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From silos to synergies: A scoping review for bridging gaps in occupational health psychology and human neuroscience

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ABSTRACT

Introduction: This study examines the neurocognitive foundations of work-related factors and their role in advancing occupational health psychology (OHP). It bridges gaps between neuroscience and OHP, exploring fields like health neuroscience and neuro-safety science, along with advancements in neurocognitive assessment and interdisciplinary collaboration. *Method*: A review of 96 studies and structural topic modeling proposes a framework integrating psychological theories with neurobiological insights to better understand workplace behaviors and neural mechanisms. *Results*: Key cognitive domains—attention, memory, executive functioning, and reaction time—are linked to safety–critical behaviors and decision-making. Using EEG and fMRI, the study introduces objective neural measures to complement self-reports, showing how stress and cognitive load affect performance. *Conclusions and Practical Applications*: Findings advance OHP theories, identifying neural markers of stress and human errors to guide interventions like neurofeedback and resilience programs. Innovations in neurocognitive assessment strengthen evidence-based strategies to enhance well-being, reduce risks, and improve organizational effectiveness, establishing a neuroscience-informed framework for workplace safety.

1. Introduction

In the intricate fabric of global workplaces, the safety, health, and well-being of employees stand as vital threads. Although occupational health psychology (OHP) has deepened our insight into the human experience at work (Spector & Pindek, 2016), the complex functions of the human brain and cognition remain an often-overlooked dimension (Fisher et al., 2017; Matthews et al., 2012). This is where the burgeoning fields of human neuroscience can contribute to OHP, presenting a compelling opportunity to advance our understanding of the fundamental mechanisms underlying employee behavior, mental health, and overall well-being. Conventional methods of OHP, such as self-report surveys and interviews, offer valuable insights into the psychological and behavioral factors associated with occupational safety and health, including stress, well-being, and unsafe acts (e.g., slips, lapses, mistakes, and violations). However, they frequently fall short of a critical piece of the puzzle: the neurobiological mechanisms underpinning these phenomena, cognition as an essential function through brain-behavior relationships (Lezak, 2004). Neuroscience provides powerful instruments, capable of shedding light on the inner workings of the mind in response to work-related stimuli.

Despite the rapid growth in both OHP and human neuroscience, a notable gap persists in integrating these two fields. Although some efforts have been made to acknowledge the implications of human neuroscience for OHP, these have been limited to specific areas such as aging (Fisher et al., 2017), sleep deprivation (Brossoit et al., 2019), and stress (Bartlett et al., 2019). Moreover, OHP research has not proactively incorporated neuroscience research designs and methods. This gap can be attributed to historical separation and a lack of awareness among researchers in each domain. The divide between OHP and human neuroscience has created a silo effect, obstructing communication and collaboration. As a result, valuable insights from each discipline remain confined within their respective boundaries, limiting the potential synergies that could emerge from a more integrated approach.

The divide is worsened by a widespread lack of awareness regarding the potential benefits arising from the intersection of OHP and human neuroscience. Many researchers in both fields may not fully recognize the valuable insights and enriched perspectives that could result from collaborative efforts. For instance, recordings of voltage on the surface of the scalp with electrodes (the electroencephalogram; EEG) characterizes brain activity in real time and could serve to measure important OHP concepts like mental effort and fatigue. At the same time, EEG

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research could gain ecological validity if it moved away from restricted laboratory tasks (e.g., those involving simple tones or flashes on screen) to tasks that more adequately resemble work environments. This lack of awareness perpetuates a sense of separation, potentially causing researchers to miss out on the opportunity to leverage the combined strengths of OHP and neuroscience perspectives.

