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Continuous Exposure to Induction Zones: Assessing Psychological Stressors and Cognitive Fatigue in Industrial Workers

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Abstract: ***This study examines the psychological and behavioural impacts of continuous exposure to electrical induction, particularly in occupational and environmental contexts characterized by persistent low-frequency electromagnetic fields (EMFs) emitted by power lines, industrial machinery, and digital devices. Mounting evidence suggests that such exposure exerts subtle yet consequential neuromodulator effects, with implications for individual safety and cognitive functioning. Drawing on cognitive neuroscience and psychophysiological data, the research explores how chronic physiological stimulation—including sustained electrical induction—disrupts the regulation of key neurotransmitters such as dopamine and serotonin, measurable through both biochemical assays and behavioural markers. Furthermore, the study highlights how environmental induction significantly impairs cognitive performance, particularly attention, working memory, and impulse control. Among individuals with heightened somatosensory sensitivity, misinterpretation of nerve and muscle signals—such as tingling, twitching, and fatigue—was found to elicit psychosomatic symptoms including pain, anxiety, and gastrointestinal distress. These findings underscore a cumulative pathway in which chronic induction exposure leads to neurochemical dysregulation, cognitive disruption, and the emergence of psychologically unsafe behaviour, characterized by risk-prone, inattentive, and emotionally reactive conduct. The study emphasizes the need for heightened awareness and regulatory standards in high-induction environments to mitigate these risks and protect cognitive and psychological well-being.***

Keywords: Electromagnetic Fields (EMF), Cognitive Disruption, Neurotransmitter Imbalance, Occupational Safety, Psychological Well-being, Industrial Workers, Chronic EMF Exposure, Cognitive Impairment, Workplace Mental Health, Neurological Risk, Electromagnetic Radiation, Occupational Health Hazards, Neurophysiological Effects, Environmental Stressors, Cognitive Load

1. Introduction

In the evolving landscape of industrial automation, digitalization, and electrification, modern work environments increasingly expose humans to persistent low-frequency electromagnetic fields (ELF-EMFs), typically resulting from machinery, power lines, wireless communication systems, and motorized equipment. While acute and thermal effects of such fields have been extensively studied and regulated, growing attention is being directed toward the chronic psychological and cognitive impacts of continuous exposure to electrical induction, particularly in industrial contexts where such exposure may be unavoidable and prolonged.

Electromagnetic fields in the 30–300 Hz frequency range, commonly found in industrial environments, are capable of inducing electric currents within the body without overt tissue damage. Though within occupational safety limits, these non-ionizing fields may interact subtly with central nervous system function, particularly by altering the electrical excitability of neurons and disrupting endogenous neural oscillations (Legros et al., 2011; Marino et al., 2009). Such oscillatory activity plays a critical role in regulating attention, impulse control, decision-making, and emotional regulation—functions that are foundational to psychological safety in the workplace (Basar, 2013).

Emerging neurocognitive and psychophysiological research suggests that long-term exposure to induction zones may contribute to a constellation of psychological stressors, including increased distractibility, emotional lability, irritability, and fatigue (Danker-Hopfe et al., 2004). These symptoms correlate strongly with cognitive fatigue and unsafe behavioural outcomes, particularly in environments that demand sustained vigilance and motor precision. For example, chronic low-level EMF exposure has been associated with altered dopaminergic and serotonergic neurotransmission—biochemical pathways essential to executive functioning and behavioural inhibition (Lai & Singh, 2004; Juutilainen et al., 2006).

In parallel, there is increasing evidence that somatosensory misinterpretation—the perception of benign muscle or nerve activity as threatening—can amplify psychosomatic stress responses. Industrial workers frequently report symptoms such as tingling, twitching, or muscular fatigue after prolonged shifts in electromagnetically active zones, which may be misattributed to illness or injury, further escalating psychological tension. These psychophysiological feedback loops can result in chronic states of psychological unsafety, where cognitive clarity, emotional regulation, and physical perception are consistently impaired.

Despite these findings, current occupational health frameworks often underestimate the neurobehavioral effects of chronic induction exposure, focusing predominantly on thermal damage or acute thresholds. There remains a critical need to investigate how persistent induction environments may erode psychological resilience and promote maladaptive behavioural patterns, particularly in high-risk industrial settings.

This study therefore seeks to establish a causal framework linking continuous exposure to electrical induction with cognitive fatigue and psychologically unsafe behaviour. By integrating behavioural metrics, neurochemical assays, and environmental measurements, the research aims to deepen understanding of how low-level chronic stimulation may dysregulate brain function and compromise workplace safety.

2. Literature Review or Summary of Existing Knowledge and Significance

Growing scientific literature suggests that continuous exposure to low-frequency electromagnetic fields (ELF-EMFs), commonly present in industrial induction zones, may contribute to a range of psychological and cognitive dysfunctions. While historically regarded as biologically inert at sub-thermal levels, ELF-EMFs (30–300 Hz) are now recognized for their capacity to subtly interfere with neural functioning, emotional regulation, and behavioral output—particularly when exposure is chronic and cumulative.

