

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

Angqi Li¹, Ab Basit Syed¹, Krishna Ika², Taosheng Liu³, Mengsen Zhang¹, Barry H. Cohen⁴, Saiprasad Ravishankar^{1,5}

Dept. Computational Mathematics, Science and Engineering, Michigan State Univ., East Lansing, MI¹
Brainwave Science, Inc., Southborough, MA², Dept. Psychology, Michigan State Univ., East Lansing, MI³, Dept. Applied Psychology, New York Univ., New York, NY⁴
Dept. Biomedical Engineering, Michigan State Univ., East Lansing, MI⁵



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.

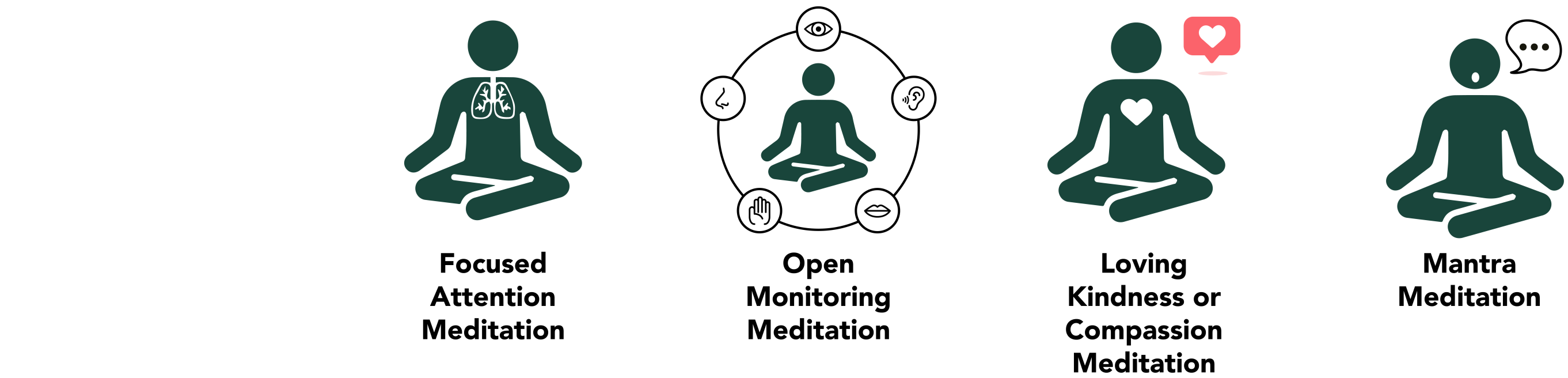


Figure 1: Four types of studied meditation techniques.

