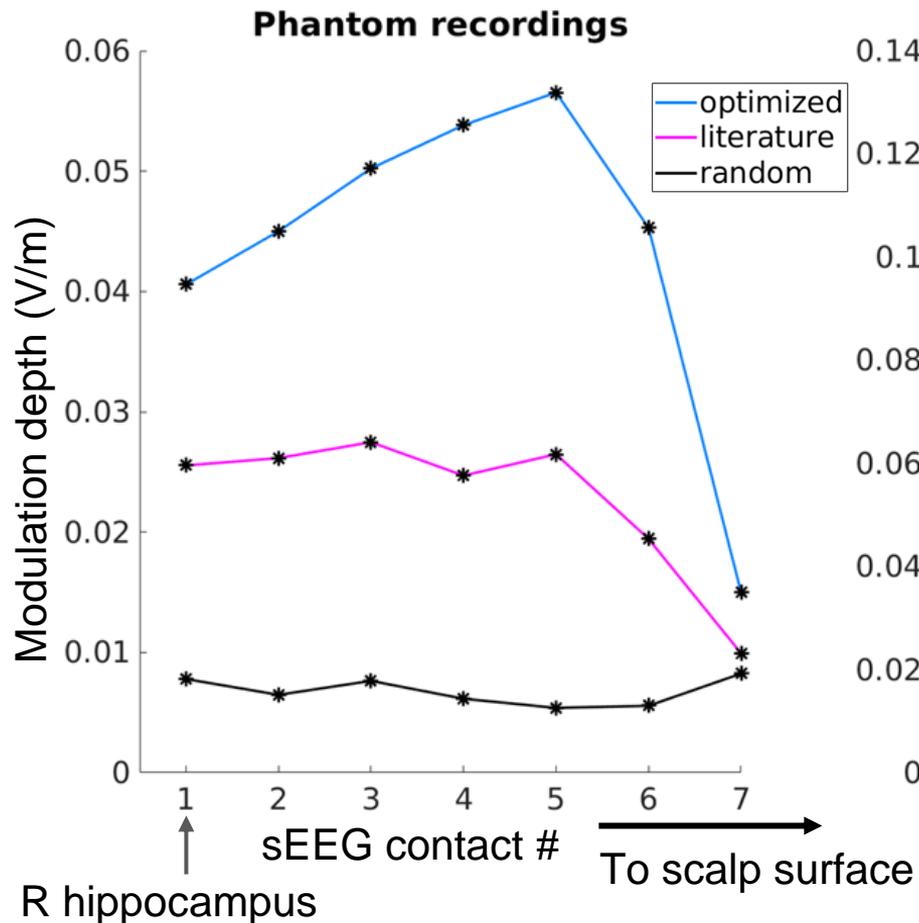
# Sensitivity of TI



## Validation on a phantom



# Validation results

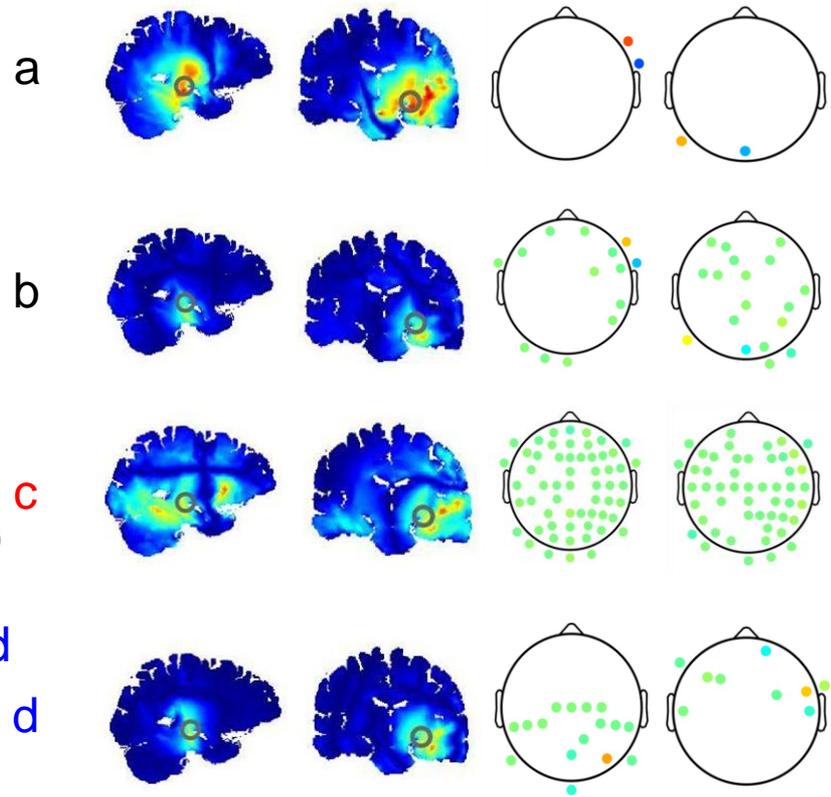
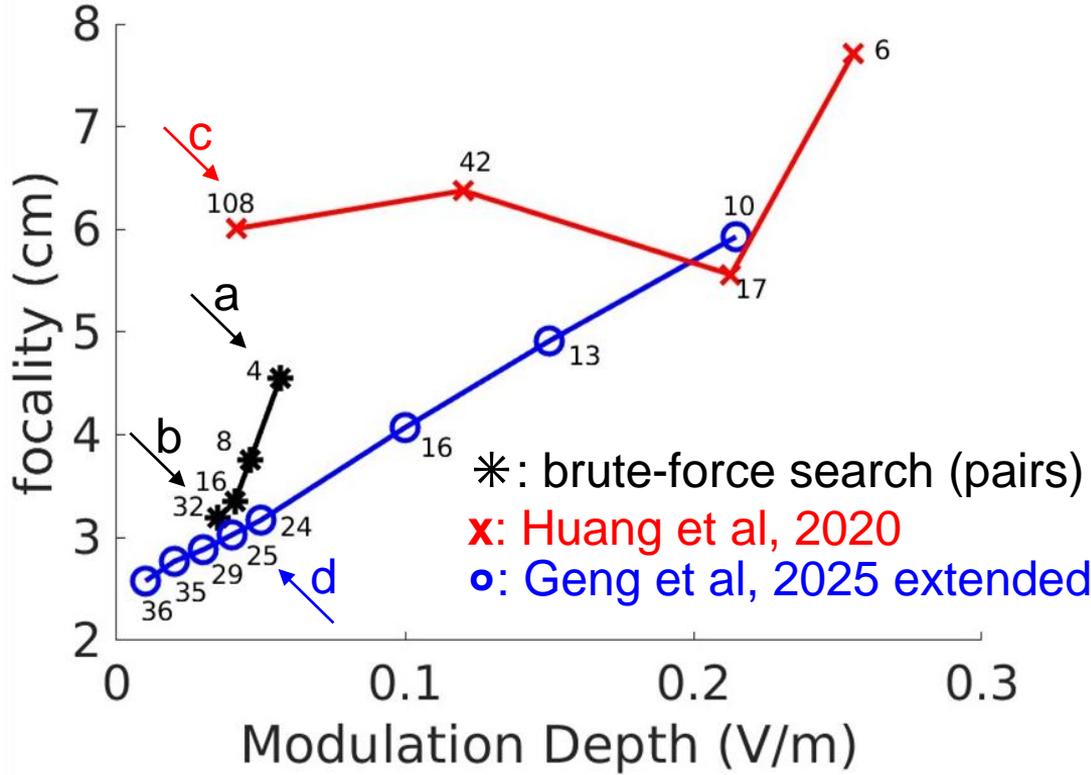


Inter-individual variability of optimized TI

# Summary

- TI (IFS) could be weaker in modulation compared to HD-TES
- TI is more focal than HD-TES if optimized
- TI induces fast rotational E-field
- No personalization leads to focality loss of up to 9 cm
- The need for individualization is validated by preliminary phantom recordings

# 2-array TI: a new paradigm



# Acknowledgement

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Q & A