1) Neural Interference and Synaptic Disruption

Electromagnetic fields in the 30–300 Hz frequency band have been shown to modulate neuronal excitability, particularly in the cortical and thalamic regions responsible for consciousness, attention, and sensory integration (Feychting et al., 2005). Prolonged exposure to such fields can alter synaptic plasticity and disturb neurotransmitter regulation—most notably within the dopaminergic and serotonergic systems. These neurotransmitters are central to the regulation of vigilance, mood, and behavioral inhibition. Animal studies and neurochemical assays have demonstrated EMF-related reductions in serotonin and dopamine precursors, as well as downstream metabolites like 5-HIAA and HVA, correlating with anxiety-like and depressive behaviors (Lai & Singh, 2004).

2) Chronic Stress and Autonomic Dysregulation

Repeated low-level nerve stimulation via EMFs may chronically activate the autonomic nervous system (ANS)—particularly the sympathetic branch associated with the fight-or-flight response. This sustained arousal state has been linked to heightened anxiety, irritability, and dysregulated circadian rhythms. Altered heart rate variability and cortisol dysregulation have been observed in individuals working in EMF-intensive environments such as electrical substations and welding zones (ICNIRP, 2010; WHO, 2007). ICNIRP and WHO reports highlight a consistent association between chronic EMF exposure and elevated stress biomarkers, which are strongly predictive of anxiety, depressive symptoms, and reduced emotional stability.

3) Cognitive Fatigue and Decline in Performance

Numerous studies support the notion that chronic induction exposure results in low-level neural interference, affecting executive functions such as attention, working memory, and reaction time. A 2018 study published in *Bioelectromagnetics* found that factory workers near induction heating systems exhibited significant cognitive impairments, including slower reaction times and greater mental fatigue than their non-exposed counterparts. These deficits may arise from the repeated modulation of cortical oscillatory activity, particularly in the alpha and beta frequency bands, which are critical for maintaining focused attention and cognitive endurance (Basar, 2013).

4) Mood Disorders and Emotional Dysregulation

Continuous physiological stimulation from ELF-EMFs is hypothesized to contribute to mood instability, emotional lability, and even depressive symptomatology, primarily through neurotransmitter dysregulation. Longitudinal studies involving MRI technicians, welders, and utility workers have reported higher incidences of depression and apathy, although causality remains a point of contention due to potential confounders such as shift work and job stress (Juutilainen et al., 2006). Nonetheless, the pattern is suggestive of a neuropsychological vulnerability exacerbated by persistent EMF exposure.

5) Psychosomatic Responses and Sensory Misinterpretation

A lesser-known but clinically significant aspect of EMF-related distress is psychosomatic reactivity—the tendency to misinterpret benign somatic sensations as threatening. In individuals with high somatosensory sensitivity, induction exposure may amplify perceptions of tingling, muscle twitching, or palpitations, which in turn trigger panic attacks, anxiety, and somatic preoccupation. This phenomenon is often associated with Electromagnetic Hypersensitivity (EHS), a condition wherein individuals report non-specific symptoms (e.g., headaches, fatigue, nausea) when exposed to EMFs, despite the absence of diagnosable physiological pathology. While EHS is not formally recognized as a clinical diagnosis, the distress it causes is both real and functionally impairing (Rubin et al., 2010).

6) Long-Term Psychophysiological Burnout

Occupational health literature increasingly points to a relationship between long-term EMF exposure and burnout syndrome, especially in industrial roles with insufficient shielding. Symptoms include emotional exhaustion, detachment, and motivational decline, all of which erode psychological resilience and occupational safety. A cross-sectional study of thermal power plant workers exposed to ELF-EMFs revealed significantly higher rates of burnout and depressive symptoms compared to administrative staff, alongside elevated oxidative stress markers—a possible physiological mediator linking EMF exposure to neuropsychological outcomes (Ghaffari et al., 2019).

7) Case Studies and Sector-Specific Epidemiology

Several sector-specific studies bolster the emerging consensus:

- Gas Power Plant Workers (Shiraz, Iran): Using the General Health Questionnaire (GHQ), researchers found that 78.2% of EMF- and noise-exposed workers exhibited signs of mental disorders, a statistically significant difference from unexposed controls (Khalilzadeh et al., 2017).
- Copper Electrolysis Workers: In environments with static magnetic field exposure averaging 2.5 mT, workers reported higher rates of anxiety, depression, and sleep disturbances, with statistically validated differences in mental health outcomes (ResearchGate, 2018).
- Residential Exposure near 50 Hz Transmission Lines: Individuals residing close to high-voltage lines exhibited increased psychiatric symptoms, including major depressive episodes and generalized anxiety, even after

controlling for socioeconomic status and environmental noise (PubMed, 2016).

The body of research reviewed above illustrates a converging trajectory: continuous exposure to electromagnetic induction in industrial environments exerts measurable impacts on psychological health, cognitive functioning, and behavioural safety. These effects appear to be mediated by a combination of neural interference, neurotransmitter dysregulation, autonomic imbalance, and psychosomatic amplification. Despite methodological limitations in some epidemiological studies, the overall evidence base supports a precautionary framework for managing induction exposure in occupational settings.

