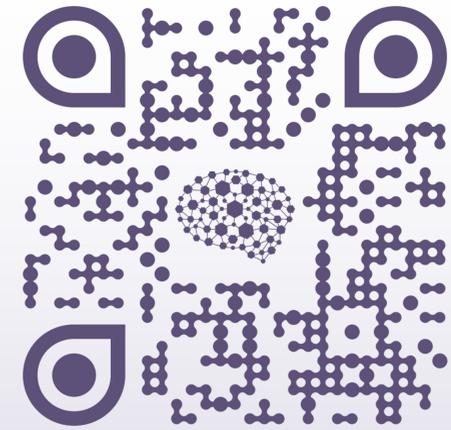


Inducing Meditation with Ultrasound Brain Stimulation:

Effective Deepening of Meditative-States with Focused Ultrasound Stimulation and its Moderation by Prior-Experience

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SHORT ON TIME? HERE'S THE SUMMARY

Focused ultrasound (FUS) was utilized to precisely disrupt the Posterior cingulate cortex, head of the Caudate Nucleus, and Ventral –Anterior Insula during 1-hour meditation sessions in 12 expert and 12 novice Vipassana meditators, while assessing changes in meditative depth and subjective intensity compared to baseline. Results indicate **PCC and Caudate-FUS effectively induce greater meditative depth in experts versus a validated Sham-FUS procedure**, with similar subjective intensity changes. Crucially, **these effects were absent in trained novices**, highlighting the importance of experience in modulating FUS-induced meditative states.

RESULTS

INTRODUCTION

(Vipassana) Meditation and It's Benefits

> Benefits—both psychological and physical—for health and well-being (Roberts et al., 2017)
 > Aspiring practitioners experience considerable difficulty maintaining the consistent, years-long practice required (i.e., “meditative development”) (Lomas et al., 2015)—even while using extant meditative-aids (e.g., mobile applications, neurofeedback) (Huberty et al., 2019).

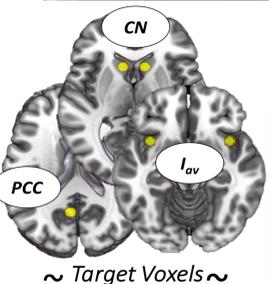
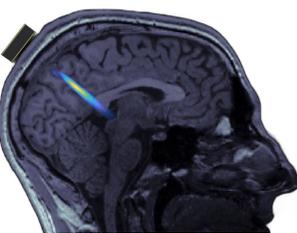
Focused Ultrasound Stimulation (FUS)

> Works by *painlessly and safely* passing ultrasound waves (the same used in ultrasound imaging) through the skull and concentrating them on a single point in the brain (Dell'Italia et al. 2022)
 > Use in humans is *less than a decade old* (Bystritsky et al. 2011).
 > **Safety & Efficacy** is (now) well-validated (Dell'Italia et al. 2022)
 > Very **Precise & Versatile**: i.e., can selectively target small regions *anywhere* in the brain, including our targets (Cain et al., 2021).

The **Posterior Cingulate Cortex (PCC)**, a key component of the default mode network (DMN), is linked to self-referential thinking⁵ and “effortless awareness”⁶. Its activity is reduced during mindful meditation⁷.

Caudate damage may result in “Athymhormia,” a condition described as mental emptiness with loss of motor and affective motivation but without anxiety or pain⁸. There exist clear similarities between this and mindfulness.

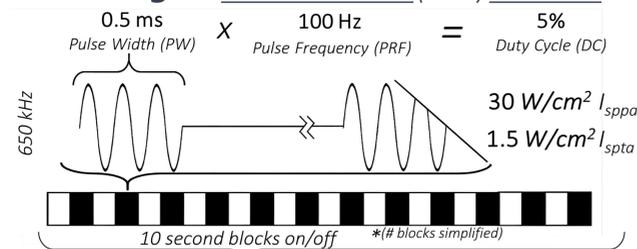
The **Insula** appears to mediate emotional regulation and interoception⁹ and may play a particular role in particular meditative techniques (e.g., body scanning)¹⁰.