Compounding this challenge are methodological obstacles, particularly the complexity and cost associated with neuroscience techniques (López-Gil et al., 2016; Suomala, 2018). The tools used in human neuroscience research, like EEG, eye-tracking, and functional magnetic resonance imaging (fMRI), are often intricate and resource-intensive. This complexity not only practically hinders the application of these techniques in occupational settings but also contributes to the perceived distance between the disciplines. Additionally, OHP research often does not involve controlled experimental designs, which are crucial for effectively integrating neuroscience methods. The financial investment and specialized expertise required for neuroscience methods may act as barriers, preventing seamless collaboration and knowledge exchange.

The present study sheds light on these gaps and offers insights for addressing these barriers to foster a more integrated and collaborative approach. This approach aims to facilitate the mutual exchange of knowledge and expertise, advancing our understanding of the intricate interplay between the mind and the workplace.

2. Bridging neuroscience and occupational health Psychology: Emerging pathways

Despite longstanding disciplinary divides, there are encouraging signs of convergence between OHP and human neuroscience. One of the most promising developments is the emergence of health neuroscience, an interdisciplinary field that explores how the brain influences physical health, well-being, and health-related behaviors. As outlined by Erickson et al. (2014) and Inagaki (2020), health neuroscience integrates principles from psychology, neuroscience, and behavioral science to examine how stress, emotion, and social interactions impact physical health through underlying neural mechanisms.

Key areas of inquiry include: (a) How stress and emotion contribute to inflammation and disease; (b) Neural underpinnings of health-related behaviors like sleep, exercise, and diet; and (c) The brain's role in resilience, recovery, and perceptions of pain and illness.

This knowledge has direct implications for OHP. For example, brain imaging can help assess the effectiveness of workplace well-being programs, while neural biomarkers may help predict which workers are most vulnerable to stress-related illnesses. Table 1 outlines the ways health neuroscience can inform and enhance OHP practices.

Another complementary development is the emergence of neuro-safety science, a more targeted subfield at the intersection of neuroscience and safety science. While health neuroscience offers a broad framework for understanding how the brain contributes to overall health, neuro-safety science focuses specifically on the neural mechanisms underlying safety-related behaviors, such as risk perception, attention to hazards, and safety decision-making (Caixeta et al., 2012; Zhang et al., 2023). This field is especially relevant to OHP's long-standing interest in accident prevention and psychological safety at work. Neuro-safety science uses neuroscientific tools to enhance safety training, improve risk assessments, and personalize interventions for at-risk workers. Table 2 summarizes these applications.

Table 1
Implications of Health Neuroscience (Erickson et al., 2014; Inagaki, 2020) for Occupational Health Psychology.

OHP application area	Benefit from Health Neuroscience
Understanding how stress impacts health	Neuroscience can identify neural mechanisms linking social experiences (e.g., work stress) with health outcomes (e.g., inflammation)
Developing interventions to improve workplace well-being	Brain imaging can be used to assess effectiveness of interventions (e.g., social support programs) by measuring changes in brain activity
Predicting worker health risks	Biomarkers like brain connectivity patterns may predict susceptibility to stress-related illnesses
Designing workplaces that promote health	Understanding how brain responds to work environment (e.g., social interactions, workload) can inform workplace design

By positioning neuro-safety science within this review, we aim to illustrate how its narrower focus can complement the broader aims of health neuroscience. Together, these two fields provide a dual foundation for integrating neuroscience into OHP—one addressing overall health and well-being, the other targeting workplace safety and injury prevention. Importantly, this conceptual integration is supported by practical trends. Funding bodies are increasingly prioritizing interdisciplinary research that bridges domains such as OHP, neuroscience, and behavioral science. A Google search for "interdisciplinary occupational health grant" reveals growing interest over the past two decades (Fig. 1), suggesting rising institutional support for such integrative efforts.

Taken together, these developments indicate a fertile ground for cross-disciplinary collaboration. This paper proposes that by drawing from health neuroscience and neuro-safety science, researchers can introduce neuroscience-informed methodologies into OHP, thereby enhancing both theoretical insight and practical interventions. In doing so, this work aims to help lay the groundwork for a more integrated science of occupational health—one that leverages the brain to better protect and promote worker well-being and safety.