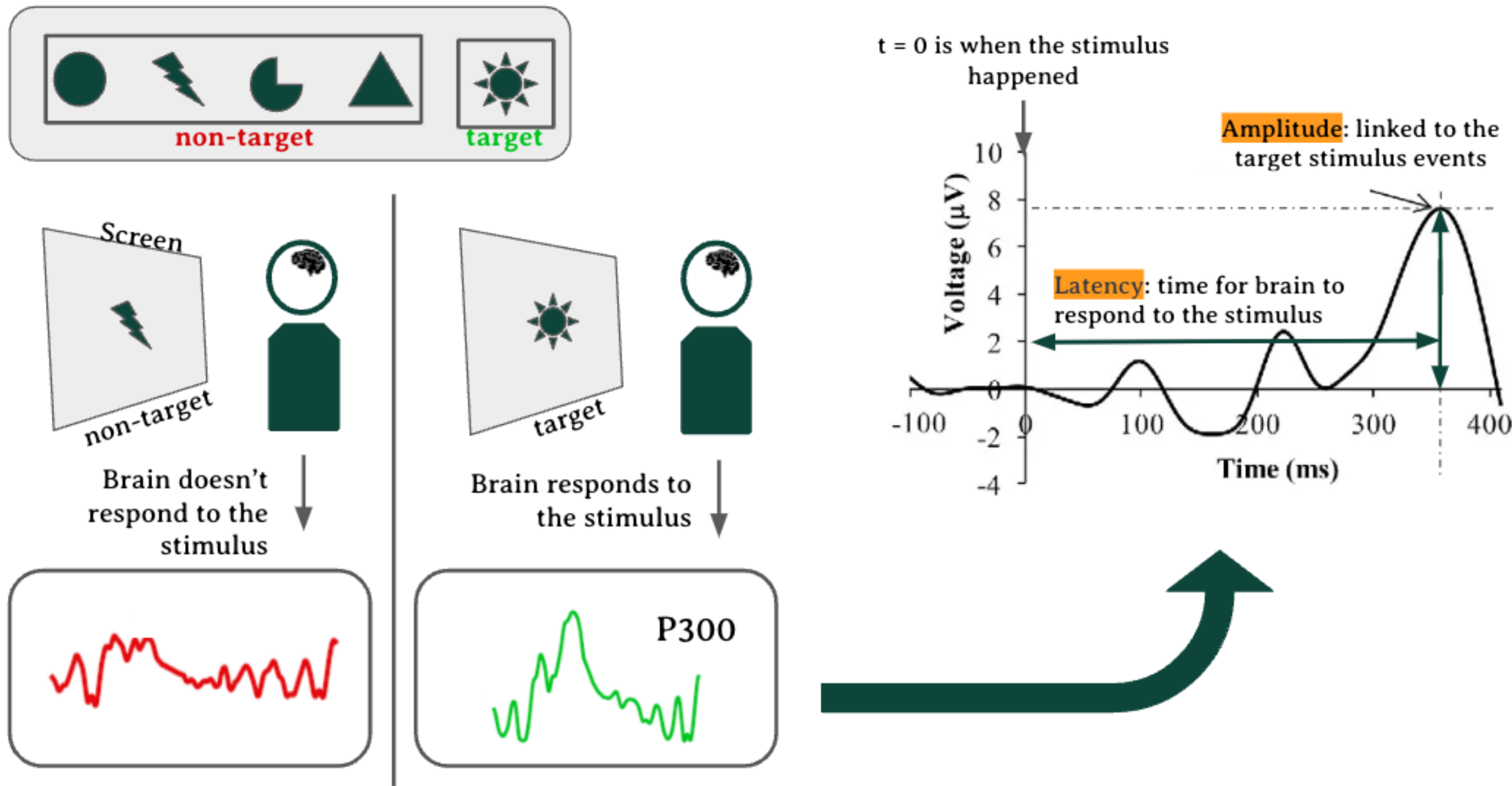


Figure 2: Generation of the P300 waveform.

Acknowledgments

- This research was funded in part by Brainwave Science, Inc., whose EEG headset and software were used in the study. The P300 results were collected by iCognitive instrumentation made by Brainwave Science, Inc.
- 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

[1] K. Matko and P. Sedlmeier, "What is meditation? proposing an empirically derived classification system," *Frontiers in psychology*, vol. 10, p. 2276, 2019.

[2] J. P. Dudgea, "Scientific analysis of mantra-based meditation and its beneficial effects: An overview," *International Journal of Advanced Scientific Technologies in Engineering and Management Sciences*, vol. 3, no. 6, pp. 21–26, 2017.

[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. Mehling, "Interception, 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.

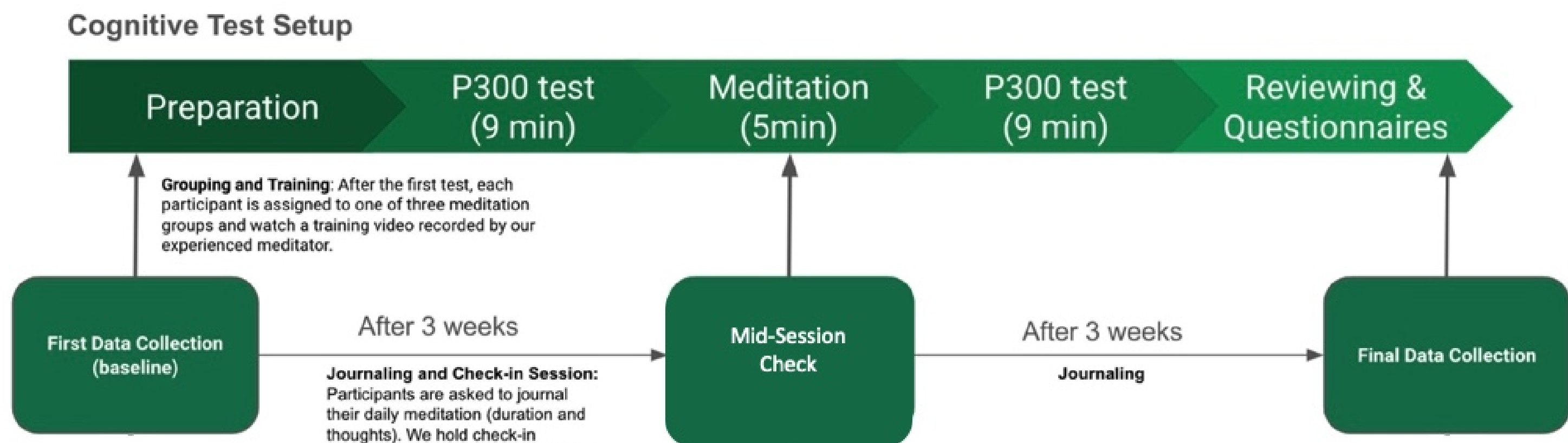


Figure 3: Pipeline for whole study setup

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.