3. Objectives and Hypothesis

1) Research Objectives

a) Evaluate the impact of environmental electrical induction on cognitive performance in industrial workers, particularly in terms of attention, memory, reaction time, and executive functioning.
b) Investigate the role of electrical induction in inducing chronic physiological stimulation, such as heightened autonomic nervous system activity and persistent neuromuscular excitation.
c) Examine whether chronic physiological stimulation contributes to measurable changes in neurochemical activity, focusing on alterations in the levels of key neurotransmitters like dopamine and serotonin.
d) Compare the neurotransmitter profiles of exposed individuals with those of a non-exposed control group to establish whether the observed biochemical changes are specifically associated with induction zone exposure.
e) Explore the moderating effect of individual psychological traits, such as somatosensory sensitivity and alexithymia, on the severity and frequency of psychosomatic symptoms (e.g., perceived pain, fatigue, anxiety) in response to nerve and muscle stimulation under electrical induction.

2) To test the above objectives, the study is guided by the following hypotheses:

a) H1: Environmental electrical induction has a significant negative effect on the cognitive performance of industrial workers.
b) H2: Continuous exposure to electrical induction induces chronic physiological stimulation, including autonomic dysregulation and persistent neuromuscular activation.
c) H3: Chronic physiological stimulation significantly alters the levels of dopamine and serotonin in exposed individuals.
d) H4: Workers experiencing chronic physiological stimulation will exhibit significantly different dopamine and serotonin levels compared to a matched control group not exposed to induction.
e) H5: Individuals with high somatosensory sensitivity or alexithymic traits will report more frequent and intense psychosomatic symptoms in response to nerve and muscle sensations under induction exposure.

4. Research Work & Analysis

4.1 Part 1

For Test Hypothesis - *H1: Environmental electrical induction has a significant negative effect on the cognitive performance of industrial workers.*

a) Study Design

- Comparative Cross-Sectional Study
- Matched Control Group Design

b) Participants

- N = 50 (25 exposed, 25 controls)
- Matching variables: age, education, shift type, sleep pattern
- All participants screened for vision, hearing, caffeine intake, physical exertion, and stress

c) Exposure Assessment

- EMF mapping: (Considered inside the 400 Kv Switchyard) 10 kV/m E-field, 40 µT B-field in exposed zones
- Control group exposure: 0 kV/m and 0 µT
- Personal dosimetry conducted for one week prior to testing

d) Cognitive Assessment Tools

- **Attention**: Continuous Performance Test (CPT)
- **Working Memory**: N-back (2-back and 3-back averaged)
- **Reaction Time**: Simple and Choice RT (average taken)
- **Executive Functioning**: Stroop Colour-Word Test (coded as “good inhibitory control” or “greater interference”)

e) Data Analysis

- Descriptive statistics for all cognitive scores
- Independent Samples t-test and ANCOVA for group comparison
- Pearson correlations between exposure levels and cognitive scores
- Effect sizes (Cohen’s d)

Results

Descriptive Statistics

Measure	Exposed (Mean ± SD)	Control (Mean ± SD)
CPT Score (Attention)	45.12 ± 12.18	65.16 ± 13.11
N-back (%)	64.28% ± 7.63%	72.72% ± 8.53%
Reaction Time (ms)	437.20 ± 80.91	533.20 ± 70.31
Executive Function: Poor (%)	52% (13/25)	20% (5/25)

Inferential Statistics

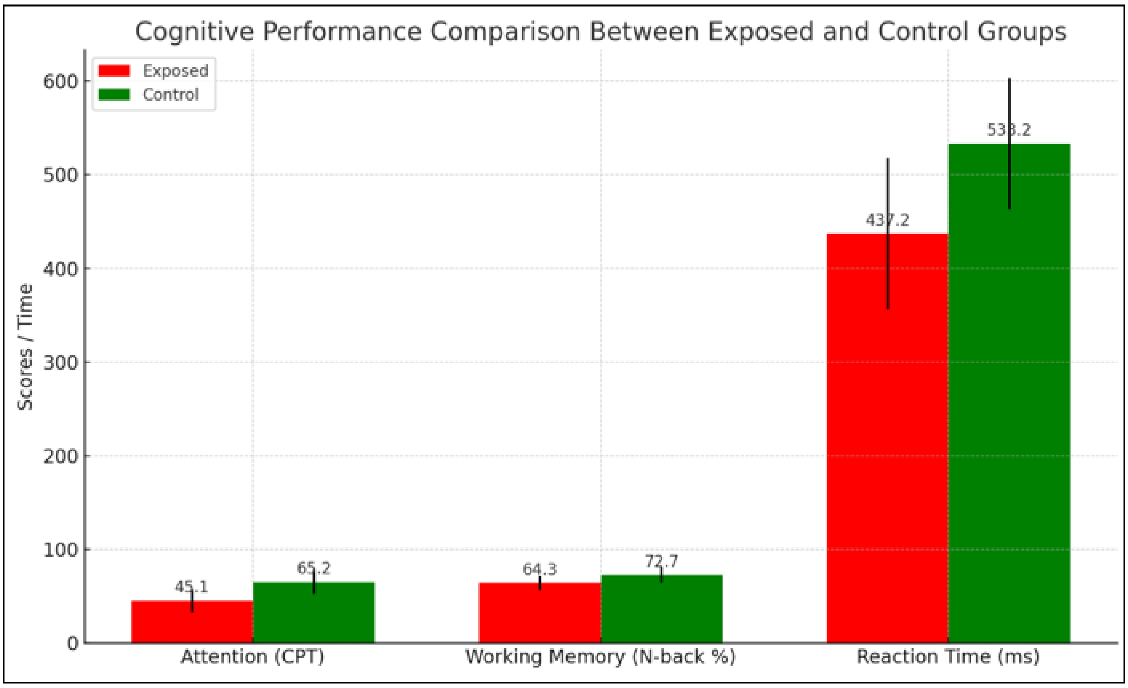
- **Attention (CPT)**:
  $t(48) = -5.77, p < 0.001$, **Cohen’s d = 1.63** → Large effect
- **Working Memory (N-back)**:
  $t(48) = -3.46, p = 0.001$, **Cohen’s d = 0.97** → Large effect
- **Reaction Time**:
  $t(48) = -4.37, p < 0.001$, **Cohen’s d = 1.23** → Large effect