3. Study Objectives

In this study, we present a broad aim of advancing understanding at the intersection of human neuroscience and OHP, with a particular emphasis on applications to workplace safety and health. We provide an overview of human neuroscience methodologies that have potential applications in OHP with specific examples based on a scoping review. This manuscript comprises two interrelated components: a conceptual discussion of neuroscience integration into OHP, and a scoping review of empirical studies illustrating this integration. It endeavors to embark on a pioneering exploration of the evolving field of neuroscience applied to workplace safety and health. One key objective is to conduct a critical examination of existing studies that delve into the neural correlates of work-related factors, including stress (Erickson et al., 2014), cognitive load (Liao et al., 2021), fatigue (Xing et al., 2020), attention (Wang et al., 2017), decision-making (Chen et al., 2022), and risk perception (Zhang et al., 2023). The focus is on elucidating the explanatory mechanisms of safety–critical human errors, spanning slips, violations, and mistakes (Reason, 1995), with potential consequences ranging from safety non-compliance and near misses to accidents, injuries, and even fatalities (Murphy et al., 2019; Vincoli, 2024; Zohar & Lee, 2016). By synthesizing these findings, the review aims to: (a) identify knowledge gaps; (b) derive key themes in existing research at the intersection of OHP and human neuroscience; and (c) propose directions for future

Table 2
Implications of Neuro-Safety Science (Zhang et al., 2023) for Occupational Health Psychology.

OHP application area	Benefit from Neuro-Safety Science
Understanding unsafe behaviors	Identify brain activity patterns related to risky behaviors, informing interventions to prevent accidents and injuries.
Improved safety training	Inform the design of more effective safety training programs by understanding how the brain learns.
Personalized interventions	Tailor safety interventions to individual workers based on their brain activity.
Risk assessment	Improve risk assessment methods by incorporating brain-based measures alongside traditional methods.