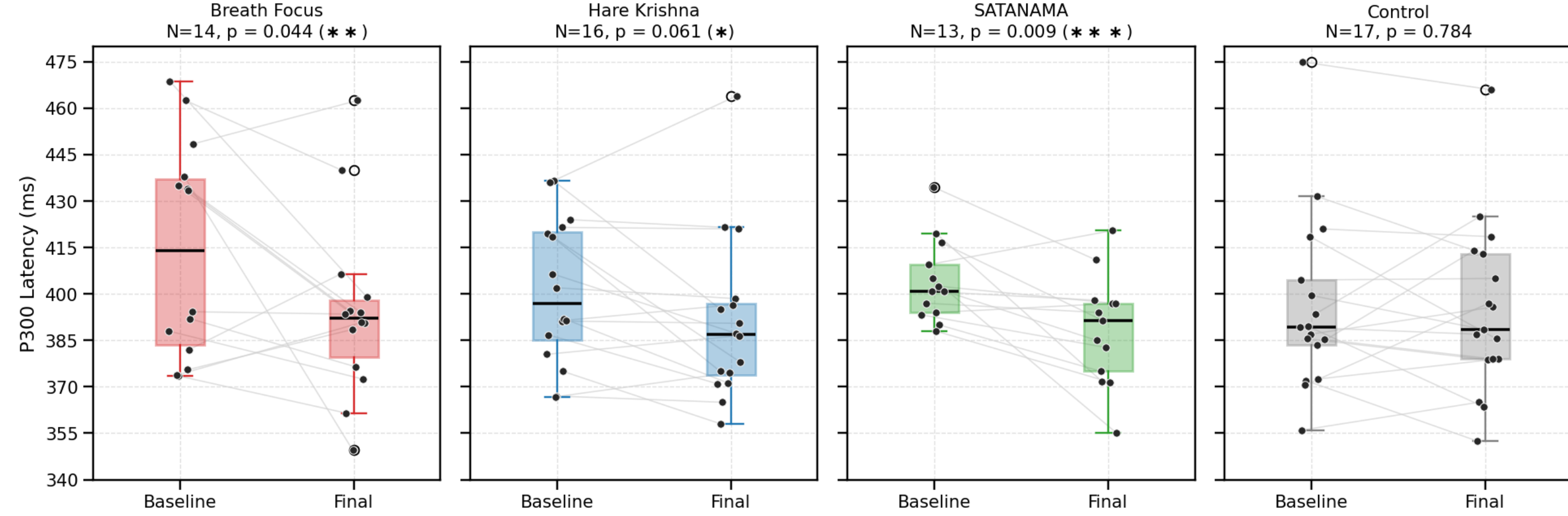


Figure 4: Latency comparison from P300 task across meditation groups, with p-values reported comparing the baseline and final phase. The results shown in this figure are based on data from which outliers were removed.

