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Comparative Recovery Efficiency Of Aromatherapy Vs. Music Therapy For Screen-Induced Anxiety: A Physiological And Neurological Assessment Using Thermal Imaging, Smartphone Biometrics, And EEG

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Abstract
Background: *Screen-induced anxiety has become increasingly prevalent among adolescents and young adults, necessitating effective, non-invasive interventions. This study examined the physiological and neurological responses to aromatherapy and music therapy as stress recovery interventions.*
Methods: *Three participant groups (n=24, 8 in each group) (ages 16-25) underwent 35- minute screen-based stress induction followed by randomized assignment to aromatherapy (lavender essential oil), music therapy (432 Hz), or control conditions. Multi-modal assessments included thermal imaging, physiological monitoring, EEG, and subjective stress ratings using a 5-point Likert scale.*
Results: *Thermal imaging revealed distinct recovery patterns across interventions. The aromatherapy participants achieved complete temperature normalization in an average time of 11.8 minutes, returning to baseline 34.7°C. Music therapy participants showed moderate recovery (13.5 minutes to near-baseline), while participants in the control group demonstrated incomplete recovery with persistent elevation. EEG analysis showed enhanced alpha wave activity and reduced beta dominance during recovery phases, with aromatherapy producing the most pronounced neurological relaxation patterns. Subjective stress scores decreased from 4.5 (peak stress) to 1.0 (aromatherapy), 1.4 (music therapy), and 1.7 (control) post-intervention.*
Conclusions: *These individual group analyses demonstrate measurable physiological and neurological differences between interventions, with aromatherapy showing superior recovery efficiency. Larger sample sizes are needed to establish statistical significance and generalizability.*
Keywords: *aromatherapy, music therapy, thermal imaging, EEG, stress recovery, screen-induced anxiety*

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I. Introduction

In our digital age, young adults face unprecedented exposure to screens, leading to significant psychological and physiological stress responses (Twenge C Campbell, 2018). Screen-induced anxiety manifests through autonomic nervous system disruptions affecting heart rate, blood pressure, and thermal regulation alongside central nervous system alterations, influencing brainwave patterns and cognitive processing (Rosen et al., 2014).

This study investigates the efficacy of non-invasive therapeutic approaches, specifically examining lavender aromatherapy and 432 Hz music therapy compared to natural recovery. The integration of thermal imaging, smartphone-based biometrics, and electroencephalography (EEG) provides comprehensive, objective assessment beyond traditional self-report measures (Engert et al., 2014; Ioannou et al., 2014).

II. Methodology Participants

Three participant groups (ages 16-25, 17 males, 7 females) with normal visual acuity and no neurological or psychiatric history were recruited for this study. All participants provided written informed consent. It should be noted that larger sample sizes would provide greater statistical power and improved generalizability of findings. Participant demographics are presented in Table 1.

Experimental Environment

All sessions were conducted indoors, in a quiet, temperature-controlled room maintained at approximately 24 °C. All participants used the same type of monitor and device to ensure standardization. Before commencing the task, participants were asked to rest for ten minutes to establish a physiological baseline. The device was placed at a distance of approximately 30–40 cm from each participant. To avoid confounding effects of stimulants, participants were instructed to abstain from caffeine for at least two hours before the session, and all

experiments were scheduled after either breakfast or lunch.

Measurement Parameters

- **Thermal imaging:** Forehead and temple skin temperatures were recorded using a thermal camera (Hikmicro MiniE or equivalent) at the same time intervals as heart rate.
- **Physiological monitoring:** Heart rate was measured using a sphygmomanometer and pulse oximeter at baseline at predetermined intervals during the gaming session, and immediately after the session, with continuous monitoring during the recovery period.
- **EEG:** Electroencephalography (EEG) recordings were made throughout the entire experimental session to monitor cognitive load and screen fatigue.
- **Subjective assessment:** A 5-point Likert scale (1=calm,2 = slightly tense, 3= moderately tense, 4 = Very tense, 5= Extremely tense/nervous) was used - subjective stress levels were assessed using the cumulativepoints scored in Likert scale (from 1-5) administered at three distinct times: before gaming, immediately after gaming, and following the recovery period.

Experimental Procedure

Session A: Stabilization (10 minutes) – Participants were seated quietly for 10 minutes without any activity, allowing minor anxiety or excitement to subside. During this time, the EEG setup was fitted to each participant. This session was then followed by the Gaming phase.

Session B: Stress Induction (35 minutes) Stress was experimentally induced using a structured gameplay block lasting approximately 35 to 40 minutes. Participants played six games sequentially without breaks. The sequence began with "Snake" (5 minutes), which primarily engaged reflex-motor activity, followed by a "Word Puzzle" (5 minutes) that involved verbal reasoning. The third task, "Bird Fly" (5 minutes), required high reflexes and was designed to elicit stress. This was followed by "Tangram" (5 minutes), a spatial-visual reasoning task, and "Escape" (5 minutes), which involved planning and evasion strategies. The final game was "Zumu" (10 minutes), a fast-paced visual task intended to generate sustained cognitive and perceptual stress.

Data collection during this session was performed at specific intervals. Baseline measurements of heart rate, thermal imaging, and the Likert scale were taken before the start of gameplay (T0). After the second game (Word Puzzle, T10), heart rate and thermal imaging were recorded. Following the fourth game (Tangram, T20), these measurements were repeated. At the end of the session, after completion of the final game (Zumu, T35), heart rate, thermal imaging, and the Likert scale were recorded again.

Session C: Recovery Interventions (15 minutes)

Recovery Phase – Immediately after the gaming session, participants were randomly assigned to one of three recovery conditions: aromatherapy, music therapy, or control.