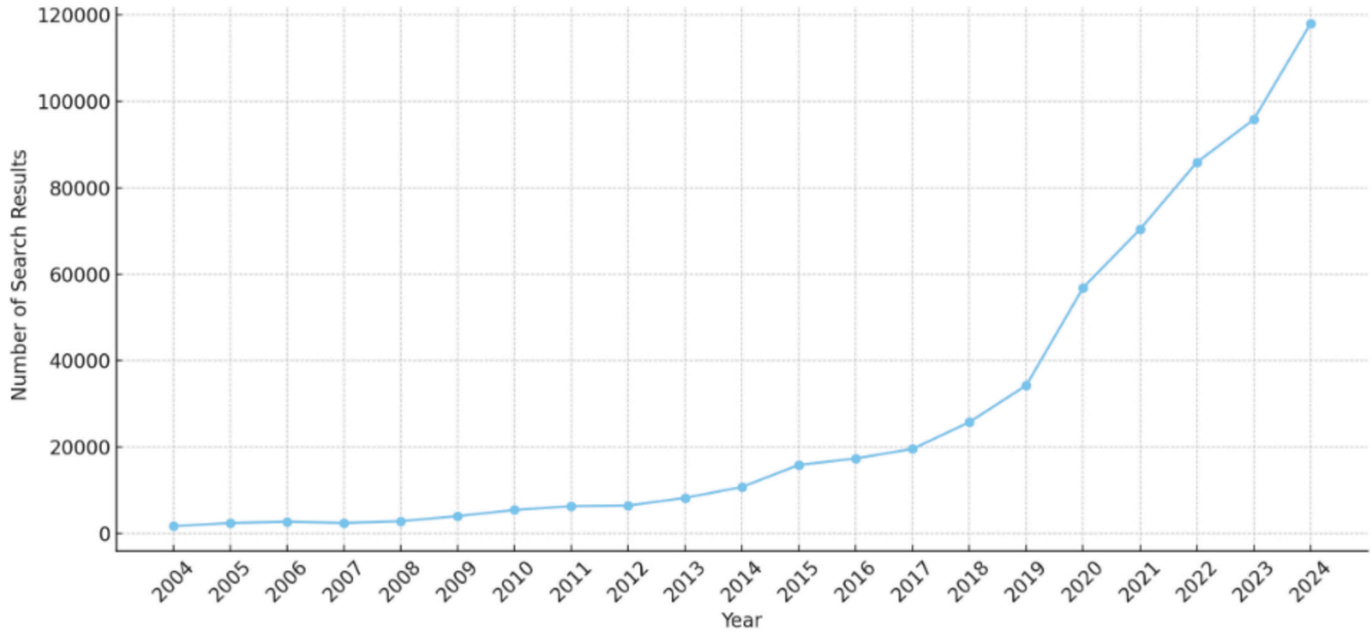

Fig. 1. Number of search results for "Interdisciplinary occupational health grant" over 2004–2024.

research and practice in this crucial area of workplace safety and health. Beyond mapping the existing terrain, this review serves as a catalyst for the integration of neuroscience frameworks and methods into OHP. It proposes a robust selection of human neuroscience research examples and methods ripe for integration.

4. Method

4.1. Procedure

The search for scientific publications in this review was performed using four databases: Scopus, Web of Science, PsycINFO, and PubMed, in accordance with key methodological principles outlined in the PRISMA Extension for Scoping Reviews (PRISMA-ScR) (Tricco et al., 2018; Page et al., 2021). To ensure comprehensiveness, we conducted two rounds of searches using different sets of keywords. The search terms entered in the first round were as follows: ("occupational safety" OR "occupational health") AND (neuroscience*, "executive function", "cognitive function", neuropsychology) AND (workplace, workers, organization) AND (hazard, risk, "human error", accident, injury).

In the second round, the terms were: (workplace OR occupational OR organizational) AND (stress OR fatigue OR "decision-making" OR biases OR "risk perception" OR "risk appraisal" OR "risk evaluation") AND (safety OR health OR well-being OR wellbeing OR hazard OR injury OR accident OR error OR mistake OR near-miss) AND (neuropsychology* OR neuroscience OR neurocognitive OR neurocognition OR cognitive OR cognition OR "human factors" OR ergonomics) AND (executive function OR cognitive function). There were no search filters by year, and the review included articles published up to 2023. Review articles and prior systematic reviews were excluded to focus on primary empirical findings.

No formal protocol or registration exists for this review. The search strategy was developed iteratively and applied consistently across all databases. Full search strings for each round are available upon request. Screening took place in two stages: first, titles and abstracts were screened for relevance to occupational safety and neurocognitive content; second, full-text articles were reviewed for alignment with inclusion criteria. Data charting was performed manually using a standardized extraction sheet, which included fields for study design, sample characteristics, neurocognitive measures, work-related outcomes, and key findings. This approach ensured a structured synthesis of study characteristics and thematic patterns. No critical appraisal of study quality was conducted, as it is not a required element in scoping reviews. The following paragraph clarifies the eligibility criteria, which were specified according to the Population, Concept, and Context (PCC) framework recommended for scoping reviews.

The selection of keywords was guided by overarching themes from foundational studies in health neuroscience (Erickson et al., 2014; Inagaki, 2020; see Table 1) and neuro-safety science (Zhang et al., 2023; see Table 2). The emphasis was placed on workplace safety and well-being rather than physiological illnesses, given the limited relevance of disease-focused studies to applied OHP contexts. In line with the PCC framework recommended for scoping reviews, the inclusion criteria were structured around three core elements, population, concept, and context. The population of interest included workers and workplace populations across a range of occupations and industries. The conceptual focus centered on neurocognitive mechanisms relevant to occupational safety, such as cognitive load, attention, decision-making, and fatigue. The context encompassed occupational settings where risk, injury, or other safety-related outcomes were present. More specifically, studies were included if they met three criteria: they were conducted in work-related environments (context), addressed safety and health concerns such as hazards, risks, injuries, accidents, or errors (content), and involved the explicit investigation of neuropsychological or cognitive processes using objective neurocognitive measures (e.g., EEG, fMRI). Studies that did not meet all three criteria were excluded. The screening process was led by the principal investigator using the "*revtools*" package (Westgate, 2019), and all inclusion and exclusion decisions were reviewed collaboratively by the co-authors, with any disagreements resolved through discussion.