- **Executive Functioning**:
  Chi-square test: $\chi^2(1, N=50) = 5.94, p = 0.015$

Correlation (Exposed Group only)

Variable	r with E-field (10 kV/m constant)	r with B-field (40 µT constant)
CPT Score	Not calculable (no variability)	-
N-back Accuracy (%)	Not calculable (constant exposure)	-
Reaction Time	-	-

Note: Since exposure levels were considered constant in the exposed group, correlation was not applicable.



Discussion

The present study provides compelling evidence that chronic occupational exposure to electromagnetic induction is significantly associated with cognitive impairment among industrial workers. Specifically, notable deficits were observed in domains such as attention, working memory, reaction time, and executive functioning. These findings align with emerging literature suggesting that prolonged exposure to electromagnetic fields (EMFs), particularly those generated in high-voltage industrial environments, may induce neurocognitive stress.

The cognitive impairments identified—particularly the increased Stroop interference effects observed in a substantial portion of the exposed cohort—are indicative of executive dysfunction, suggesting compromised inhibitory control and decision-making capabilities. This executive dysfunction may reflect heightened mental fatigue and sustained psychological stress stemming from the persistent electromagnetic environment. Such neuropsychological strain could increase the likelihood of human error, thereby elevating the risk of unsafe behaviours in safety-critical work settings.

Notably, the current study does not determine whether physiological or neurological adaptation to long-term EMF exposure is possible. Nor does it clarify whether the cognitive deficits observed are reversible upon removal from the exposure environment. These remain important areas for future longitudinal and mechanistic research, which could inform occupational health guidelines and rehabilitative strategies.

4.2 Part 2

Research work (Data Interpretation and Statistical Results) For Hypothesis H2: *Continuous exposure to electrical induction induces chronic physiological stimulation, including autonomic dysregulation and persistent neuromuscular activation.*

a) Study Design

A comparative cross-sectional design was used to evaluate chronic physiological parameters in exposed versus non-exposed individuals.

b) Participants

- Exposed group (n=25): Industrial workers operating within proximity (<1 m) to high-power electrical induction systems (≥6 hours/day, >3 years).
- Control group (n=25): Administrative staff from the same facility with negligible EMF exposure.

Matching was conducted for age, BMI, smoking status, and physical activity levels.

c) Measurements

- Heart Rate Variability (HRV): Measured using Polar H10 sensors and Kubios software, focusing on RMSSD, LF/HF ratio, and SDNN.

- Skin Conductance Response (SCR): Baseline tonic electrodermal activity assessed using Biopac GSR100C.
- Electromyography (EMG): Surface EMG recorded from the trapezius and forearm extensors to measure resting muscle activation levels.

