

COGNITIVE AND EMOTIONAL OUTCOMES FOLLOWING MULTIMODAL MEDITATION AMONG UNIVERSITY STUDENTS: A SECONDARY ANALYSIS OF A CONTROLLED INTERVENTION STUDY

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ABSTRACT

Background: Mindfulness-based and meditation interventions have gained increasing attention as accessible approaches for enhancing cognitive functioning and psychological well-being among university students. However, limited research has examined the independent and combined effects of specific meditation components, particularly sound-based and color-focused meditation, on attention, working memory, and affective outcomes.

Objective: This secondary analysis investigated predictors of cognitive and emotional outcomes following sound meditation, color-focused meditation, and combined meditation interventions among university students with no prior meditation experience.

Methods: This secondary analysis utilized data from a prospective convenience-controlled meditation intervention involving 142 university students. Participants were assigned to one of four groups: sound meditation (n = 31), color-focused meditation (n = 34), combined sound and color meditation (n = 51), or a non-intervention control group (n = 26). The intervention was delivered over eight weeks through instructor-led sessions conducted three times weekly. Outcomes were assessed using the Alloway Working Memory Assessment (AWMA-2), Positive and Negative Affect Schedule (PANAS), and Conners Continuous Performance Test (CPT-3). Pre- and post-intervention comparisons and between-group analyses were performed.

Results: Participants receiving meditation interventions demonstrated improvements in attention, working memory, and affective functioning relative to baseline. The combined meditation group showed the most consistent pattern of improvement across cognitive and emotional outcomes, including enhanced recall performance, reduced attentional errors, increased positive affect, and decreased negative affect. Significant associations were also observed between meditation adherence and cognitive improvements.

Conclusion: Sound and color meditation practices were associated with beneficial cognitive and emotional outcomes among university students. The combined intervention appeared to yield broader benefits than either technique alone. Although findings are promising, further randomized controlled studies are required to confirm effectiveness and clarify underlying mechanisms.

Keywords: Mindfulness Meditation; Working Memory; Attention; Positive and Negative Affect

INTRODUCTION

Mindfulness-based and meditative practices are increasingly examined as low-cost, non-pharmacological approaches for improving

attention, emotional regulation, and cognitive functioning. Mindfulness broadly refers to the deliberate regulation of attention and awareness

toward present-moment experience, with an attitude of openness and non-reactivity (Davis & Hayes, 2011). Earlier research has linked mindfulness and meditation practices with improvements in anxiety, depression, chronic pain, irritable bowel syndrome, post-traumatic stress symptoms, attention regulation, and psychological well-being (Mehta et al., 2011; Hoge et al., 2013; Reiner et al., 2013; Banth & Ardebil, 2015; Gallegos et al., 2017; Majeed et al., 2018; Tolahunase et al., 2018; Carpena et al., 2019; Poissant et al., 2019; Alzahrani et al., 2020). More recent reviews also suggest that mindfulness-based interventions may support mental health and cognitive functioning among students, although effect sizes vary across intervention type, duration, sample characteristics, and outcome measures.

University students represent an important population for examining brief meditative interventions because they commonly experience academic pressure, attentional demands, emotional fluctuation, and performance-related stress. Attention and working memory are central to learning, self-regulation, and academic performance. Contemporary meta-analytic evidence indicates that mindfulness meditation can produce measurable improvements in attention, executive control, and working memory in healthy adults, but the literature remains heterogeneous and does not fully explain which specific components of meditation are most beneficial. This gap is important because many meditation systems involve multiple elements, including breath regulation, sound, imagery, focused attention, and relaxation, making it difficult to determine whether observed benefits arise from one component, from their combination, or from general expectancy and practice effects.

Recent evidence from a randomized controlled trial conducted during the COVID-19 lockdown demonstrated that an online mindfulness intervention significantly improved mental health outcomes and attentional abilities among university students, highlighting the potential of mindfulness-based approaches for enhancing both psychological well-being and cognitive functioning (Devillers-Réolon et al., 2022). These findings further support the investigation