The initial database search yielded 1,268 articles. After removing 179 duplicates, 1,089 unique articles remained. These were screened using the above inclusion criteria, resulting in 192 potentially relevant studies. We then excluded 27 articles without full-text access, 15 reviews, and 54 studies that did not include objective neurocognitive measures (e.g., relied solely on self-reports). This left 96 unique empirical studies included in the final review. Fig. 2 presents the PRISMA-ScR flow diagram, which illustrates the full review process, including the initial identification of records from both search rounds and the final selection of studies included in the review. Full data on

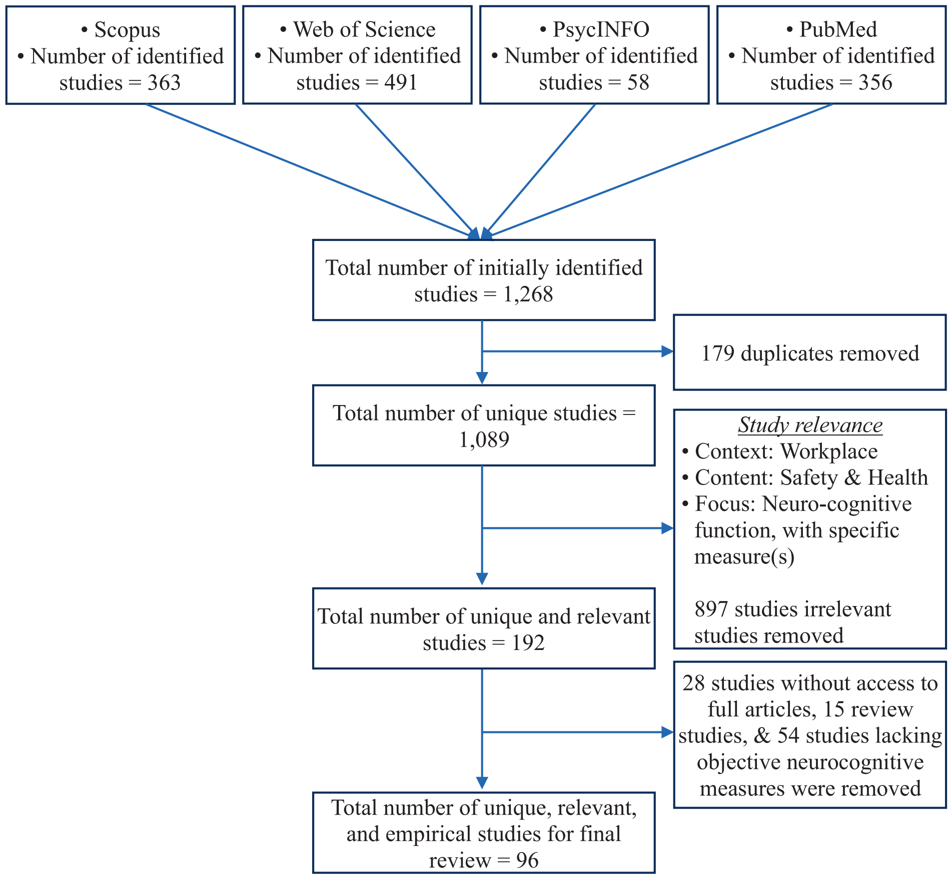

Fig. 2. The PRISMA-ScR flow diagram.

study characteristics, including design, population, neurocognitive measures, and outcomes, are available at https://osf.io/pefjk/files/osfstorage.

