

Quantifying Improvements in Cognitive Skills, Stress, and Mindfulness from Mantra-based and Breath-focus Meditation Techniques

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Overview

- Prior studies have primarily compared expert meditators with novices, leaving the progression of neural mechanisms and cognitive changes as a result of daily meditation practice relatively unexplored.
- This study aims to compare the longitudinal changes in cognitive ability, mental health, and neural dynamics associated with mantra-based meditation and breath-focused meditation over a period of regular practice.

Background

- **Types of Meditation [1]:** Most meditation research has focused on one or another of four types of meditation (Figure 1). Our main focus is on Japa meditation.
- **Mantra-Based Meditation (MBM):** Involves repeating a specific word or sound (mantra) [2] for deep concentration and relaxation.
- **P300:** The P300 [3] event-related brain potential (Figure 2) can serve as a measure of attention to a novel or relatively rare stimulus.
 - **Shorter latencies** are related to superior cognitive performance.

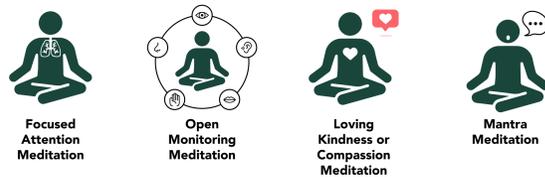


Figure 1: Four types of studied meditation techniques.

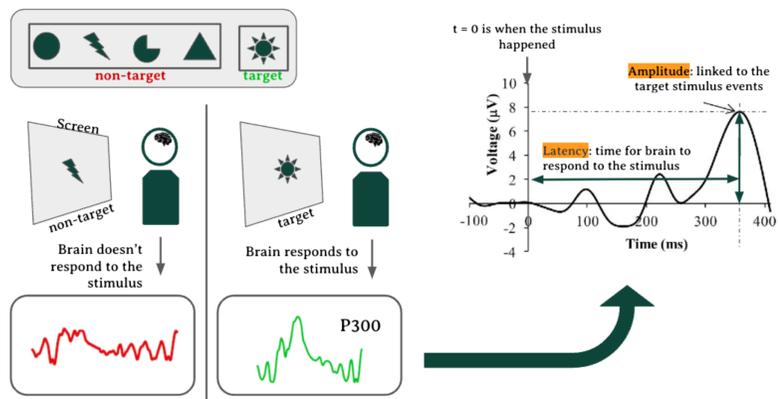


Figure 2: Generation of the P300 waveform.

Acknowledgments

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- Thanks to our data collectors Vu Song Thuy Nguyen, Annie Wozniak, Pratham Pradhan and Wei-ting Tan, from Michigan State University
- Thanks to our expert meditators Devin O'Rourke and Sidharth Chhabra, from Harmony Collective, Ypsilanti, Michigan.

References

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- [3] T. W. Picton et al., "The p300 wave of the human event-related potential," *Journal of clinical neurophysiology*, vol. 9, pp. 456–479, 1992.
- [4] N. Farb, J. Daubenmier, C. J. Price, T. Gard, C. Kerr, B. D. Dunn, A. C. Klein, M. P. Paulus, and W. E. Mehlh, "Interoception, contemplative practice, and health," *Frontiers in psychology*, vol. 6, p. 763, 2015.

Methods

- **EEG Device:** EEG data for P300 task was collected using the EEG headset (Brainwave Science, Inc.), with 8 electrodes. P300 results were processed through the company's software.
- **Participants:** EEG data was obtained from 65 pre-screened participants, all of whom signed IRB-approved consent forms. Participants were quasi-randomly divided into three meditation groups and a non-meditating control group (see Table 1).
- **Procedures:** Three different meditation techniques were used: Hare Krishna (MBM), Sa Ta Na Ma (MBM), and Breath Focus. Each meditation group followed the pipeline outlined in Figure 3.
- **P300 Speller Test (Cognitive test):** The flowchart for this task is provided in Figure 3.
- **Questionnaires:** FFMQ, MAIA-2, and PSS questionnaires were completed after the meditation sessions revealing changes in mindfulness, bodily awareness, and stress perception.