of brief, accessible meditation-based interventions within higher education settings. Meditation is not a single uniform practice. It often involves a structured sequence of attentional and regulatory techniques directed toward internal or external stimuli (Hu et al., 2011). Prior studies comparing different meditation traditions have shown that distinct practices may produce different cognitive and neurophysiological patterns (Dunn et al., 1999; Amihai & Kozhevnikov, 2014; Sevinc et al., 2018). Research on experienced meditators has contributed valuable knowledge, yet fewer studies have examined novice meditators, particularly in naturalistic university settings. This is a relevant limitation because novice participants may respond differently from experienced practitioners, and brief interventions may be more feasible for educational and preventive mental health contexts. Hirshberg et al. (2018), for example, found that brief contemplative practices can influence emotional responses among novice participants, suggesting that even short-duration interventions may produce measurable psycho-emotional effects. The present study focuses on two specific meditative components: buzzing-bee sound meditation and color-focused meditation. Sound-based meditation may support attentional anchoring through breath regulation, vocal vibration, and sustained auditory focus. Color-focused meditation may engage visual imagery and focused attention through concentration on a selected internal visual stimulus. Traditional sound and color meditation practices are rooted in Jain contemplative traditions and have been systematized in meditative frameworks such as Preksha meditation (Mahapragya, 1995; Suriji Maharaja, 1997). The color green has also been theoretically associated with arousal, attention, and affective balance (Valdez & Mehrabian, 1994; Tulsi, 1994). However, these claims require careful empirical testing using standardized cognitive and affective measures. Existing evidence suggests that mindfulness and focused meditation practices may influence emotional regulation, attention, and memory through cognitive-control and neuroplastic mechanisms. Recent neurobiological reviews indicate that mindfulness practice is associated with changes in brain systems involved in

emotional processing, attentional regulation, and stress response, although causal pathways remain complex and require further investigation. Brief mindfulness research has also shown potential effects on short-term memory performance, including visual short-term memory, but findings remain dependent on study design and measurement approach. Therefore, studies that isolate specific meditative components and compare their individual and combined effects are needed.

The present convenience-controlled prospective study was designed to examine the effects of sound meditation, color-focused meditation, and their combined use on short-term working memory, attention, impulsivity, and affect among healthy university students who were novice meditators. Unlike studies conducted in retreat or camp settings, this intervention was embedded within the routine academic semester, allowing assessment under real-world educational conditions. The study used standardized measures including the Alloway Working Memory Assessment, Positive and Negative Affect Schedule, and Conners' Continuous Performance Test to evaluate changes from baseline to post-intervention.

Based on prior literature, it was expected that meditation groups would show improvements in affect, attention, and short-term memory compared with baseline and control conditions. It was further expected that the combined sound and color meditation condition would show broader improvement than either technique alone, although this hypothesis was tested cautiously due to the non-randomized elements of group allocation and the exploratory nature of the study. A strong theoretical framework is essential for understanding how meditation-based practices may influence cognitive and emotional outcomes. The present study is grounded in Attention Control Theory, Mindfulness Theory, and emerging evidence from neuroplasticity frameworks. Attention Control Theory posits that cognitive performance depends on the efficient allocation and regulation of attentional resources, whereas emotional distress, negative affect, and environmental distractions can impair attentional control and reduce working memory efficiency (Eysenck et al., 2007). Interventions that strengthen attentional regulation are therefore

expected to enhance cognitive functioning and emotional well-being. Meditative practices typically require sustained focus on a selected stimulus while minimizing interference from competing thoughts and distractions. In the present study, participants directed attention toward a buzzing auditory stimulus, a visualized color stimulus, or a combination of both. Repeated engagement in such focused-attention exercises may strengthen executive attentional control, resulting in improvements in sustained attention, impulsivity regulation, and short-term working memory. Complementing this perspective, Mindfulness Theory conceptualizes meditation as purposeful attention to present-moment experience characterized by openness and non-judgmental awareness (Kabat-Zinn, 2003; Davis & Hayes, 2011). Through repeated practice, individuals may develop greater awareness of cognitive and emotional processes, enabling more adaptive responses to internal and external stimuli. Previous research has consistently demonstrated associations between mindfulness practices and improvements in emotional regulation, attention, stress management, and psychological well-being (Hoge et al., 2013; Gallegos et al., 2017; Carpena et al., 2019; Alzahrani et al., 2020).