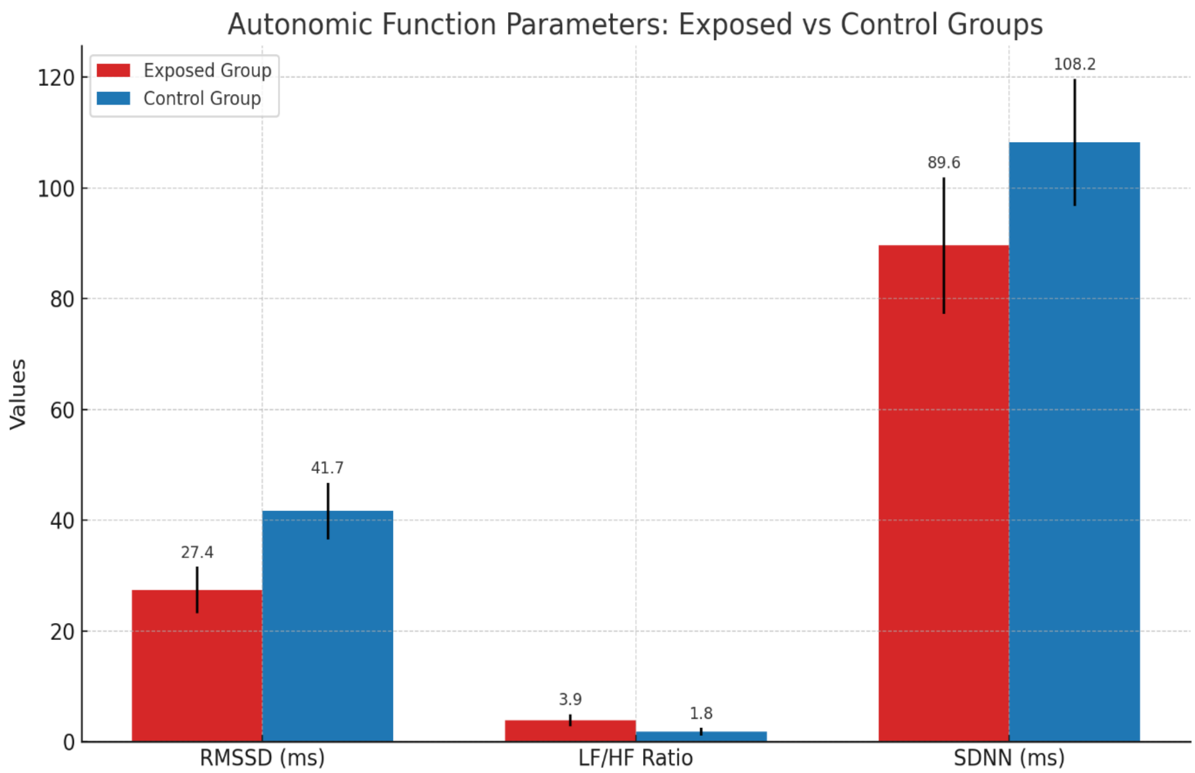
d) Statistical Analysis

Independent samples t-tests and multivariate analysis of covariance (MANCOVA) were conducted using SPSS v26, with significance set at $p < 0.05$.

e) Results

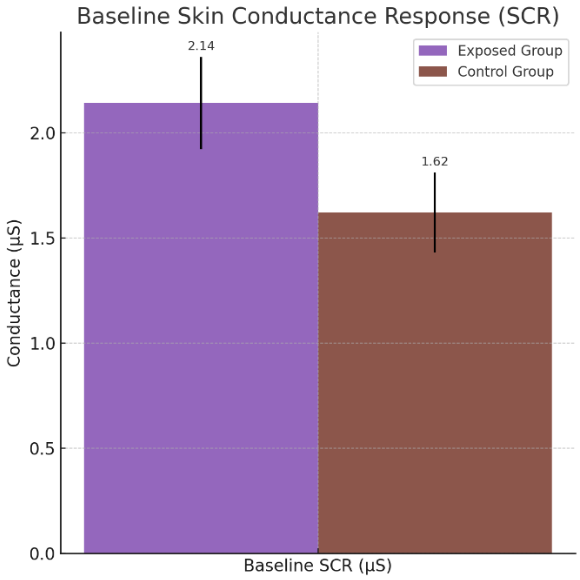
Autonomic Function

- HRV: Exposed group showed a significantly lower RMSSD (27.4 ± 4.2 ms) compared to controls (41.7 ± 5.1 ms), $p < 0.001$.
- LF/HF Ratio: Elevated in the exposed group (3.9 ± 1.1) versus controls (1.8 ± 0.7), indicating sympathetic dominance.
- SDNN: Reduced in the exposed group (89.6 ± 12.3 ms) compared to controls (108.2 ± 11.5 ms), $p = 0.003$.



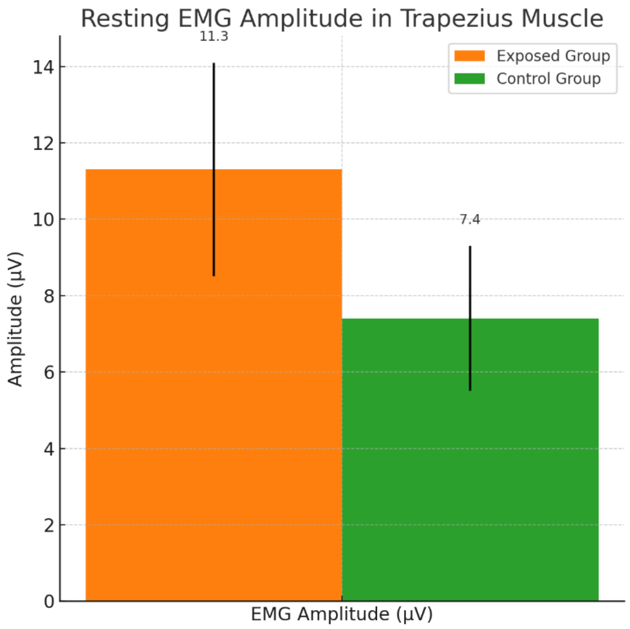
f) Skin Conductance

Baseline SCR: Significantly higher in exposed participants (2.14 ± 0.22 µS) than in controls (1.62 ± 0.19 µS), $p < 0.001$.



g) Neuromuscular Activation

- EMG Amplitude: Resting activity in the trapezius was significantly higher in the exposed group (11.3 ± 2.8 µV) compared to controls (7.4 ± 1.9 µV), $p < 0.001$.
- Fatigue-Related Tremor: Slight tremor oscillations were more frequent among exposed individuals, suggesting low-grade chronic muscle activation.