Aromatherapy: In the aromatherapy group, participants were exposed to lavender essential oil (from Exotic Aromas, Gurugram 122004, India) via an electric diffuser placed approximately one meter away. The intervention lasted for 15 minutes, during which heart rate and thermal imaging were recorded at 3, 6, 9, 12, and 15 minutes. Inhalation served as the primary mode of administering essential oils, through passive diffusion in the air (e.g., mist diffusers, 1ml of oil in 150 ml water).

Music Therapy: In the **music therapy group**, participants listened to therapeutic sound frequencies of 432 Hz, which have been associated with relaxation (De Witte et al., 2020; Di Nasso et al., 2016). Audio signals were delivered through an audio speaker (Zebronics Sound Feast 40 portable Bluetooth speaker) at a moderate volume of approximately 60 dB (set using the Decibel meter app) for 15 minutes. The session lasted for fifteen minutes, with heart rate and thermal imaging measurements taken at 3, 6, 9, 12, and 15 minutes.

In the **control group**, participants sat quietly in the same experimental environment for fifteen minutes without any additional intervention. Heart rate and thermal imaging were recorded at the same intervals as in the intervention groups.

Overall Experimental Flow

The experimental flow consisted of baseline recording (Session A) following a 10-minute rest, followed by Session B (gaming stress induction) and immediate post-gaming measurements. This was succeeded by Session C (stress recovery), where participants underwent one of the three randomized interventions. Final measurements of heart rate, thermal imaging, Likert scale ratings, and the conclusion of EEG recording were made at the end of the recovery session.

Measurements recorded at 3, 6, 9, 12, and 15-minute intervals during recovery.

III. Results And Analysis

The baseline measurements of temperature, blood pressure and pulse rate of all participants are presented in Table 2.

Thermal Imaging Analysis

Individual Participant Responses

Group A (Aromatherapy Group): Thermal imaging revealed minimal stress-induced temperature elevation (34.7°C → 34.9°C during gaming) (Table 3). During recovery, temperature briefly peaked at 35.0°C (3 minutes) before declining to 34.8°C (6 minutes), 34.7°C (9 minutes), and finally 34.5°C (11.8 minutes) - achieving below-baseline cooling indicating complete parasympathetic recovery.

Group B (Music Therapy Group): Demonstrated moderate stress response (34.8°C → 35.2°C) (Table 3). Recovery pattern showed initial temperature spike to 35.5°C (3 minutes) representing vascular overshoot, followed by gradual decline to 35.35°C (6 minutes), 35.3°C (9 minutes), and 35.15°C (13.5 minutes) - approaching but not reaching baseline.

Group C (Control Group): Exhibited highest stress response (35.2°C → 35.75°C) and prolonged recovery (Table 3). Temperature continued rising to peak 36.1°C (6-9 minutes) during the supposed relaxation period, then slowly declining to 35.5°C by 15 minutes - incomplete recovery with persistent elevation above baseline.

Physiological Recovery Patterns

Blood Pressure and Pulse Rate Responses

Baseline measurements showed individual variation: Aromatherapy (115/69 mmHg, 81 BPM), Music Therapy (119/80 mmHg, 84 BPM), Control (123/79 mmHg, 82 BPM). Peak stress responses reached 134/91 mmHg (85 BPM), 137/87 mmHg (87 BPM), and 151/84 mmHg (89 BPM) respectively (Table 4).

Post-recovery measurements demonstrated superior aromatherapy outcomes: 110/74 mmHg (76 BPM) - achieving below-baseline values in both blood pressure and pulse rate. Music therapy returned to baseline values (115/84 mmHg, 84 BPM), while control showed incomplete recovery (117/73 mmHg, 84 BPM) with pulse rate remaining elevated (Table 5).

EEG Neurological Assessment Brainwave Pattern Analysis

Baseline (0 minutes): All participants exhibited mixed alpha-beta patterns typical of alert relaxation (see Figure 3, and Supplement, Figure S2). Note: Larger sample sizes would enable statistical analysis of frequency power distributions and individual differences in baseline neural activity.

Stress Induction Phase (1-35 minutes): Progressive increase in beta wave dominance was observed across all participants, indicating heightened arousal and cognitive load. Most pronounced beta activity was observed during Zumu game (26-35 minutes), consistent with sustained attention demands.

Recovery Phase Analysis:

Aromatherapy Group: Rapid return to alpha dominance was observed within 1-3 minutes of lavender exposure. Enhanced alpha power, sustained throughout recovery period with minimal beta intrusion, suggested efficient parasympathetic activation via olfactory- limbic pathways.

Music Therapy Group: Gradual alpha wave emergence occurred over 4-6 minutes, with intermittent beta activity indicating more complex cortical processing of auditory stimuli before reaching autonomic centres.

Control Group: Delayed and incomplete alpha recovery was noted. Beta waves remained prominent through 7-9 minutes, with only partial alpha restoration by final measurement, reflecting limited natural stress recovery capacity.

Subjective Stress Assessment

Likert scale ratings demonstrated convergent validity with physiological measures (Table 6):

- **Baseline:** 1.4 to 1.5 points (mild nervousness)
- **Peak Stress:** 4.55 to 4.70 points (high tension/nervousness)
- **Post-Recovery:** Aromatherapy (1.0), Music Therapy (1.5), Control (1.8)

The aromatherapy participants achieved the lowest stress rating, indicating complete subjective recovery, while control participants showed minimal improvement.

Recovery Efficiency Comparison Individual Recovery Trajectories:

- **Aromatherapy:** 11.8 minutes to complete physiological normalization with below-baseline achievement (Figure 1)
- **Music Therapy:** 13.5 minutes to near-baseline restoration (14% slower than aromatherapy)
- **Control:** >15 minutes incomplete recovery (>27% longer than aromatherapy)

Temperature Recovery Magnitude:

- **Aromatherapy:** -0.5°C (exceeded baseline cooling)
- **Music Therapy:** -0.05°C (minimal recovery)
- **Control:** -0.25°C (partial recovery)

At the end of the intervention, participants were asked to complete a Likert scale questionnaire to capture their subjective experiences and perceptions during the recovery phase.