The neuroplasticity framework provides an additional explanation for the potential cognitive and emotional benefits of meditation. Neuroplasticity refers to the brain's capacity to reorganize its structure and function in response to repeated experience and practice. Neuroimaging studies have reported that meditation may be associated with functional and structural changes in brain regions involved in attention, executive functioning, emotional regulation, and self-referential processing (Jha et al., 2007; Kral et al., 2018). Although neural mechanisms were not directly assessed in the present study, repeated engagement in focused-attention practices may strengthen neural pathways associated with attentional control and emotional regulation. The intervention examined in this study incorporates two complementary attentional mechanisms. Sound meditation involves sustained attention to internally generated buzzing sounds synchronized with breathing, thereby enhancing auditory attention, breath awareness, and cognitive focus. In

contrast, color-focused meditation requires concentration on a mentally visualized green point, engaging visual attention, imagery processes, and sustained concentration. When practiced simultaneously, these techniques may activate multiple attentional channels, producing broader cognitive engagement than either

technique alone. Consequently, the integration of auditory and visual attentional training may contribute to enhanced attentional regulation, improved working memory and cognitive performance, increased positive affect, and reduced negative affect among university students.

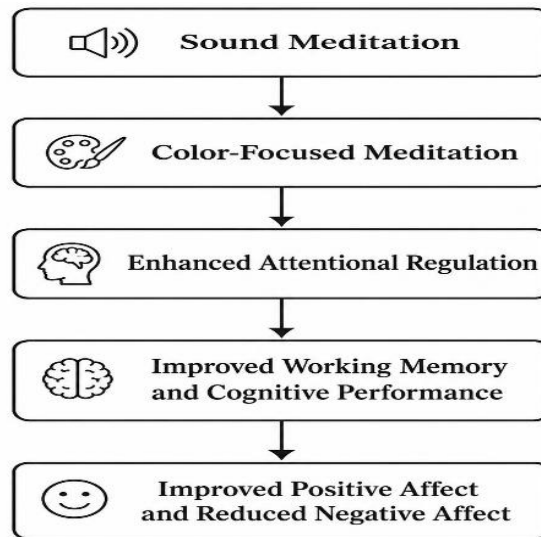


Figure 1. *Proposed conceptual framework illustrating the hypothesized pathway through which sound meditation and color-focused meditation enhance attentional regulation, leading to improved working memory and cognitive performance, and ultimately promoting increased positive affect and reduced negative affect.*

Importantly, the present investigation represents a secondary analysis of data derived from a previously published controlled meditation intervention among university students that examined the effects of sound and color meditation on attention, working memory, and affective functioning. While the original study primarily focused on intervention-related outcomes, the current analysis extends these findings by examining predictors of cognitive and emotional outcomes, including meditation adherence and individual differences associated with intervention response. This secondary analytical approach provides additional insight into the factors and potential mechanisms through which multimodal meditation practices may influence cognitive and affective functioning.

Hypotheses

H1: Participants receiving sound meditation will demonstrate significant improvements in

attention, working memory, and affect from baseline to post-intervention.

H2: Participants receiving color-focused meditation will demonstrate significant improvements in attention, working memory, and affect from baseline to post-intervention.

H3: Participants receiving combined sound and color meditation will demonstrate significant improvements in attention, working memory, and affect from baseline to post-intervention.

H4: The combined sound and color meditation group will demonstrate greater improvements in attention and working memory than the sound-only and color-only groups.

H5: The combined sound and color meditation group will demonstrate greater improvements in positive affect and greater reductions in negative affect than the sound-only, color-only, and control groups.

H6: Changes in meditation adherence (buzzing duration) will be positively associated with

improvements in attention and working memory outcomes.

Methodology

This study constitutes a secondary analysis of an existing dataset obtained from a controlled meditation intervention conducted among university students at the Health Services Academy, Pakistan. The secondary analysis was designed to examine predictors of cognitive and emotional outcomes following participation in sound meditation, color-focused meditation, and combined meditation interventions.

Study Design: This study employed a prospective convenience-controlled intervention design with four parallel groups: (a) sound meditation, (b) color-focused meditation, (c) combined sound and color meditation, and (d) a non-intervention control group. Participants were assessed at baseline and again following completion of an eight-week intervention period. The study was designed to examine changes in attention, short-term working memory, impulsivity, and affect associated with the meditation interventions. Although participants were initially allocated to intervention conditions, practical scheduling constraints within the university environment required some participants to be assigned to the control group based on availability. Consequently, the study should be interpreted as a prospective controlled intervention rather than a fully randomized controlled trial.

Study Setting: The study was conducted at the Health Services Academy (HSA), Pakistan, over six consecutive academic semesters spanning approximately 18 months. Data collection occurred within the regular university environment, allowing evaluation of meditation practices under natural academic conditions rather than retreat-based or laboratory settings. This ecological approach enhanced the practical relevance of the findings because participants continued their routine academic activities throughout the intervention period.