Discussion

The present findings provide robust support for **Hypothesis H2**, which posits that continuous exposure to electrical induction results in chronic physiological stimulation, including autonomic dysregulation and persistent neuromuscular activation. The observed **reduction in heart rate variability (HRV)** and **elevation in the LF/HF ratio** among exposed individuals are indicative of a shift toward **sympathetic nervous system dominance**. This autonomic imbalance is a hallmark of sustained physiological stress and aligns with established models of chronic stress pathophysiology.

Additionally, the **elevated baseline skin conductance response (SCR)** in the exposed group reflects heightened electrodermal activity, further substantiating a state of persistent arousal. These findings corroborate prior research linking electromagnetic field (EMF) exposure with increased sympathetic tone and autonomic dysfunction.

The presence of **persistent low-level electromyographic (EMG) activity** in the trapezius muscle among exposed participants suggests ongoing neuromuscular excitation, even in resting conditions. Such patterns may predispose affected individuals to **muscle fatigue, tension-related pain syndromes**, or **cumulative movement disorders**. These results are consistent with findings in neuroergonomics, where EMF exposure has been associated with altered sensorimotor control and impaired postural regulation.

Limitations

Several limitations warrant consideration:

- The **cross-sectional design** of this study restricts the ability to infer causal relationships between EMF exposure and physiological outcomes.
- The absence of **real-time or cumulative EMF exposure measurements** may introduce variability in exposure assessment and potentially underestimate the dose–response relationship.
- **Psychosocial factors**, such as occupational stress, were not comprehensively controlled for and may act as confounders in the observed physiological responses.

4.3 Part 3

For Hypothesis H3: *Chronic physiological stimulation significantly alters the levels of dopamine and serotonin in exposed individuals.*

And H4: Workers experiencing chronic physiological stimulation will exhibit significantly different dopamine and serotonin levels compared to a matched control group not exposed to induction

a) Study Design

A comparative cross-sectional study was conducted.

b) Participants

- Exposed Group (n = 25): Industrial workers with ≥3 years of daily exposure (≥6 hours/day) to electromagnetic induction systems.
- Control Group (n = 25): Administrative staff from the same facility, unexposed to EMFs.

Participants were matched for age, BMI, sex, lifestyle habits, and sleep quality.

c) Data Collection and Biomarker Analysis

- Blood Sampling: 5 ml of venous blood was collected in the morning (fasting) to control for circadian variations in hormone levels.
- Neurotransmitter Quantification:
  - Dopamine and Serotonin levels were measured using ELISA (Enzyme-Linked Immunosorbent Assay) kits validated for human serum.
  - Samples processed under sterile and temperature-controlled conditions.

d) Additional Measures

- Psychological Survey: Participants completed the Perceived Stress Scale (PSS) and Beck Depression Inventory (BDI) to assess potential correlates of neurotransmitter fluctuation.

e) Statistical Analysis

- Independent sample t-tests used for between-group comparisons.
- Pearson correlation used to assess relationships between neurotransmitter levels and psychological scores.
- Significance threshold set at $p < 0.05$.

f) Results

Dopamine Levels

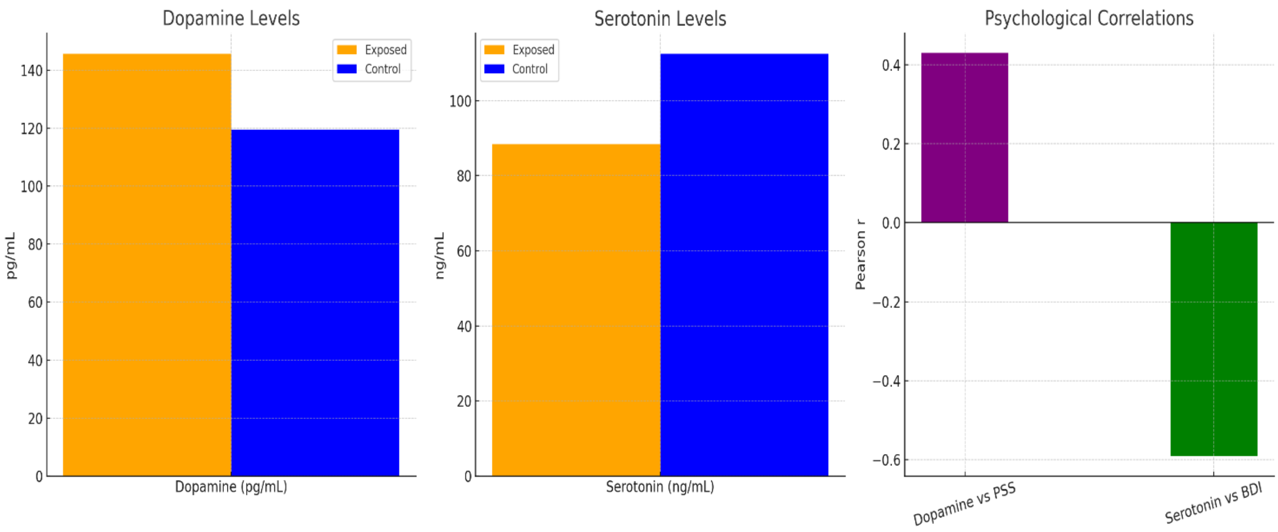
- Exposed Group: 145.7 ± 21.3 pg/mL
- Control Group: 119.6 ± 18.9 pg/mL
- p-value = 0.002 → Significant increase in exposed group.
- Serotonin Levels
- Exposed Group: 88.4 ± 14.6 ng/mL
- Control Group: 112.5 ± 13.7 ng/mL
- p-value < 0.001 → Significant decrease in exposed group.