4.2. *Structural topic modeling*

Topic modeling is an unsupervised machine learning technique that identifies latent topics based on frequently co-occurring words in textual data. In this study, we applied structural topic models (STMs) (Roberts et al., 2014, 2019) to infer latent topics by measuring patterns of word co-occurrence. STMs are a powerful tool in natural language processing for uncovering underlying themes in document collections (Mostafa, 2023; Tonidandel et al., 2022). Unlike Latent Dirichlet Allocation (LDA), which assumes independence between topics, STMs account for the fact that certain topics often co-occur within the same documents, reflecting natural correlations between themes. Additionally, STMs incorporate document-level metadata (e.g., publication year, journal source), enabling analysis of how topic prevalence varies across different document attributes. Each topic is represented as a cluster of words that frequently appear together, and each document is modeled as a mixture of these topics. This approach allows us to identify and understand the main thematic structures in a large corpus of texts.

The 96 studies included in our review employed objective neurocognitive measures within occupational safety and health research. We conducted STM analysis using the "*stm*" package (Roberts et al., 2019) in R (R Core Team, 2024) to summarize common research methods and thematic approaches. Before modeling, the textual data were preprocessed through a standard cleaning pipeline: texts were converted to lowercase, punctuation, numbers, and URLs were removed, common English stop words were filtered out, and stemming was applied to reduce words to their root forms. This ensured high-quality input for the topic modeling process.

To select the optimal number of topics, we employed an iterative model comparison approach, fitting STM models with topic counts ranging from 5 to 15. Each model was evaluated using quantitative metrics such as semantic coherence (measuring the degree to which top words co-occur within a topic) and exclusivity (assessing the distinctiveness of top words relative to other topics). Alongside these metrics, we considered qualitative interpretability by reviewing the meaningfulness and clarity of the resulting topics. Based on these criteria, a 10-topic model was chosen as providing the best balance of coherence, exclusivity, and interpretability.

Topic interpretation involved examining the top weighted words for each topic and representative exemplar documents highly associated with those topics. We validated topics through cross-referencing with domain expertise and explored topic correlations to understand thematic relationships. To ensure reproducibility and transparency, all analytic code used for text preprocessing, model fitting, and evaluation is publicly available at https://osf.io/pefjk/files/osfstorage, along with the underlying textual data extracted from the studies.

This methodological approach allowed a nuanced exploration of latent thematic structures, offering valuable insights into the current state of neurocognitive research in occupational safety and health and guiding directions for future studies.

5. Results

The structural topic modeling of neurocognitive function measures identified 10 distinct topics within the 96 reviewed studies. Each topic highlights a unique focus area in the assessment of neurocognitive functions, with varying prevalence across the corpus. All 10 topics were retained and interpreted regardless of their proportional weight, as even less prevalent topics may capture meaningful and specialized areas of research. These findings are considered to have important implications for OHP practice and research.

5.1. Topic 1: Attention and neurocognitive functioning (proportions: 14.30%)

This topic encompasses evaluations that focus on attention, distraction, and overall neurocognitive functioning. The measures used aim to assess various cognitive capacities, crucial for maintaining concentration and minimizing errors in work settings. For instance, tasks such as visual attention tests and exercises evaluating attentional capacity are employed to enhance focus and reduce workplace distractions. These findings underscore the importance of regular assessments in identifying individuals who may benefit from interventions to strengthen attention spans and cognitive resilience, thereby promoting safer and more productive work environments.

This topic has significant implications for OHP theories like Conservation of Resources (COR) (Hobfoll, 1989) and Cognitive Activation Theory of Stress (CATS) (Ursin & Eriksen, 2004). For COR, neuroimaging studies of attention networks, such as the anterior cingulate cortex and prefrontal regions, could provide objective markers of resource depletion, allowing for better monitoring and strategies to manage cognitive load. For CATS, examining interactions between the prefrontal cortex (attention control) and the amygdala (stress response) could explain individual stress resilience. Brain activity could even be presented to workers in real-time. This neurofeedback could be used in targeted interventions to improve performance in high stress situations. These integrations connect theoretical insights with practical, neuroscience-based applications.