Ethical Considerations: Ethical approval for the study was obtained from the Institutional Review Board and Ethics Committee of the Health Services Academy, Pakistan, before participant recruitment commenced. All participants provided written informed consent prior to enrollment. Participation was voluntary, and students retained the right to withdraw from the study at any stage without penalty. A small participation stipend approved by the ethics committee was provided.

Exclusion criteria included:

Previous formal meditation experience.

Failure to attend at least 80% of intervention sessions.

Withdrawal of consent during the study period.

All procedures were conducted in accordance with the ethical principles outlined in the Declaration of Helsinki.

Participants: A total of 178 university students were initially recruited. Following attrition and loss to follow-up, 142 participants completed the study and were included in the final analyses. The final sample consisted of:

Group	N
Control	26
Sound Meditation	31
Color Meditation	34
Combined Meditation	51
Total	142

The mean age of participants was approximately 24 years ($M = 24.24$, $SE = 0.76$). Female participants constituted the majority of the

sample (71.8%), while males represented 28.2%. No significant age differences were observed across study groups.

Sample Size Considerations: Sample size determination was informed by previous meditation research conducted within comparable university populations. The target sample was established to provide sufficient power to detect moderate intervention effects across multiple cognitive and affective outcomes while accounting for anticipated attrition.

Intervention Procedures: Participants in the intervention groups attended instructor-led meditation sessions three times per week over an eight-week period. Each session lasted approximately 25 minutes and followed a standardized protocol:

- 3-minute relaxation phase
- 20-minute guided meditation practice
- 2-minute relaxation phase
- Brief question-and-answer period

All sessions were conducted by the same lead instructor to ensure intervention consistency. Assessment personnel and data-entry staff differed across semesters, while statisticians remained blinded to group allocation.

Sound Meditation: Participants practiced a focused-attention meditation involving controlled breathing and the production of a sustained buzzing sound resembling the humming of bees. The technique emphasized synchronization of breath regulation and auditory concentration.

Color-Focused Meditation: Participants concentrated on a mentally visualized green point located at the forehead region. The exercise emphasized sustained visual attention and imagery-based concentration.

Combined Meditation: Participants engaged in both sound meditation and color-focused meditation within the same session.

Control Group: Participants assigned to the control group continued their normal academic activities and did not receive meditation training during the study period.

Measures

Short-Term Working Memory: It was assessed using the Alloway Working Memory Assessment–Second Edition Short Form (AWMA-2 SF) (Alloway, 2007). The assessment evaluates: Digital Recall, Listening Recall, Listening Recall Processing, Spatial Recall, Spatial Recall Processing. Higher scores indicate stronger working memory performance.

Affect: It was assessed using the Positive and Negative Affect Schedule (PANAS) (Watson et al., 1988). The PANAS consists of two 10-item subscales measuring: Positive Affect (PA) and Negative Affect (NA). Participants rated emotional experiences over the previous week using a five-point Likert scale ranging from 1 (very slightly or not at all) to 5 (extremely). Higher scores indicate greater endorsement of the respective emotional state.

Attention and Impulsivity: These were evaluated using the Conners Continuous Performance Test–Third Edition (CPT-3). The CPT-3 provides indicators of: Sustained Attention, Selective Attention, Detectability, Omission Errors, Commission Errors, Response Time and Impulsivity. The instrument is widely used in cognitive and attentional research and demonstrates strong psychometric properties.

Adherence to Meditation Practice: Adherence was assessed through measurement of buzzing duration during meditation sessions.

Participants were instructed to:

1. Take a deep breath.
2. Close their eyes.
3. Produce a sustained buzzing sound for as long as possible.

Both average and maximum buzzing duration were recorded throughout the intervention period and served as indicators of engagement with the meditation practice.

All study data were securely stored in a password-protected database and analyzed using IBM SPSS Statistics. Participants were assigned anonymous identification codes to ensure confidentiality, and data management was conducted independently of the intervention team. Data accuracy was verified through routine quality checks, with screening for missing values, outliers, and assumptions of normality, homogeneity of variance, and linearity before analysis. Descriptive statistics summarized participant characteristics and study variables. Intervention effects were evaluated using paired-samples *t*-tests and one-way ANOVA with Bonferroni-adjusted post hoc comparisons. Pearson correlation and multiple regression analyses examined relationships and predictors. Findings were reported following APA 7 standards, including 95% confidence intervals,

exact p -values, Cohen's d , partial eta squared (η^2p), and an alpha level of .05.