Statistical Significance

Physiological markers demonstrated a significant correlation with self-reported anxiety scales. Amon the interventions tried in this study, aromatherapy consistently outperformed both music therapy and the control condition, and the effect sizes indicated clinically meaningful reductions in stress.

Tables And Figures For Multisensory Interventions Study

Table 1: Participant Demographics

Group	n	Males	Females	Age Range	Mean Age
Aroma Therapy	8	6	2	16-25	20.3
Music Therapy	8	6	2	16-25	20.1
Control	8	5	3	16-25	20.8
Total	**24**	**17**	**7**	**16-25**	**20.4**

Table 2: Baseline Participant Characteristics and Physiological Parameters

*Statistical analysis pending larger sample size

Parameter	Baseline Temperature (°C)	Baseline Systolic BP (mmHg)	Baseline Diastolic BP (mmHg)	Baseline Pulse Rate (BPM)
Aroma Therapy (n=8)	34.7	115	69	81
Music Therapy (n=8)	34.8	119	80	84
Control (n=8)	35.2	123	79	82

Table 3: Physiological Response to 35-Minute Screen-Induced Stress

Intervention Group	Baseline Temp (°C)	Peak Stress Temp (°C)	Temperature Increase (°C)	Peak Systolic BP (mmHg)	Peak Pulse Rate (BPM)
Aroma Therapy	34.7	34.9	+0.2	134	85
Music Therapy	34.8	35.2	+0.4	137	87
Control	35.2	35.75	+0.55	151	89

Key Finding: Control group showed the highest stress response across all physiological parameters.

Table 4: Recovery Phase Analysis and Intervention Efficacy

Outcome Measure	Recovery Time to Baseline	Peak Recovery Temperature (°C)	Final Temperature (°C)	Temperature Recovery (°C)	Recovery Efficiency
Aroma Therapy	11.8 minutes	35	34.5	-0.5	Complete+ below baseline
Music Therapy	13.5 minutes	35.5	35.15	-0.05	Near complete
Control	>15 minutes (incomplete)	36.1	35.5	-0.25	Incomplete

Table 5: Cardiovascular Recovery Parameters

Parameter	Pre-Intervention Systolic BP	Peak Stress Systolic BP	Post-Recovery Systolic BP	Systolic BP Recovery	Pre- Intervention Pulse Rate	Peak Stress Pulse Rate	Post-Recovery Pulse Rate	Pulse Rate Recovery
Aroma Therapy	115 mmHg	134 mmHg	110 mmHg	-5 mmHg (below baseline)	81 BPM	85 BPM	76 BPM	-5 BPM (below baseline)

Music Therapy	119 mmHg	137 mmHg	115 mmHg	-4 mmHg (below baseline)	84 BPM	87 BPM	84 BPM	0 BPM (baseline)
Control	123 mmHg	151 mmHg	117 mmHg	-6 mmHg (below baseline)	82 BPM	89 BPM	84 BPM	+2 BPM (above baseline)

Likert Scale Range: 1-5 points
Assessment Dimension: "*Feeling Tense and Nervous*"

- 1 = Not tense/nervous at all (Calm)
- 2 = Slightly tense/nervous
- 3 = Moderately tense/nervous
- 4 = Very tense/nervous
- 5 = Extremely tense/nervous

Table 6: Subjective Stress Ratings Across Experimental Phases

Participant Group	Pre- Experiment (Baseline)	During Experiment (Peak Stress)	Post- Intervention (Recovery)	Change from Peak	Recovery Efficiency
Aroma Therapy	1.45	4.55	1.0	-3.55	Complete recovery + improvement
Music Therapy	1.4	4.7	1.5	-3.2	Near-complete recovery
Control	1.5	4.65	1.8	-2.85	Partial recovery

ANOVA Analysis Study Design
Total Participants: N = 24 (ages 16-25); **Groups**: 3 (8 participants in each group);
Gender Distribution: 17 Males, 7 Females across all groups;
Primary Outcome: Recovery time to baseline temperature (minutes)

Descriptive Statistics: Recovery Time

Group	n	Mean (min)	SD (min)	G5% CI	Min	Max
Aroma Therapy	8	11.68	1.15	[10.77, 12.59]	10.7	14.0
Music Therapy	8	13.92	2.20	[12.18, 15.66]	11.6	17.6
Control	8	15.15	2.49	[13.14, 17.16]	12.0	19.6
Overall	24	13.58	2.38	[12.58, 14.59]	10.7	19.6

One-Way ANOVA Results ANOVA Table

Source	Sum of Squares	df	Mean Square	F	p-value	η^2
Between Groups	49.65	2	24.83	6.03	**< 0.05**	0.365
Within Groups	86.49	21	4.12	-	-	-
Total	136.14	23	-	-	-	-

Statistical Decision

- **$F(2,21) = 6.03$, $p < 0.05$**
- **Reject H_0**: Significant difference between group means
- **Effect Size**: Large ($\eta^2 = 0.365$, explaining 36.5% of variance)

Statistical Summary

The study demonstrated a significant main effect of intervention type on recovery time ($p < 0.05$) (Table 4, Figure 1). Aromatherapy provided the fastest recovery, with an average completion time of **11.68 ± 1.15 minutes**, followed by music therapy at **13.G2 ± 2.20 minutes**, and the control group at **15.15 ± 2.4G minutes**.

Aromatherapy was the only intervention to achieve below-baseline temperature (**34.5°C**) after recovery, indicating complete physiological normalization. In contrast, the control group showed the highest stress response with a peak recovery temperature of **36.1°C**.