Group	Hare Krishna	Sa Ta Na Ma	Breath Focus	Control	Total
	M = 7 F = 12	M = 8 F = 7	M = 4 F = 10	M = 9 F = 8	65
Age (years)	23 ± 3.1	25 ± 9	23 ± 3.8	23 ± 3	24 ± 4.7

Table 1: Information for four Groups (Avg ± Std). Male (M) and female (F) counts in each group are shown.

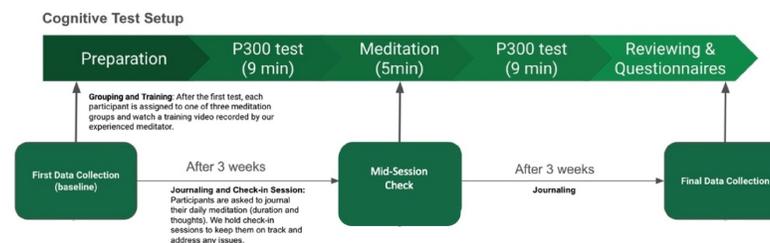


Figure 3: Pipeline for whole study setup

Results

- All meditation groups showed a significant or a strong trend of reduction in P300 latency ($Latency_{final} - Latency_{Baseline}$). In contrast, the control group showed no significant change.
- Outliers are removed by the Δ Latency boxplot within each group.

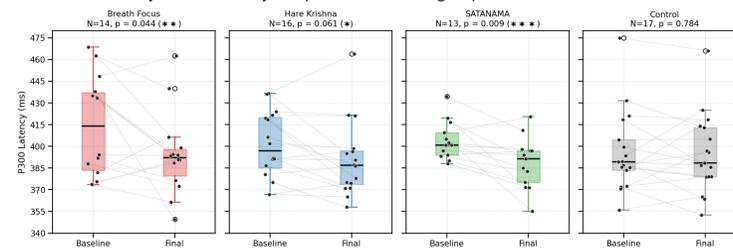


Figure 4: Latency comparison from P300 task across meditation groups, with p-values reported comparing the baseline and final phase. The results shown in this figure are based on data from which outliers were removed.

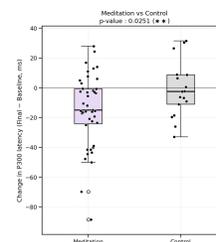


Figure 5: Latency comparison between meditation and control groups (change in P300 latency, Final - Baseline).

Note: Statistical significance is indicated as *** for $p < .025$, ** for $p < .05$, and * for $p < .1$ throughout the results section.

Results (continued)

- **Significant MAIA Improvements:** All three meditation groups showed statistically significant improvements compared to the control group.

Group	MAIA-Attention Regulation ↑	MAIA-Self Regulation ↑	MAIA-Overall ↑	FFMQ-ActAware ↑	FFMQ-NonJudge ↑	PSS ↓
Breath Focus (Baseline)	3.07 ± 0.62	2.77 ± 1.25	3.01 ± 0.60	17.25 ± 2.90	15.08 ± 5.45	18.17 ± 6.06
Breath Focus (Final)	3.13 ± 0.75	3.48 ± 1.13 (**)	3.39 ± 0.62 (***)	19.17 ± 3.93	15.00 ± 6.73	15.91 ± 6.33
Hare Krishna (Baseline)	2.78 ± 0.59	2.47 ± 0.96	2.68 ± 0.51	15.93 ± 4.06	15.07 ± 4.42	18.27 ± 4.68
Hare Krishna (Final)	3.17 ± 0.80 (**)	3.29 ± 1.00 (**)	3.25 ± 0.49 (***)	16.14 ± 2.80	15.93 ± 2.56	16.93 ± 4.71
Satanama (Baseline)	3.01 ± 0.87	3.31 ± 0.66	3.01 ± 0.42	17.69 ± 4.13	16.69 ± 3.12	18.85 ± 4.43
Satanama (Final)	3.43 ± 0.44 (**)	3.83 ± 0.61 (**)	3.39 ± 0.34 (**)	17.23 ± 2.83	17.00 ± 4.45	16.46 ± 5.43
All Meditations (Baseline)	2.94 ± 0.70	2.83 ± 1.02	2.89 ± 0.53	16.90 ± 3.76	15.60 ± 4.35	18.43 ± 4.93
All Meditations (Final)	3.25 ± 0.68 (**)	3.53 ± 0.93 (***)	3.34 ± 0.48 (***)	17.44 ± 3.35	16.00 ± 4.72	16.47 ± 5.33
Control (Baseline)	3.17 ± 0.74	3.28 ± 0.83	3.04 ± 0.47	16.94 ± 3.94	16.19 ± 2.14	16.00 ± 6.31
Control (Final)	2.86 ± 0.76	3.19 ± 0.87	3.00 ± 0.46	17.62 ± 2.92	16.38 ± 3.26	15.94 ± 3.86