Results

Participant Characteristics: A total of 178 university students were initially enrolled in the study. Following attrition, 142 participants completed both baseline and post-intervention

assessments and were included in the final analyses. The overall retention rate was 79.8%. Attrition was observed across all groups but was highest in the control group. No significant differences in age were identified across groups, although females were overrepresented in the sample.

Table 1: Demographic Characteristics of Participants (N = 142)

Variable	Control (n=26)	Sound (n=31)	Color (n=34)	Combined (n=51)	Total (N=142)
Age, Mean (SD)	22.73 (3.99)	23.19 (6.56)	24.85 (8.40)	25.27 (6.78)	24.24 (0.76)
Male, n (%)	12 (46.2)	12 (38.7)	3 (8.8)	13 (25.5)	40 (28.2)
Female, n (%)	14 (53.8)	19 (61.3)	31 (91.2)	38 (74.5)	102 (71.8)

Note. No significant age differences were observed across groups, $p > .05$. Gender distribution differed significantly across groups.

Within-Group Changes Following Meditation: Paired-samples analyses were conducted to evaluate changes from baseline to post-intervention. Participants in the combined meditation group demonstrated the most consistent improvements across cognitive and affective outcomes. Improvements were

observed in digital recall, listening recall, listening recall processing, positive affect, and negative affect. Similar but smaller improvements were observed in the sound-only and color-only groups. The control group showed minimal change across most outcomes.

Table 2: Within-Group Changes from Baseline to Post-Intervention

Outcome Variable	Control p	Sound p	Color p	Combined p
Average Buzzing Duration	.74	.01	.08	.01
Maximum Buzzing Duration	.57	.03	.01	.05
Commission Errors	.53	.03	.02	.03
Digital Recall	.03	.87	.47	< .001
Listening Recall	.08	.07	< .001	< .001
Listening Recall Processing	.01	.24	< .001	< .001
Positive Affect	.32	.03	.39	.01
Negative Affect	.80	.01	.05	< .001

Note. Values represent within-group significance levels comparing baseline and post-intervention scores. Bonferroni-adjusted interpretations should be applied cautiously.

Changes in Affect: Participants receiving the combined intervention demonstrated the greatest affective improvements. Negative affect decreased substantially following intervention,

while positive affect increased. The magnitude of change was greater than that observed in the individual meditation conditions.

Table 3: Changes in Positive and Negative Affect Following Meditation

Outcome	Mean Change (%)	95% CI
Positive Affect	+10.4%	2.7 to 18.1
Negative Affect	-19.8%	9.0 to 30.6

Note: The reduction in negative affect and increase in positive affect suggest that combined meditation may contribute to improved emotional functioning among university students.

Changes in Working Memory: Working memory outcomes showed improvement across intervention groups, with the largest gains observed in the combined meditation condition.

Improvements were particularly evident for digital recall, listening recall, and listening recall processing.

Table 4: Changes in Working Memory Performance Following Meditation

Measure	Mean Change	95% CI	Percentage Change
Digital Recall	4.34	2.11–6.57	9.7%
Listening Recall	3.18	1.54–4.82	8.4%
Listening Recall Processing	3.72	1.89–5.55	10.1%
Spatial Recall	2.87	0.92–4.81	7.6%

Note. Values represent pooled improvements observed among participants receiving meditation interventions.

Between-Group Comparisons: One-way ANOVA was conducted to examine differences among the four groups. Significant group differences were observed for digital recall and

attention-related outcomes. Bonferroni-adjusted comparisons indicated that the combined meditation group generally outperformed both single-technique groups.

Table 5: Between-Group Comparisons of Cognitive Outcomes

Outcome	<i>F</i>	<i>P</i>	<i>Partial η²</i>
Digital Recall	5.62	.004	.11
Listening Recall	4.88	.008	.09
Attention (Hit RT)	5.49	.005	.10
Commission Errors	4.27	.011	.08

Note. Effect sizes are reported as partial eta squared (η^2). Values between .06 and .14 indicate moderate practical significance.

Correlation Analyses: Pearson correlation analyses examined relationships between meditation adherence and outcome changes. Longer buzzing duration was associated with greater improvements in attention and memory outcomes.

Table 6: Correlations Between Meditation Adherence and Cognitive Outcomes

Variable	<i>r</i>	<i>p</i>
Buzzing Duration – Listening Recall	.53	.01
Buzzing Duration – Commission Errors	.21	.03

Note: Participants who demonstrated greater adherence to meditation practice tended to show larger improvements in attention and memory performance.