5.2. Topic 2: High-Risk cognitive tasks (proportions: 13.03%)

This topic delves into cognitive tasks conducted in high-risk environments, examining how individuals respond neurocognitively to stress and potential hazards. Studies often employ analyses of EEG features like Event-Related Potentials (ERPs) to gauge brain responses to specific stimuli, shedding light on workers' perception and reaction to dangers. For instance, the amplitude of an ERP response to a warning sound can be related to how likely an individual is to react to it (Gutschalk et al., 2008). Furthermore, vigilance tasks are utilized to ensure sustained attention among workers, crucial for maintaining alertness in hazardous conditions. Understanding cognitive responses in high-risk environments is pivotal for designing interventions and training programs aimed at enhancing vigilance and reducing accident rates, particularly in occupations such as construction and emergency services.

This topic advances OHP-related theories like Multiple Resource Theory (MRT) (Wickens, 2002) and organizational safety climate theory (Zohar, 2010). For MRT, incorporating ERP findings, such as the P300 component, can quantify cognitive resource allocation and workload during high-risk tasks, enabling the development of advanced monitoring systems for roles like air traffic control. For safety climate theory, neural markers from vigilance tasks can reveal how safety climate perceptions affect attention networks and decision-making, improving safety training to enhance sustained attention and risk detection. These integrations deepen our understanding of cognitive demands and safety processes in occupational settings.

5.3. Topic 3: Memory and cognitive tasks (proportions: 12.23%)

This topic encompasses assessments targeting various aspects of memory and cognitive abilities, providing insights into individuals' working memory capacity and recall capabilities. Tasks like digit span tests measure how much information workers can retain and manipulate, while episodic memory evaluations focus on the recall of specific events. Such assessments offer valuable information for identifying workers who may struggle with tasks reliant on memory, enabling targeted cognitive training and support interventions to enhance job performance.

Integrating this topic into Job Demands-Resources (JD-R) Theory (Bakker & Demerouti, 2017) and Cognitive Failure Theory (Wallace & Chen, 2005) offers valuable advancements in OHP research and practice. For JD-R, incorporating working memory research could quantify cognitive job demands more precisely, using tasks like digit span as objective measures, enabling organizations to align job demands with individual cognitive capacities and reduce burnout risk. For Cognitive Failure Theory, exploring hippocampal-prefrontal networks during cognitive failures could enhance understanding of workplace errors, leading to interventions that monitor episodic memory performance and prevent accidents in high-risk occupations.

5.4. Topic 4: Neurobehavioral testing (proportions: 11.19%)

Neurobehavioral testing explores the interaction between the nervous system and behavior to understand the impact of various factors on cognitive performance. Simple tests such as color-word tests and postural stability assessments evaluate basic cognitive and motor functions, while performance assessments gauge cognitive performance after exposure to substances like alcohol. Regular neurobehavioral testing is crucial for identifying workers affected by impairments, facilitating timely interventions to maintain workplace safety.

This topic enhances OHP-related theories like Person-Environment Fit (P-E Fit) Theory (Edwards et al., 1998) and Neuroergonomics Theory (Parasuraman & Wilson, 2008). For P-E Fit, neurobehavioral measures like color-word tests and postural stability can act as objective markers of adaptation to cognitive and physical workplace demands, enabling early detection of neurophysiological strain. For Neuroergonomics, comprehensive neurobehavioral testing can deepen understanding of how fatigue and stress impact neural functioning and behavior, guiding improved workplace safety protocols and ergonomic designs, especially in safety–critical industries.