Does FUS disruption of the PCC, Insula, or Caudate result in changes in meditative depth, intensity, physiology, or subjective quality during a 1-hour meditation in expert meditators? In Novices?

METHODS

Design & Focused Ultrasound (F.U.S.) Parameters

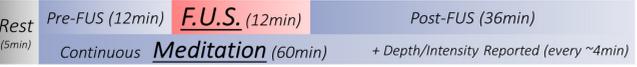


Brainsight Neuronavigation:

Infrared (IR) camera detects real-time position of transducer in relation to subject MR image

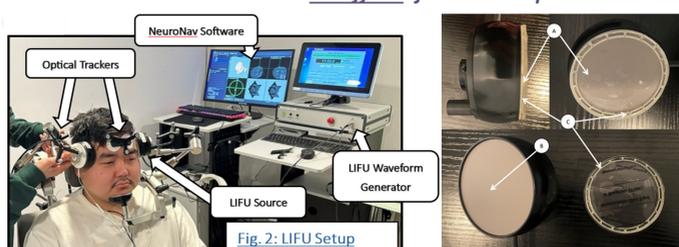


“How likely was today Sham Stimulation?”
No Effect of Condition! $p > 0.05$

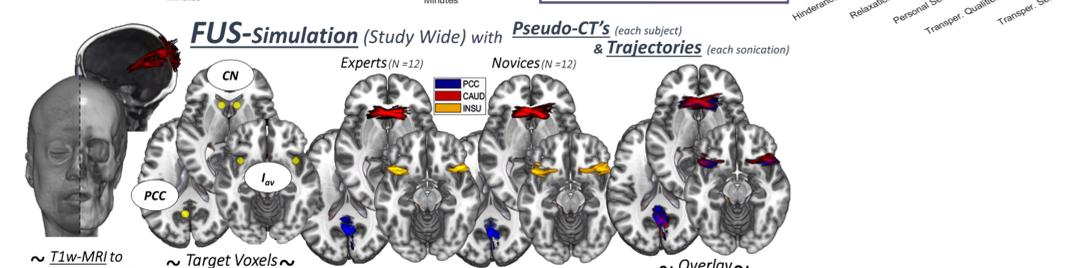
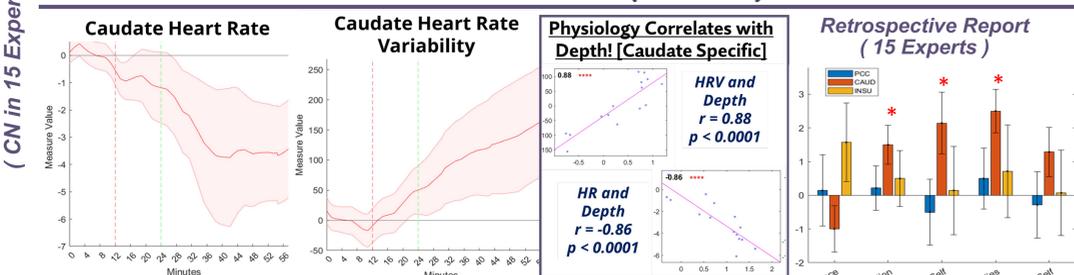
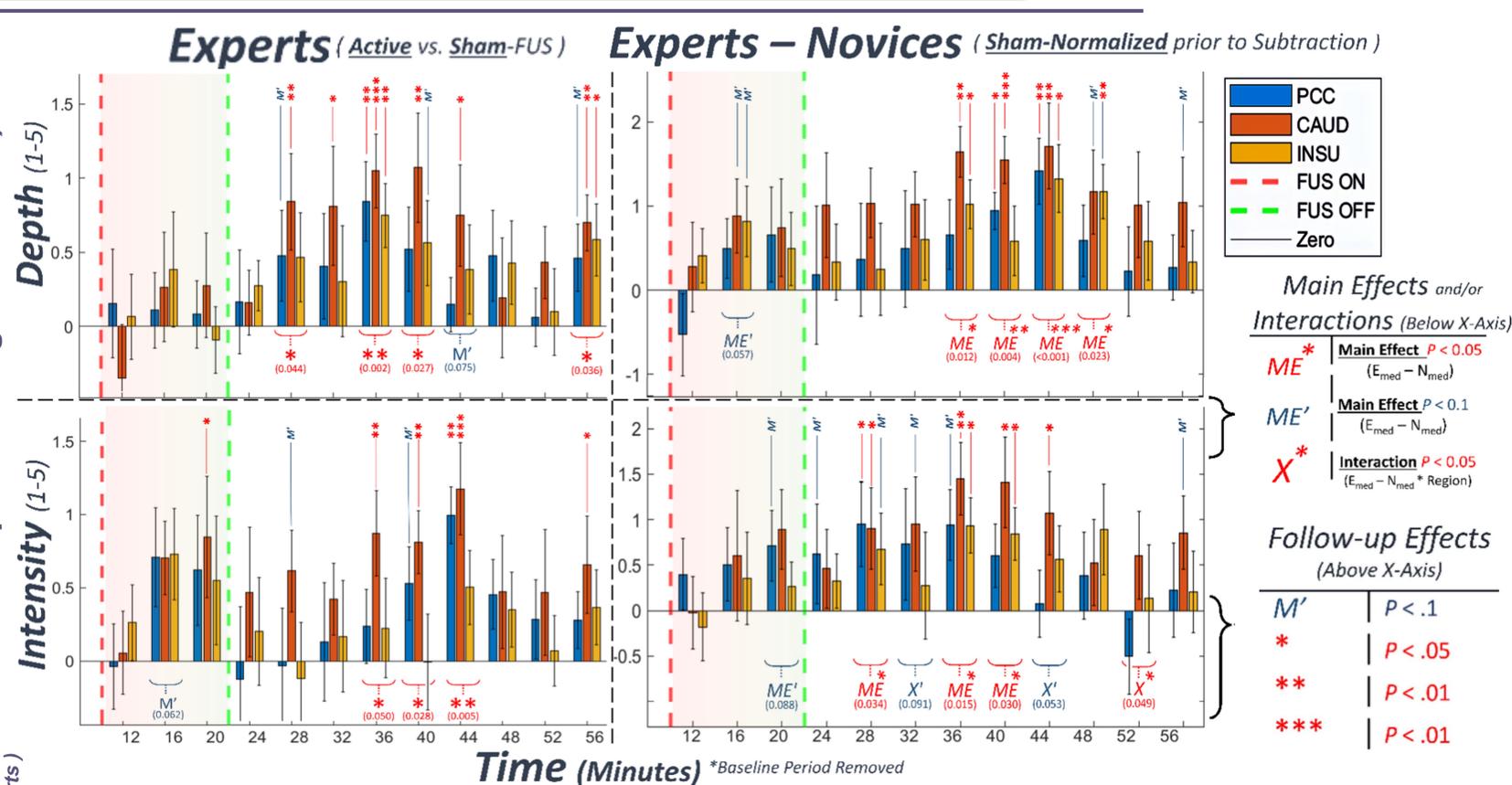


“Online” (During Meditation/FUS) Variables:
 Self-reported meditative “depth” and subjective “intensity” (probed every ~4 minutes)
 Physiological changes (GSR, EMG, HR, RR)

“Offline” (After Meditation/FUS) Variables:
 Pre- and post-meditation questionnaire to assess altered subjectivity induced by stimulation



FUS-Simulations



Conclusions

Focused ultrasound holds potential as a meditative aid for increasing depth and intensity in experts, with the strongest effects following Caudate stim (CN-FUS)

CN-FUS increased HRV and decreased HR which both correlated with meditative depth reports across time

The impact of FUS may be state-dependent, with experts refined perceptual acuity and ability to access sensitive states potentially rendering them more susceptible to stimulation-induced changes in phenomenology compared to novices.

A “therapeutic window” for this procedure may open only, at least, after the very start of contemplative practice.

ACKNOWLEDGEMENTS

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