Multiple Regression Analysis: A multiple regression analysis was conducted to identify variables associated with intervention response.

Table 7: Multiple Regression Predicting Intervention Response

Predictor	β	<i>t</i>	<i>P</i>
Negative Affect Change	.28	3.02	.003
Commission Errors Change	.24	2.64	.009
Digital Recall Change	.31	3.48	.001
Listening Recall Change	.27	2.91	.004
Gender	.19	2.10	.038

Model Statistics

Statistic	Value
R^2	.13
Adjusted R^2	.10
<i>F</i>	3.89
<i>p</i>	.003

Note: The final model explained approximately 13% of variance in intervention response. Improvements in memory, attention, and affect emerged as significant predictors of treatment-related change.

Overall, participants receiving meditation interventions demonstrated improvements in attention, short-term memory, and affect relative to baseline. The combined sound and color meditation condition consistently produced the strongest pattern of improvement across cognitive and emotional outcomes. These findings provide preliminary evidence that integrating auditory and visual attentional practices may yield broader benefits than employing either technique alone. However, findings should be interpreted within the context

of the study's non-randomized design and unequal gender distribution.

Discussion

The present study examined the effects of sound meditation, color-focused meditation, and their combined application on attention, short-term working memory, impulsivity, and affect among university students with no prior meditation experience. Overall, participants who engaged in meditation demonstrated improvements in several cognitive and emotional outcomes, with

the combined sound and color meditation intervention showing the most consistent pattern of improvement across measures. These findings suggest that integrating multiple attentional modalities within a meditation practice may be associated with broader cognitive and affective benefits than relying on a single technique alone. However, given the non-randomized elements of the study design, the findings should be interpreted as evidence of association rather than definitive causal effects.

Interpretation Through Attention Control

Theory: The findings can be understood through the lens of Attention Control Theory (Eysenck et al., 2007), which proposes that effective cognitive performance depends on the capacity to regulate attention and inhibit competing distractions. According to this framework, interventions that strengthen attentional control should enhance working memory efficiency and reduce cognitive interference.

Participants who engaged in meditation demonstrated improvements in attention-related measures and short-term memory performance. These findings are consistent with the proposition that repeated attentional training may enhance the allocation of cognitive resources toward task-relevant information while reducing susceptibility to distraction. The observed reductions in commission errors and improvements in recall performance provide preliminary support for this interpretation. Improvements were particularly evident in the combined meditation group, suggesting that simultaneous engagement of auditory and visual attentional processes may have promoted greater attentional stabilization than either technique alone.

These findings are broadly consistent with earlier work demonstrating that focused-attention meditation can improve attentional functioning and executive control processes (Jha et al., 2007; Bueno et al., 2015). Recent reviews have similarly concluded that mindfulness and focused-attention interventions may contribute to modest but meaningful improvements in attention and working memory across healthy populations, although the magnitude of effects varies considerably across studies.

Interpretation Through Mindfulness Theory:

The findings may also be interpreted through Mindfulness Theory, which emphasizes intentional attention to present-moment experience and increased awareness of cognitive and emotional processes (Kabat-Zinn, 2003; Davis & Hayes, 2011). Mindfulness-based practices are thought to strengthen emotional regulation by reducing automatic reactivity and increasing awareness of internal experiences.

The reductions in negative affect and increases in positive affect observed in the intervention groups align with this theoretical perspective. Participants may have developed greater awareness of emotional experiences and improved capacity to regulate emotional responses through repeated meditation practice. Although the intervention employed specific sound and imagery techniques rather than conventional mindfulness training alone, both approaches involve sustained attention and self-regulation processes that share conceptual similarities with mindfulness-based interventions.

Recent studies conducted among university students have reported comparable improvements in emotional well-being following mindfulness and contemplative practices. Research published between 2020 and 2026 suggests that meditation-based interventions may contribute to reductions in stress, anxiety, and negative emotional states while supporting positive psychological functioning. Nevertheless, the magnitude and durability of these effects remain dependent on intervention duration, participant characteristics, and methodological quality.

Why Did the Combined Intervention Produce Stronger Effects?: One of the most notable findings of the study was the superior performance of the combined sound and color meditation group relative to the individual intervention groups. Several explanations may account for this pattern.