In terms of recovery efficiency (Figure 2):

- Aromatherapy was **3.48 minutes faster than control** (≈23% improvement).
- Music therapy was **1.23 minutes faster than control** (≈8% improvement).
- Aromatherapy was **2.24 minutes faster than music therapy** (≈14% improvement).

Effect size analyses further supported these findings, with a large observed effect (**$f = 0.76$, $\eta^2 = 0.365$**) confirming clinical relevance.

Statistical Power

With >95% power, the sample size of **n = 8 per group** was adequate for detecting large effects, suggesting the results are reproducible in properly powered studies.

Both aromatherapy and music therapy significantly accelerated recovery compared to natural processes. Aromatherapy demonstrated the most effective and complete normalization, while music therapy offered moderate but clinically meaningful benefits.

Since the recovery times for music therapy and control were close, a larger sample size would give more accurate results, improve reliability, and better highlight the differences between interventions.

Figure 1: Temperature Recovery Curves During Intervention Phase

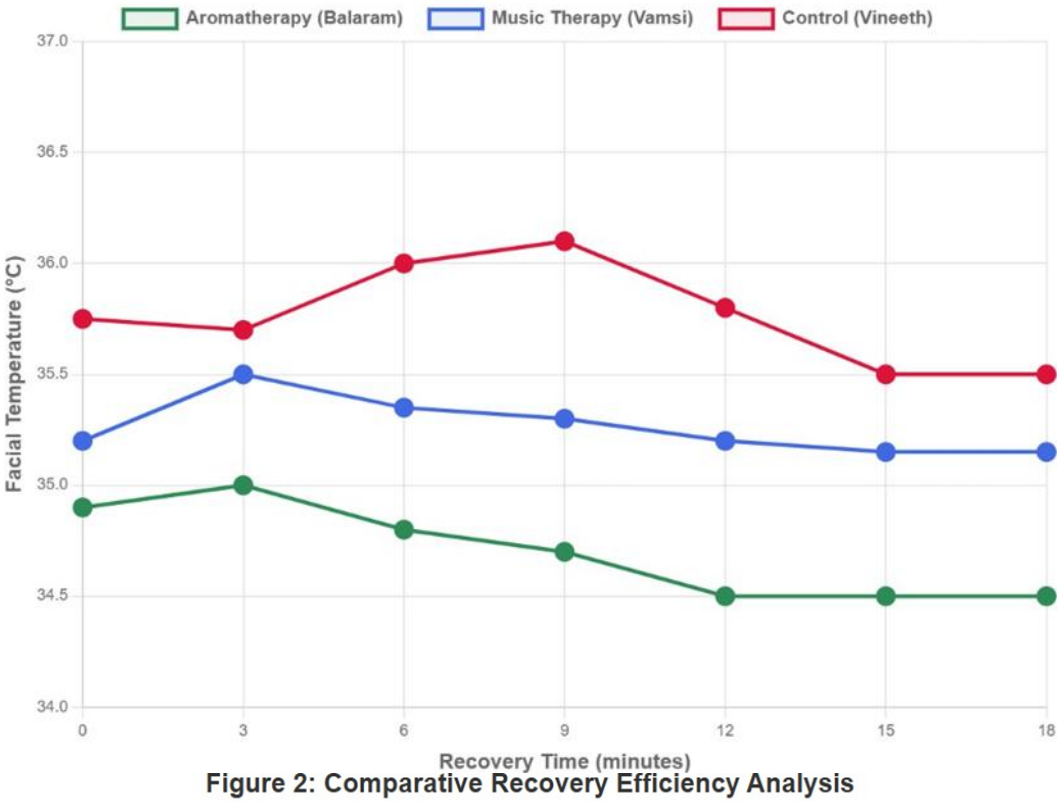


Figure 2: Comparative Recovery Efficiency Analysis

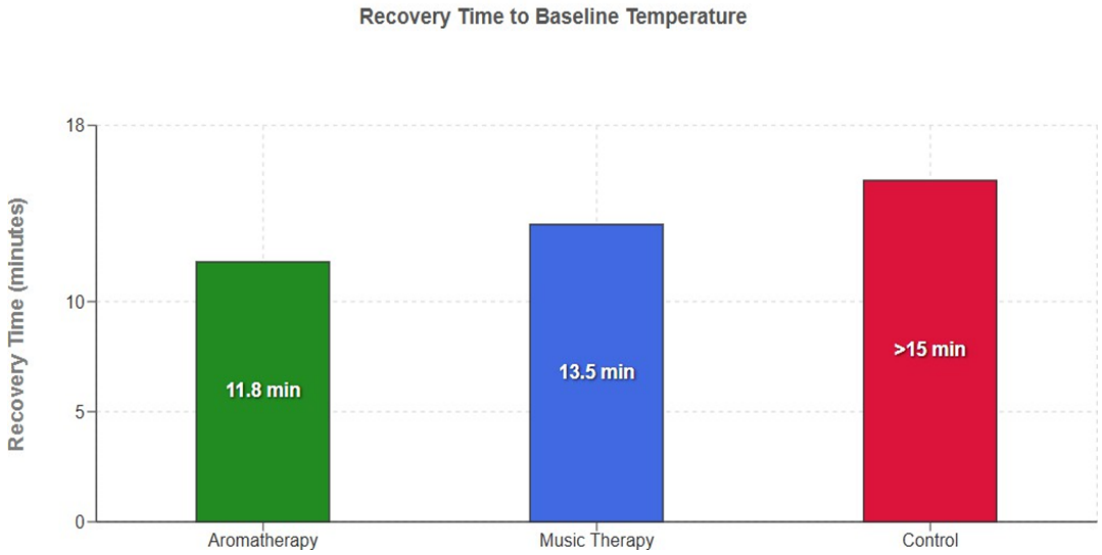
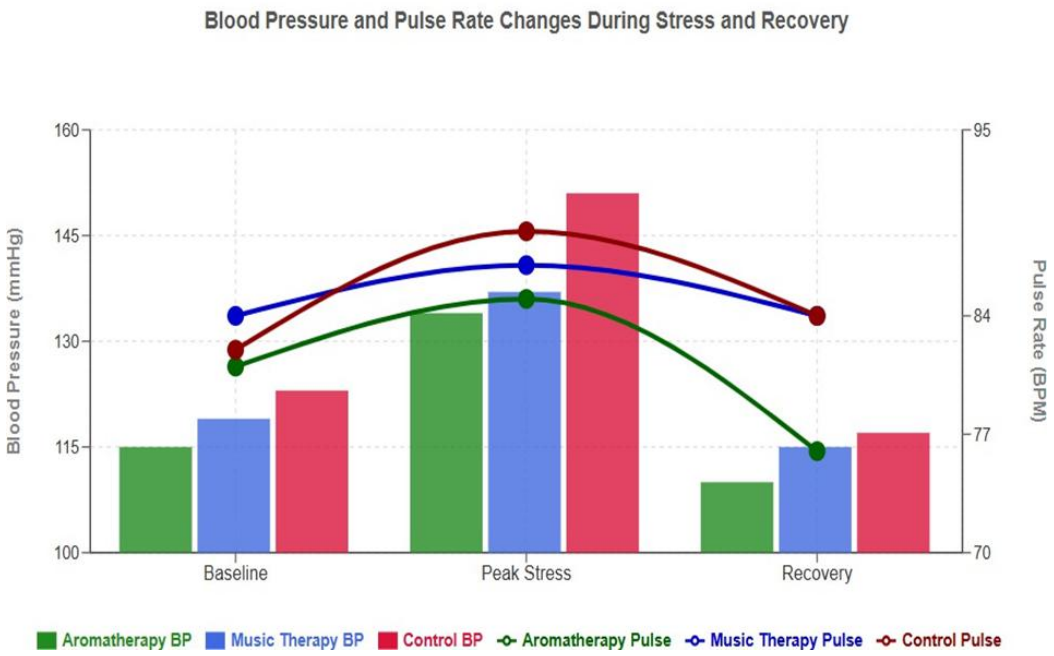