Table 2: Questionnaire data for meditation and control groups: Baseline and Final statistics (mean and standard deviation) shown.

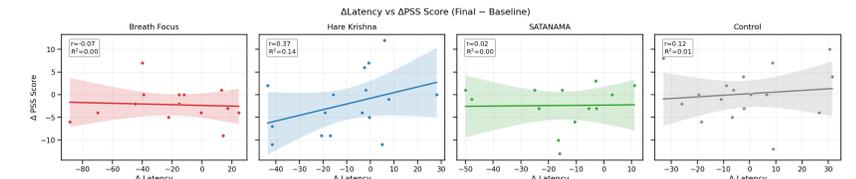


Figure 6: Relationship between changes (Final-Baseline) in PSS score (y-axis) and Latency (x-axis) for meditation and control groups.

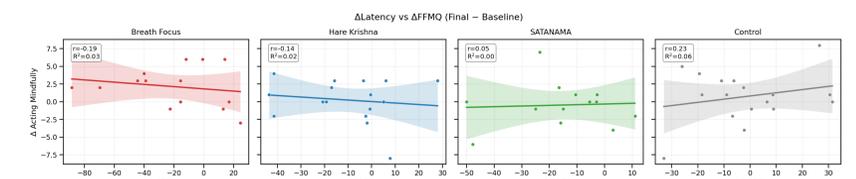


Figure 7: Relationship between changes (Final-Baseline) in MAIA-Acting Mindfully (y-axis) and Latency (x-axis) for meditation and control groups.

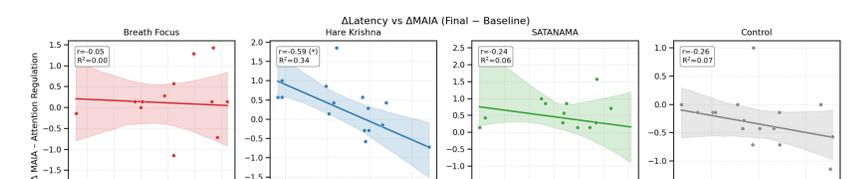


Figure 8: Relationship between changes (Final-Baseline) in FFMQ-Attention Regulation and FFMQ-Self Regulation (y-axis) and Latency (x-axis) for meditation and control groups.

Discussion

- The meditation groups showed a strong trend toward faster processing than controls by the P300 latency measure, suggesting meditation improves attentional focus by enhancing neural processing [4].
- The training's primary psychological effect was improved interoceptive awareness. This strongly suggests mechanism-specific benefits, as these focused-attention practices (breath/mantra) explicitly train attention control and internal state regulation.
- In the Hare Krishna group, the significant correlation between Δ Latency and Δ Attention Regulation scores suggests that long-mantra training enhances neural processing efficiency, directly supporting improved attentional focus.

Ongoing and Future Work

- Future research will employ larger, gender-matched samples, and include more measures for cognitive ability.