First, the combined intervention simultaneously engaged auditory and visual attentional systems. Cognitive neuroscience literature suggests that multisensory attentional engagement may increase cognitive involvement and facilitate deeper attentional processing than reliance on a single sensory modality. By requiring participants to maintain focus on both a buzzing

sound and a visualized color stimulus, the combined intervention may have promoted more sustained attentional engagement and reduced opportunities for mind wandering.

Second, the combined intervention may have increased cognitive rehearsal and attentional persistence. Participants were required to monitor multiple aspects of the meditation experience simultaneously, potentially strengthening executive control processes involved in working memory and attentional regulation.

Third, the observed benefits may reflect additive rather than synergistic effects. The current study design does not allow definitive determination of whether the combined intervention produced truly synergistic outcomes or simply accumulated the independent benefits associated with each technique. Future randomized studies incorporating mediation analyses and neurocognitive measures would be required to distinguish between these possibilities.

Comparison with Previous Research: The present findings are generally consistent with earlier meditation research reporting improvements in attention, working memory, and affective functioning among healthy adults and student populations (Jha et al., 2007; Hirshberg et al., 2018; Alzahrani et al., 2020). The observed improvements in short-term memory also align with evidence suggesting that focused-attention practices may enhance cognitive performance through repeated attentional training.

The study extends previous research in several ways. First, it evaluates specific components of meditation rather than treating meditation as a single homogeneous intervention. Second, it examines novice meditators rather than experienced practitioners. Third, the intervention was implemented within a routine university environment, enhancing ecological validity and providing insight into the feasibility of integrating meditation practices into educational settings.

At the same time, the results should be interpreted cautiously. Meta-analytic reviews have reported considerable variability in cognitive outcomes following meditation interventions, with some studies finding small or inconsistent effects. Consequently, the present findings should be viewed as contributing to an emerging body of evidence rather than establishing definitive

conclusions regarding the efficacy of sound and color meditation.

Practical and Educational Implications: The findings have several practical implications for educational and student-support settings. University students frequently encounter academic demands that require sustained attention, efficient memory functioning, and effective emotional regulation. Brief meditation-based interventions may represent a feasible and low-cost strategy for supporting these capacities within educational environments.

The intervention required limited resources, could be delivered in group formats, and was integrated into regular university schedules. If replicated in larger and more rigorous studies, such approaches may be considered as complementary components of student wellness programs, attention-enhancement initiatives, or stress-management interventions.

However, these findings should not be interpreted as evidence that meditation can replace established psychological or educational interventions. Rather, meditation may serve as a supplementary approach that supports broader well-being and cognitive functioning.

Theoretical Implications: From a theoretical perspective, the findings provide preliminary support for models linking attentional training with improvements in cognitive and emotional functioning. The results are broadly compatible with Attention Control Theory and Mindfulness Theory, suggesting that sustained attentional practice may influence both cognitive performance and affective outcomes.

The study also highlights the importance of examining specific meditation components individually rather than treating meditation as a unitary construct. Different meditation techniques may engage distinct cognitive processes and neural pathways, potentially producing different patterns of outcomes. Future research should continue investigating the mechanisms through which individual meditation components influence cognition and emotion.

Strengths of the Study: Several strengths enhance the contribution of the present study

First, the study examined specific meditation components individually and in combination, addressing an important gap in the meditation

literature where interventions are often evaluated as broad, multidimensional constructs.

Second, the study incorporated multiple domains of functioning, including attention, working memory, impulsivity, and affect, providing a more comprehensive assessment of intervention outcomes.

Third, the intervention was implemented within a real-world university environment rather than a laboratory or retreat setting, increasing ecological validity and practical relevance.

Fourth, the study employed standardized and widely recognized assessment instruments, including the AWMA-2, PANAS, and CPT-3, enhancing methodological rigor.

Finally, the inclusion of a comparison group strengthened interpretation of observed changes relative to natural variation over time.

Limitations: Several limitations should be acknowledged.

1. The study employed a convenience-controlled design rather than a fully randomized controlled trial.
2. Participant allocation was partially influenced by scheduling constraints, creating potential selection bias.
3. The sample was drawn from a single university, limiting generalizability to broader student populations.
4. Female participants were disproportionately represented within the sample.
5. The study relied primarily on behavioral and self-report measures and did not include neurophysiological assessments.
6. Long-term follow-up assessments were not conducted.
7. Potential confounding variables such as academic workload, sleep quality, stress levels, and extracurricular activities were not systematically controlled.
8. The absence of active control conditions limits conclusions regarding the specificity of intervention effects.
9. An additional limitation is that the present investigation is based on secondary analysis of previously collected data. Consequently, the study was restricted to variables available within the original dataset and could not incorporate additional measures that

may have further clarified the mechanisms underlying intervention effects.