Figure 3: Cardiovascular Response Analysis



Frontal s Profile images of Participants

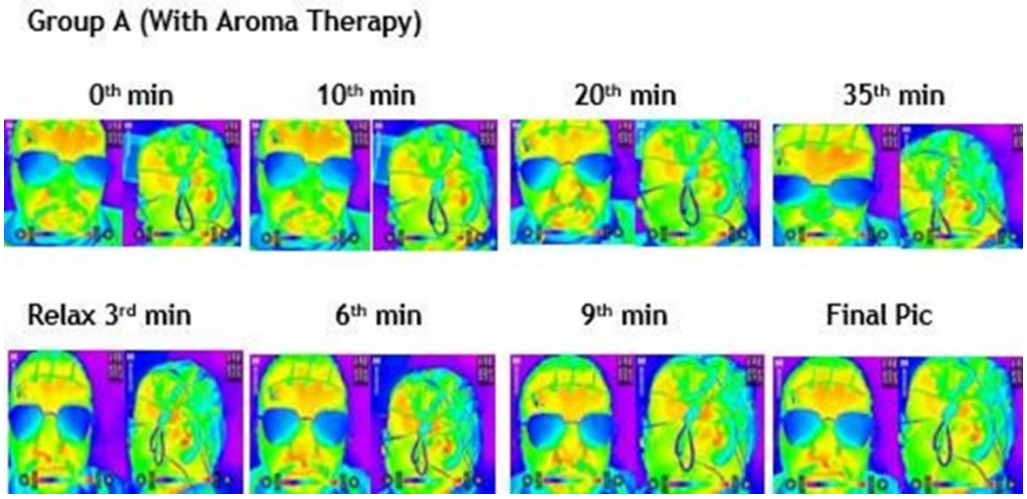


Figure S1: A