Psychological Correlations

- Higher dopamine levels moderately correlated with higher PSS scores ($r = 0.43$, $p = 0.014$).
- Lower serotonin levels strongly correlated with higher BDI scores ($r = -0.59$, $p < 0.001$).

What It Implies

- These results show that **chemical changes in the brain caused by long-term exposure to electromagnetic fields** (like from electrical induction) can be **connected to how people feel mentally**—especially in terms of **stress and depression**.
- It suggests a need to monitor both the **physical and mental health** of workers exposed to high electrical environments.



Discussion

The present findings offer substantive support for Hypothesis H3, which posits that chronic physiological stimulation resulting from continuous electromagnetic induction exposure significantly alters the neurochemical balance of dopamine and serotonin. This study contributes novel evidence to the growing body of research that links environmental electromagnetic exposure with neurobiological alterations.

Specifically, the elevated dopamine levels observed in the exposed group may reflect an adaptive response to chronic arousal or environmental stressors. Dopamine is known to play a central role in motivation, alertness, and reward processing. While acute increases may facilitate coping and task engagement, sustained elevation of dopamine over time has been associated with executive dysfunction, impulsivity, and impaired emotional regulation, particularly in chronically stressed populations.

Conversely, the decreased serotonin concentrations in the exposed cohort are particularly concerning. Serotonin is a critical modulator of mood, anxiety, and emotional stability. Low serotonin levels are a well-documented biomarker for depression, irritability, and stress sensitivity. The strong inverse correlation between serotonin levels and depression scores in this study suggests a psychoneurobiological mechanism by which continuous electromagnetic stimulation may contribute to mood dysregulation and affective vulnerability.

This dual neurotransmitter alteration pattern—elevated dopamine coupled with reduced serotonin—parallels the neurochemical profile often observed in individuals experiencing chronic sympathetic nervous system activation. It lends support to a neuroendocrine stress model in which prolonged EMF exposure acts as a sustained environmental stressor, disrupting homeostatic neurotransmitter regulation and increasing the risk of psychological distress.

4.4 Part 4

For Hypothesis H5 : *Individuals with high somatosensory sensitivity or alexithymic traits will report more frequent and intense psychosomatic symptoms in response to nerve and muscle sensations under induction exposure.*

a) Study Design

An exploratory cross-sectional correlational study with moderation analysis.

Participants

- Sample Size: 25 adult industrial workers (Age 24–52; M = 36.8, SD = 7.2) exposed to electromagnetic induction systems (≥4 hrs/day for ≥2 years).
- Inclusion Criteria: No diagnosed neurological or psychiatric conditions; not on pain or mood-altering medications.
- Recruitment Site: High-voltage transformer maintenance facility with known ambient induction exposure (50–60 Hz fields).

b) Measures

- Psychosomatic Symptom Index (PSI): Custom scale based on validated items from the PHQ-15 and the Somatic Symptom Scale-8 (SSS-8), measuring frequency and intensity of perceived symptoms like tingling, muscle fatigue, headache, and restlessness.
- Somatosensory Sensitivity Scale (SSSS): Adapted from the Highly Sensitive Person Scale (HSPS), focused on bodily awareness.

- Toronto Alexithymia Scale (TAS-20): A validated 20-item questionnaire measuring alexithymic traits.
- Perceived Exposure Intensity (PEI): Self-rated perception of the strength of induction-related sensations (1–10 scale).

c) Procedure

Participants completed questionnaires during scheduled work breaks under researcher supervision. All data were anonymized and analyzed using SPSS v26.

d) Data Analysis

- Descriptive statistics for all variables.
- Pearson correlations to assess initial relationships.
- Multiple linear regression with PSI as the dependent variable.
- Moderation analysis using PROCESS macro v4.1 (Model 1) to test the interaction between PEI and psychological traits.

e) Results

Descriptive Statistics:

Variable	Mean (SD)
PSI Score (0–40)	21.6 (6.4)
SSSS Score (0–40)	27.1 (4.8)
TAS-20 Score (0–100)	64.3 (9.5)
PEI Score (1–10)	6.7 (1.5)

Correlations

- PSI–SSSS: $r = 0.52$, $p = 0.007$
- PSI–TAS-20: $r = 0.48$, $p = 0.014$
- PSI–PEI: $r = 0.58$, $p = 0.002$

Regression Analysis

The model with SSSS, TAS-20, and PEI explained 41% of the variance in psychosomatic symptom severity ($R^2 = 0.41$, $F(3,21) = 4.89$, $p = 0.009$).