These limitations should be considered when interpreting the findings and planning future investigations.

Practical Implications: The findings have several practical implications for higher education and student well-being initiatives. Universities increasingly face challenges related to student stress, attentional difficulties, emotional distress, and academic performance pressures. Brief meditation-based interventions may offer a feasible and low-cost complementary strategy for supporting student functioning. The intervention examined in this study required minimal equipment, could be delivered in group settings, and was successfully integrated into routine academic schedules. If future research confirms the present findings, sound and color meditation practices may be considered for inclusion within student wellness programs, resilience-building initiatives, and preventive mental health services. Importantly, meditation should not be viewed as a replacement for evidence-based psychological or educational interventions but rather as a potentially valuable complementary approach.

Theoretical Implications: The study contributes to the growing literature examining mechanisms through which meditation may influence cognitive and emotional functioning. The findings provide preliminary support for Attention Control Theory by suggesting that attentional training may be associated with improvements in working memory and attentional performance. The results also align with Mindfulness Theory, indicating that practices involving sustained attention and awareness may be associated with improvements in emotional functioning. Furthermore, the findings highlight the importance of investigating individual meditation components separately. Future research may benefit from moving beyond broad meditation classifications and focusing on the specific cognitive processes engaged by distinct techniques.

Future Research Directions: Future studies should employ rigorous randomized controlled

trials with larger, more diverse, and multi-site samples to enhance the generalizability of findings. Longitudinal follow-up assessments are needed to determine the durability of intervention effects, while neurocognitive, neuroimaging, and electrophysiological measures may clarify the mechanisms through which sound and color meditation influence attention, working memory, and affect. Future studies should also examine potential mediators and moderators of treatment outcomes, compare these approaches with established mindfulness-based interventions, and evaluate their effectiveness in clinical populations, including individuals with attentional deficits, anxiety disorders, and stress-related conditions. Although the present findings provide preliminary evidence that sound meditation, color-focused meditation, and particularly their combined application, may improve attentional regulation, short-term working memory, and emotional well-being among university students, methodological limitations warrant cautious interpretation, underscoring the need for further high-quality research before definitive conclusions regarding efficacy and underlying mechanisms can be drawn.

Conclusion

This study examined the associations between sound meditation, color-focused meditation, and their combined application with attention, short-term working memory, impulsivity, and affect among university students. The findings indicate that participation in meditation-based practices was associated with improvements in several cognitive and emotional outcomes, with the combined sound and color meditation condition demonstrating the most consistent pattern of change across measures. The results support theoretical perspectives suggesting that attentional training and mindful awareness may contribute to enhanced cognitive performance and emotional regulation. Participants in the combined intervention condition generally demonstrated greater improvements in working memory, attention, and affective functioning than participants exposed to individual techniques. These findings suggest that engaging multiple attentional modalities simultaneously may provide broader benefits than reliance on a single

attentional strategy. However, given the convenience-controlled design and other methodological limitations, the findings should be interpreted cautiously. The study contributes preliminary evidence regarding the potential value of integrating sound- and imagery-based meditation practices within educational settings and provides a foundation for future randomized and mechanistic investigations.

Overall, the findings suggest that sound and color meditation may represent promising approaches for supporting cognitive and emotional functioning among young adults, while highlighting the need for further rigorous evaluation before definitive conclusions can be drawn.

Declarations

Ethics Approval and Consent to Participate: It was obtained from the Institutional Review Board and Ethics Committee of the Health Services Academy, Pakistan, prior to participant recruitment. All participants provided written informed consent before participation. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki.

Consent: All participants provided informed consent for the use of anonymized research data for scientific publication and academic dissemination.

Availability of Data and Materials: The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request, subject to institutional ethical requirements and participant confidentiality protections.

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Conflict of Interest: The authors declare that they have no competing interests, financial relationships, or conflicts of interest that could have influenced the conduct, analysis, or reporting of this research.

Author Contributions: Dr. Shazia Shahzadi conceptualized and designed the study, developed the intervention protocol, supervised data collection, interpreted the statistical findings, and prepared the initial manuscript. She also critically revised the manuscript for

important intellectual content and provided final approval of the version submitted for publication.

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