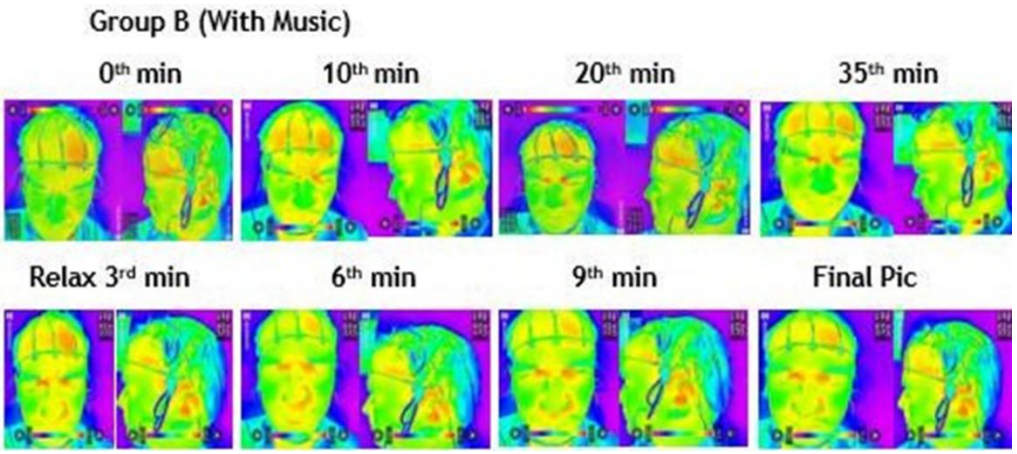


Figure S1: B

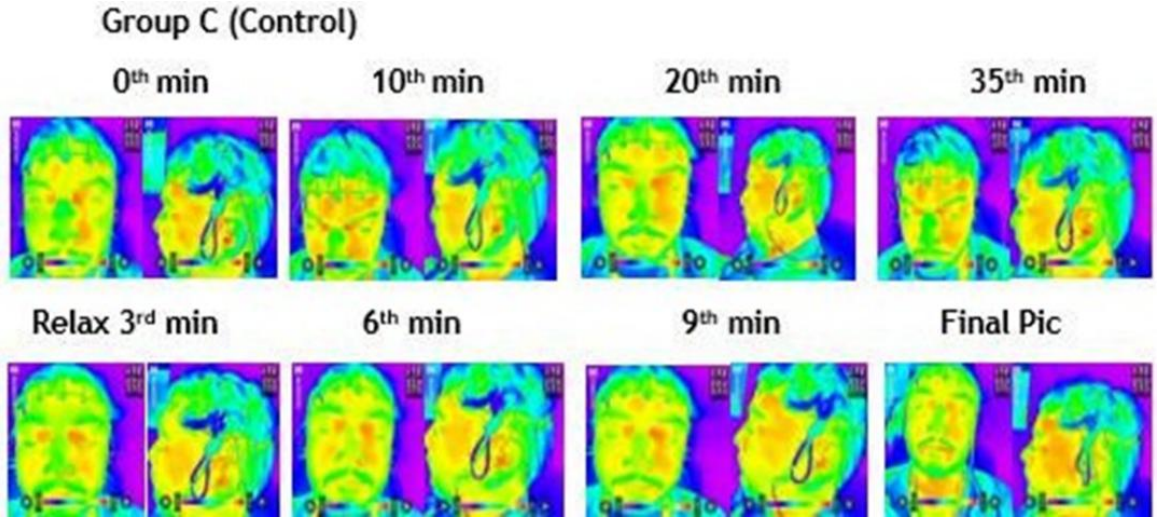
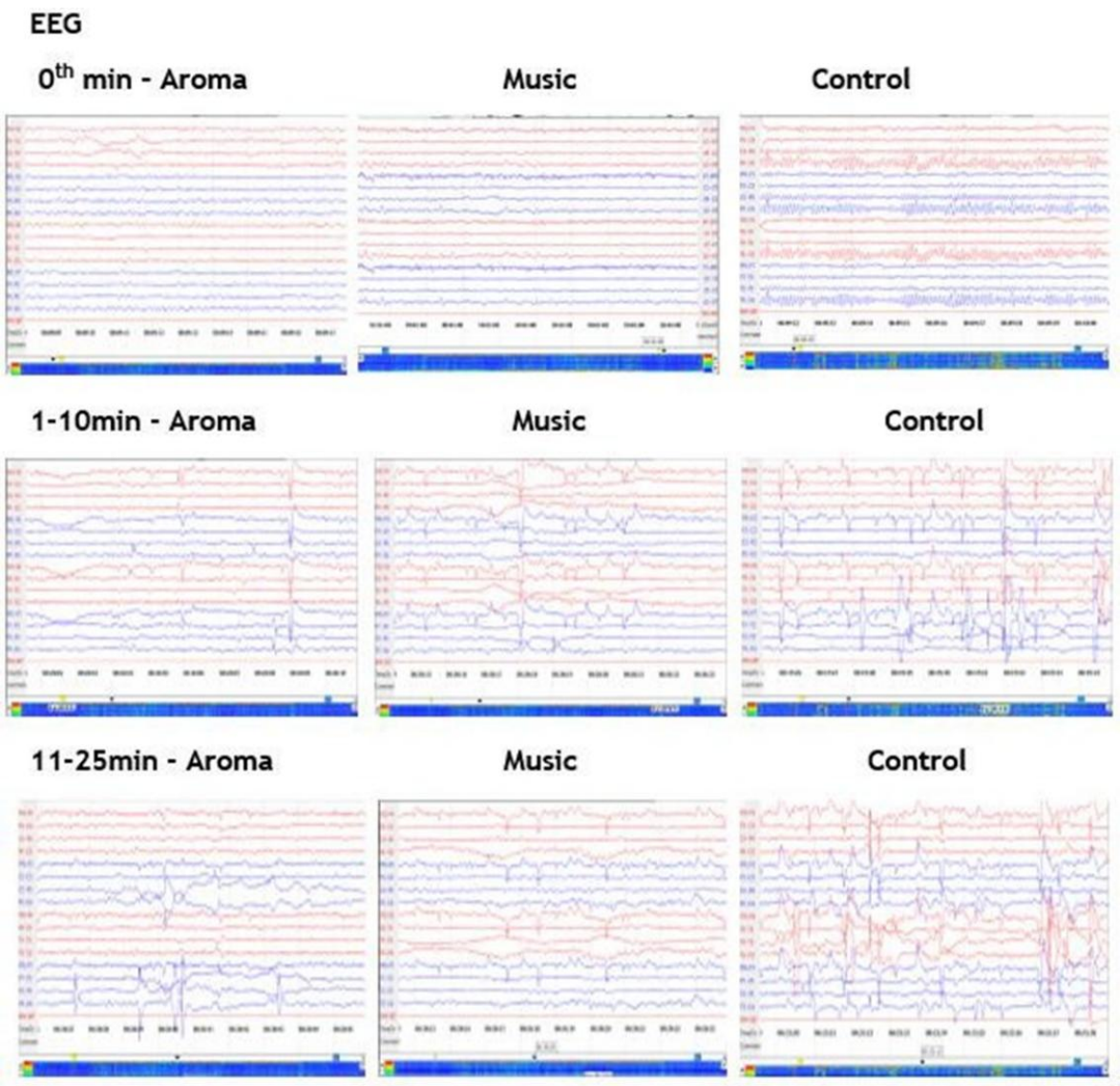