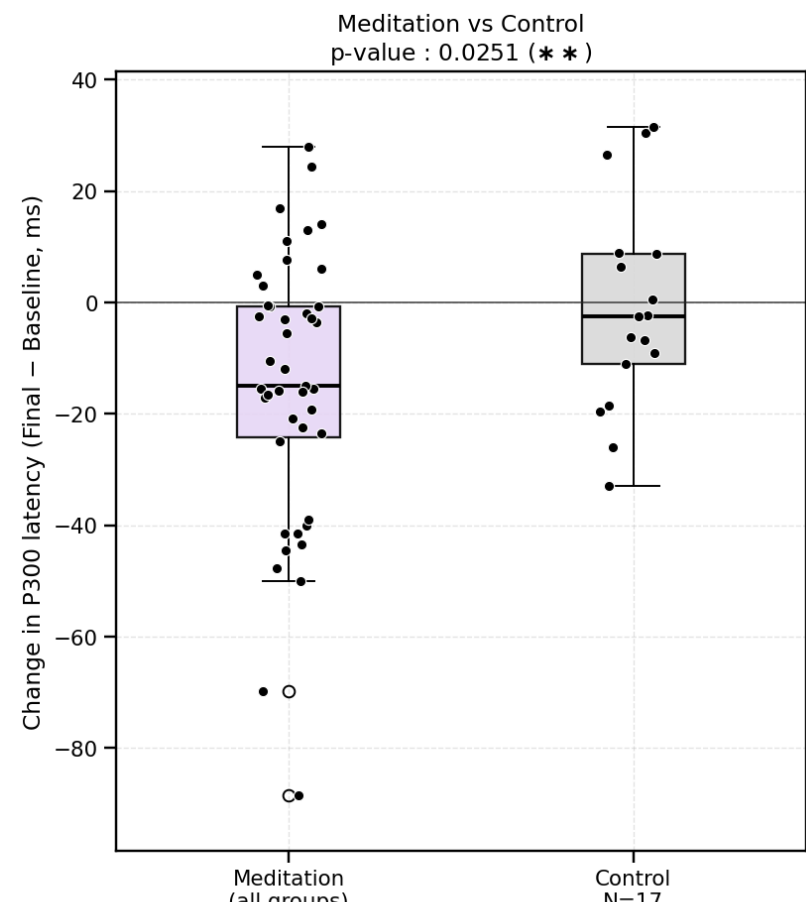


Figure 5: Latency comparison between meditation and control groups (change in P300 latency, Final - Baseline).

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.

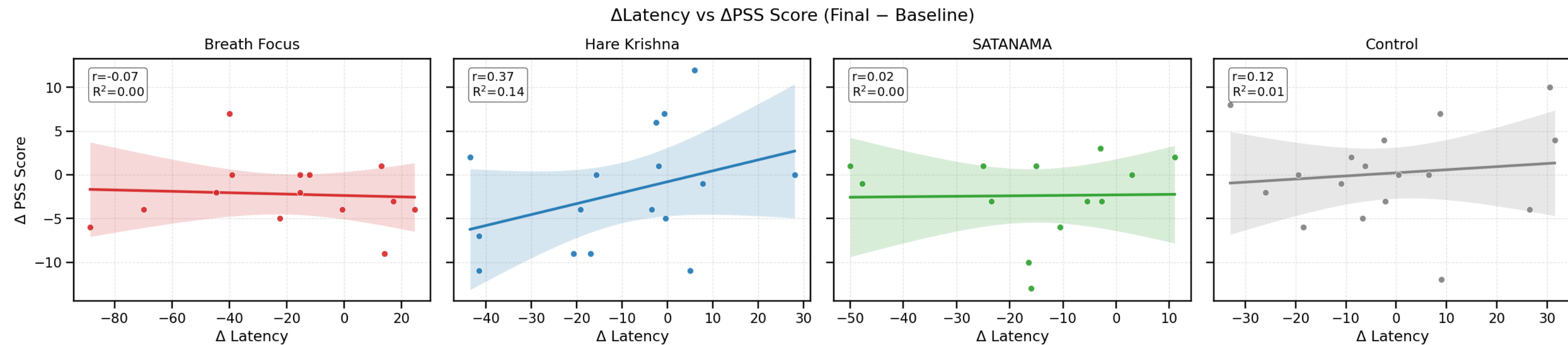


Figure 6: Relationship between changes (Final-Baseline) in PSS score (y-axis) and Latency (x-axis) for meditation and control groups.

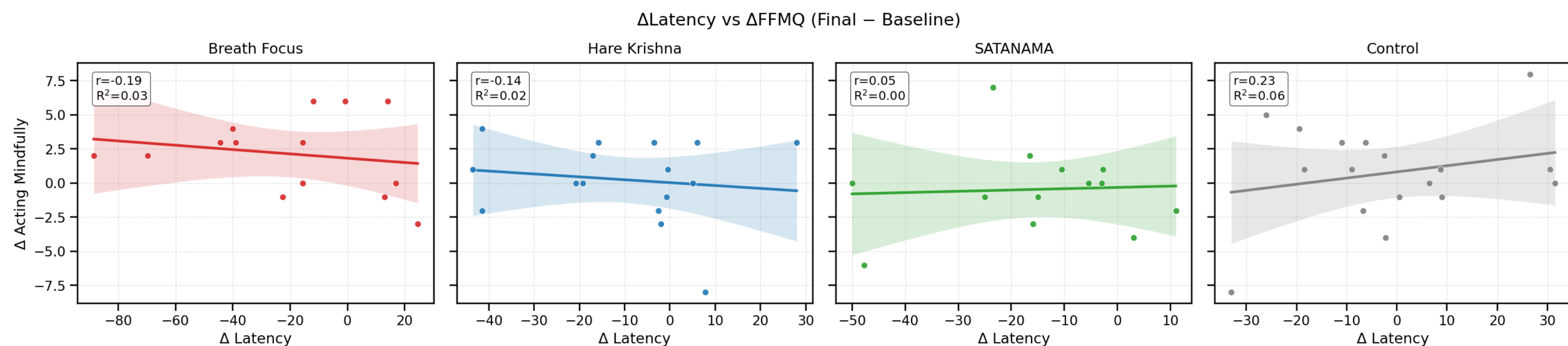


Figure 7: Relationship between changes (Final-Baseline) in MAIA-Acting Mindfully (y-axis) and Latency (x-axis) for meditation and control groups.