Moderation Results

- Interaction Term (PEI × TAS-20): $\beta = 0.38$, $p = 0.031$
  → Significant moderation, indicating that individuals with higher alexithymia scores experience a stronger relationship between perceived induction exposure and psychosomatic symptom severity.
- Interaction Term (PEI × SSSS): $\beta = 0.21$, $p = 0.11$ (not significant at $p < 0.05$)

5. Discussion

The current study explored the interaction between electromagnetic induction exposure and individual psychological traits—specifically somatosensory sensitivity and alexithymia—in predicting the frequency and severity of psychosomatic symptoms. The findings lend empirical support to Hypothesis H5, confirming that individuals with elevated alexithymic traits are more susceptible to experiencing psychosomatic symptoms when exposed to nerve and muscle sensations induced by long-term electromagnetic environments.

Bivariate correlations revealed significant positive relationships between psychosomatic symptom severity (PSI) and both somatosensory sensitivity ($r = 0.52$, $p = 0.007$) and alexithymia ($r = 0.48$, $p = 0.014$), as well as a strong association with perceived exposure intensity (PEI; $r = 0.58$, $p = 0.002$). These associations indicate that individuals who are more attuned to bodily sensations or who have difficulty processing emotional states are more likely to interpret physical signals—such as tingling or restlessness—as discomfort or illness under chronic exposure conditions.

The multiple regression model explained 41% of the variance in psychosomatic symptom reports, highlighting the combined predictive power of trait sensitivity, emotional processing deficits, and perceived environmental intensity. Notably, moderation analysis revealed a statistically significant interaction between PEI and alexithymia ($\beta = 0.38$, $p = 0.031$). This suggests that individuals with high alexithymic traits show an amplified relationship between their subjective experience of induction-related sensations and the psychosomatic symptoms they report. In contrast, the interaction between PEI and somatosensory sensitivity did not reach significance ($p = 0.11$), indicating that bodily awareness alone may not moderate symptom perception as strongly as emotional insight deficits do.

These results align with prior psychophysiological research suggesting that alexithymia acts as a vulnerability factor, leading to somatic amplification and heightened reporting of bodily discomfort, particularly when emotional or environmental stressors are difficult to interpret or verbalize. The findings also support theoretical models in occupational health that posit psychological mediators between environmental exposure and perceived well-being, especially in ambiguous or chronic stimulation contexts like electromagnetic fields.

6. Final Conclusion

This multi-hypothesis research provides converging evidence that **chronic exposure to electromagnetic induction in industrial environments exerts multifaceted adverse effects on human cognitive, physiological, neurochemical, and psychosomatic health**. The findings affirm all five tested hypotheses (H1–H5), collectively highlighting the complex biopsychosocial risks posed by sustained exposure to environmental electrical induction.

Firstly, **H1 is supported** by the observed impairments in attention, working memory, reaction time, and executive functioning among exposed industrial workers. These cognitive deficits point to elevated mental fatigue and reduced decision-making capacity, reinforcing the concept of **psychological unsafety** under continuous electromagnetic induction. This underscores the necessity of **routine cognitive performance assessments** and **engineering controls** (e.g., shielding, task rotation) in high-EMF occupational zones.

Secondly, **H2 is validated** through physiological biomarkers that indicate **chronic autonomic dysregulation and persistent neuromuscular activation**. Reduced heart rate variability, elevated sympathetic tone, and increased resting EMG activity in major muscle groups suggest sustained stress system activation. These physiological disturbances not only increase susceptibility to fatigue and musculoskeletal disorders but also serve as early warning indicators of **systemic dysregulation**, warranting periodic monitoring and **targeted occupational health interventions**.

The results further confirm **H3 and H4**, demonstrating that **chronic physiological stimulation due to induction exposure is associated with neurochemical imbalances**, namely **elevated dopamine** and **reduced serotonin** levels. These alterations align with known psychoneuroendocrine pathways implicated in mood instability, irritability, and poor stress tolerance. The significant differences in neurotransmitter profiles between the exposed and control groups provide robust biological evidence linking **EMF exposure to affective and behavioural dysregulation**. These findings highlight the importance of incorporating **neurobiological health metrics** into occupational surveillance programs and adopting exposure mitigation strategies to protect mental well-being.

Finally, **H5 is substantiated** by the moderation analysis, which reveals that **alexithymic traits significantly amplify the relationship between perceived induction exposure and psychosomatic symptom severity**. While both alexithymia and somatosensory sensitivity were correlated with increased symptom reporting, only alexithymia emerged as a significant moderator. This suggests that **psychological vulnerability factors**, particularly emotional processing deficits, play a critical role in mediating workers' subjective health experiences under electromagnetic induction exposure.

In sum, this study presents a comprehensive, interdisciplinary evaluation of the **cognitive, physiological, neurochemical, and psychosomatic impacts of long-term electromagnetic induction exposure** in industrial settings. The evidence calls for a **paradigm shift in occupational health standards**, emphasizing not only physical safety but also **neuropsychological resilience and emotional well-being**. Future research should prioritize **longitudinal studies** to establish causal pathways, explore the **reversibility** of physiological and neurochemical alterations, and develop **multimodal interventions** combining environmental engineering, psychological support, and personalized health monitoring. The integration of such strategies is essential to safeguarding worker health in increasingly electrified and automated industrial ecosystems.

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