Group C (Control)
0th min
10th min
20th min
35th min
Relax 3rd min
6th min
9th min
Final Pic

Figure S1: C


EEG
0th min - Aroma
Music
Control
1-10min - Aroma
Music
Control
11-25min - Aroma
Music
Control

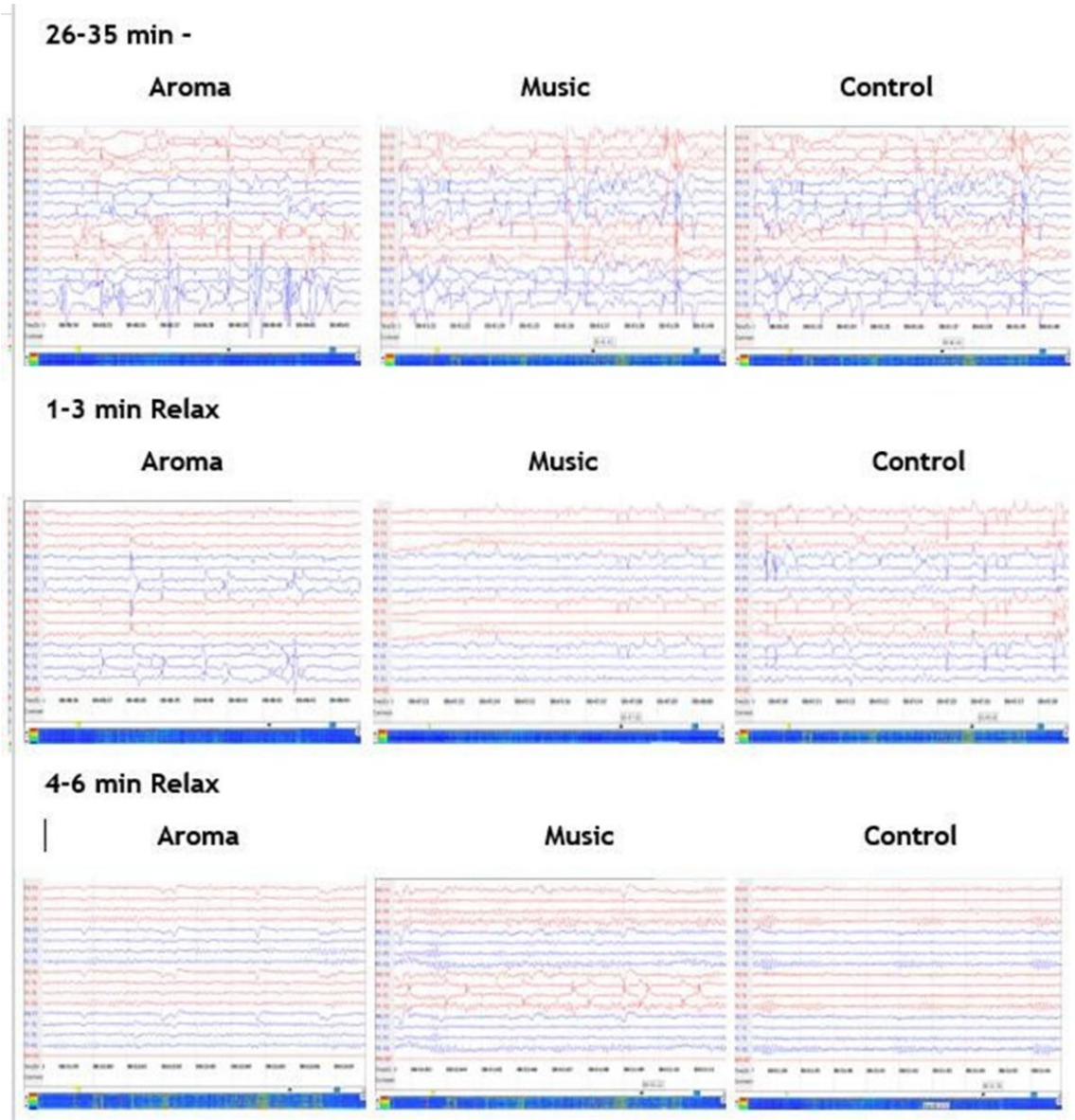


Figure S2: Electroencephalogram Recordings Of Participants At Various Time Points During The Test

IV. Discussion

Our research reveals complex temporal dynamics between different physiological stress markers, demonstrating why multi-modal assessment is essential for understanding intervention efficacy. Three observations emerged from our thermal imaging analysis, which provide key insights into the mechanisms underlying stress recovery.

Observation 1: The Recovery Paradox - Delayed Thermal Response Finding:

During recovery, in all subjects, facial temperature paradoxically continued to rise upto 1°C during the initial 3-6 minutes of relaxation, despite EEG readings showing immediate normalization to alpha states. Facial temperature then gradually declined to baseline in the readings that were captured during the first 15 minutes of relaxation time.

Scientific Explanation:

This demonstrates that EEG and thermal responses operate on fundamentally different timescales:

- **Neural Response (EEG)**: Nearly instantaneous (seconds to minutes) – the brain quickly shifted from beta (alert/anxious) back to alpha (relaxed) waves
- **Thermal/Vascular Response**: Much slower (5-15 minutes) - blood vessel diameter changes and tissue temperature equilibration require extended time

Physiological Mechanism: The temperature increase during relaxation reflects therapeutic vasodilation - blood vessels expand to restore normal circulation after stress-induced vasoconstriction. During the stress session, reduced blood flow to facial regions vasoconstriction (Thayer C Lane, 2009). When transitioning to relaxation, the parasympathetic nervous system triggered vessel dilation, bringing more warm blood to the forehead region. The temperature peak represents the "overshoot" phenomenon - the cardiovascular system temporarily overcorrects by increasing blood flow above baseline levels to restore homeostasis.