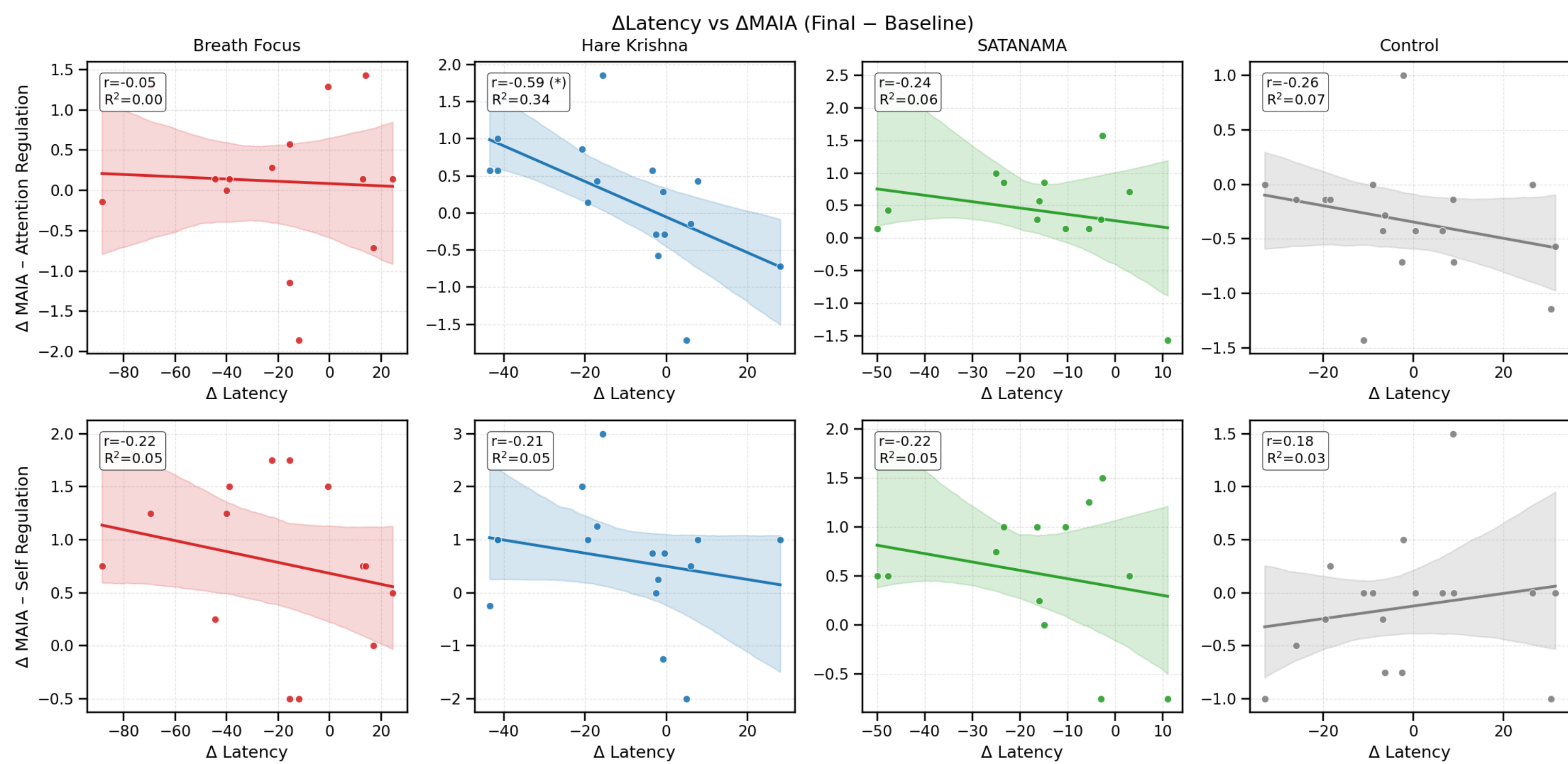


Figure 8: Relationship between changes (Final-Baseline) in FFMQ-Attention Regulation and FFMQ-Self Regulation (y-axis) and Latency (x-axis) for meditation and control groups.

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.