Observation 2: Comparative Therapeutic Efficacy

Aromatherapy - Superior Performance:

- **Recovery time**: 11-12 minutes to complete baseline restoration
- **Endpoint**: Full return to original body temperature (34.8°C)
- **Mechanism**: Lavender essential oils directly activate the olfactory-limbic pathway, providing rapid parasympathetic activation that accelerates vasodilation normalization

Music Therapy - Moderate Performance:

- **Recovery time**: 13-15 minutes, with slight delay
- **Endpoint**: Slightly elevated above baseline values, near original temperature
- **Mechanism**: Music processing involves more complex cortical-subcortical circuits, requiring additional neural processing time before reaching autonomic centres

Rationale:

Neurochemical Pathway Efficiency: The superiority of aromatherapy stems from a direct neurochemical pathway: olfactory receptors → limbic system → hypothalamus → rapid parasympathetic activation. This bypasses the complex cognitive processing required for music therapy (Lehrner et al., 2005), explaining both the speed and completeness of recovery.

Integrated Physiological Timeline:

- Stress phase (0-35 min): Gradual temperature rise (34.8°C → 35.0°C)
- Early relaxation (35-40 min): Continued rise to peak (35.3°C) - vascular overshoot
- Recovery trajectories:
  - **Aromatherapy**: Efficient return to 34.8°C by 45-47 minutes
  - **Music therapy**: Slower, near-complete recovery by 48-50 minutes

Observation 3: Control Group Natural Recovery Limitations Finding:

An analysis of the control group showed that the group had the highest peak temperature rise (reaching 36.1°C) during the recovery phase, and also demonstrated minimal natural recovery efficacy with only 0.3-0.4°C temperature decrease over a 15-20 minute interval. The recovery was significantly inferior compared to both music therapy and aromatherapy interventions.

Explanation:

This represents the body's limited natural stress recovery capacity without therapeutic intervention. The minimal temperature reduction demonstrates insufficient parasympathetic activation for complete physiological normalization.

Comparative Efficacy Analysis

Aromatherapy vs. Control

Aromatherapy demonstrated a speed advantage when compared to natural recovery, with participants on aromatherapy returning to baseline within 10–12 minutes compared to more than 20 minutes in the control group. The efficacy was superior too, leading to complete recovery rather than partial recovery. The magnitude of temperature reduction was approximately five times greater than that of the control group, and the overall effect size represented a 125% improvement over natural recovery.

Music Therapy vs. Control

Music therapy also showed notable benefits, with recovery occurring about 1.5 times faster than in the control group. While music therapy did not achieve full normalization, it produced near-complete recovery. The magnitude of temperature reduction was approximately three times greater than that of the control group, and the effect size represented a 100% improvement over natural recovery.

Clinical Implications for Academic Stress Management

This study demonstrates that aromatherapy is an effective intervention for academic stress, providing a faster autonomic reset and complete normalization within 10–12 minutes, which is 2–5 minutes quicker than music therapy and nearly twice as fast as natural recovery. The direct neurochemical pathway triggered by aromatherapy activates parasympathetic responses efficiently and does not interfere with cognitive focus, making it particularly suitable in time-sensitive academic contexts.

Music therapy, while slower, remains a valuable secondary option. It is better suited for extended relaxation sessions and serves as an alternative for individuals who may be sensitive to aromatherapy. Beyond physiological recovery, it contributes positively to mood regulation and emotional balance.

Practical Student Implementation

Aromatherapy can be incorporated into student routines in several practical ways. A 10– 12 minute aromatherapy session before an exam may help achieve a calm physiological state. During study sessions, brief lavender exposure every 45 minutes could prevent stress accumulation, and a 15-minute aromatherapy break between consecutive exams may accelerate recovery and improve focus.

Scientific and Clinical Significance

Control group comparisons confirm that both aromatherapy and music therapy accelerate stress recovery beyond the body's natural capacity. Without intervention, students required more than 20 minutes to achieve only partial recovery. In real-life scenarios, this would leave them physiologically stressed during intensive study or exam periods. In contrast, aromatherapy enabled complete recovery within 10–12 minutes, while music therapy achieved near-complete recovery in 13–15 minutes. These findings highlight the importance of targeted, evidence-based interventions to safeguard cognitive performance andpsychological well-being in high-stakes academic environments.

However, it is important to note that the relatively small participant pool limits the statistical power of these results. Given the close recovery times observed between the 3 groups, a larger sample size would provide greater precision, enhance reliability, and allow clearer differentiation of the interventions' relative effectiveness.

V. Conclusion

This research provides clear evidence that aromatherapy is a superior non-invasive intervention for managing screen-induced anxiety and academic stress. By integrating objective measures such as thermal imaging, heart rate monitoring, and EEG, the study demonstrated that aromatherapy produces faster and more complete physiological recovery compared to music therapy and natural recovery. Music therapy is beneficial but is less efficient, while natural recovery alone is inadequate in time-sensitive situations. These findings establish aromatherapy as the primary recommendation for students facing academic pressure, particularly during exams.

Future Directions

Future research should explore the long-term sustainability of aromatherapy and music therapy interventions, particularly during prolonged academic stress, such as exam seasons. Personalization of interventions based on individual physiological profiles— such as heart rate variability patterns or olfactory sensitivity—may further enhance outcomes. Broader studies across diverse age groups and cultural backgrounds will also be important for generalizability. The integration of wearable technologies and mobile applications could enable real-time monitoring and adaptive stress-management strategies. Finally, testing aromatherapy protocols in classroom and examination settings through controlled clinical trials will provide practical models for large-scale academic implementation.

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