5.5. Topic 5: Executive functioning and intelligence (proportions: 10.66%)

Studies within this topic concentrate on executive functioning and general intelligence, often employing standardized scales to evaluate cognitive abilities comprehensively. Tests like the Wechsler Intelligence Scale assess various aspects of intelligence, including problem-solving and abstract thinking, while learning and Intelligence Quotient (IQ) tests provide insights into overall cognitive ability and learning potential. Understanding executive functioning and intelligence aids in selecting and training workers for roles demanding high cognitive demands, ensuring better performance and decision-making.

This topic has implications for Action Regulation Theory (ART) (Hacker, 2003) and Trait Activation Theory (TAT) (Tett & Burnett, 2003) in OHP. For ART, insights into how prefrontal networks regulate goal-directed behavior can enhance understanding of cognitive regulation, helping design jobs that align task complexity with individual executive functioning. For TAT, exploring how intelligence and executive functioning interact with situational cues can improve personnel selection and development by linking cognitive abilities and personality traits to job performance. These integrations promote safer and healthier work practices by optimizing the fit between workers' neurocognitive traits and work settings.

5.6. Topic 6: Cognitive measures in sleep studies (proportions: 8.82%)

Studies in this topic focus on assessing how sleep and sleepiness affect cognitive performance. These investigations employ various cognitive measures to understand these impacts comprehensively. For example, studies evaluate driving errors to assess how sleepiness influences performance behind the wheel. Additionally, researchers use EEG to monitor sleep patterns and detect cognitive errors during different sleep stages defined by EEG. These findings are crucial for developing strategies to mitigate the adverse effects of sleep deprivation and improve cognitive functioning, especially in professions requiring high levels of alertness and safety.

Integrating this topic into Effort-Recovery Theory (E-R Theory) (Zijlstra & Sonnentag, 2006) and Compensatory Control Theory (Hockey, 2013) offers valuable insights for OHP. For E-R Theory, incorporating EEG findings on sleep patterns and cognitive recovery could provide neurobiological markers to better quantify recovery and its impact on workplace performance, aiding in more effective work schedule design. For Compensatory Control Theory, understanding how chronic sleep deprivation affects cognitive control through EEG measures of alertness and attention could improve fatigue management, especially in safety–critical industries. These integrations optimize recovery strategies and enhance performance under fatigue.

5.7. Topic 7: Cognitive functioning (proportions: 8.50%)

Cognitive functioning assessments examine how individuals acquire knowledge and understand through thought, experience, and sensory perception. These evaluations utilize various tests to assess critical cognitive abilities that support mental health and performance. For instance, memory tests like the Mini-Mental State Examination (MMSE) and tasks measuring episodic memory evaluate cognitive health and retention abilities. Verbal fluency tests assess language skills and cognitive flexibility. Screening tools for cognitive health play a pivotal role in early detection of impairments, facilitating proactive interventions to enhance mental well-being and optimize cognitive performance in diverse occupational contexts. These assessments underscore the importance of comprehensive cognitive evaluations in promoting cognitive health and effectiveness across different groups.

This topic presents OHP implications for Cognitive Load Theory (CLT) (van Merriënboer & Sweller, 2010; Sweller et al., 2019) and Sociotechnical Systems Theory (STS) (Clegg, 2000). For CLT, incorporating cognitive screening tools and memory assessments could quantify cognitive demand in workplace settings, enabling job designs that align task complexity with individual processing capacities and assess cognitive fatigue in communication-intensive roles. For STS, understanding cognitive functioning in sociotechnical interactions can inform better work system designs, training programs, and person-technology fit measures, improving worker well-being and performance.

5.8. Topic 8: Comprehensive cognitive functioning (proportions: 8.25%)

This topic involves overall assessments of cognitive functioning, considering the influence of physical and emotional health on cognitive performance. Assessments may include measuring the impact of fatigue on cognitive performance and evaluating how emotional and physical factors influence cognitive functioning. Comprehensive cognitive assessments aid in identifying broader impacts on worker performance, guiding interventions for well-being and organizational effectiveness.

This topic aligns with Cognitive Reserve Theory (CRT) (Stern, 2009) and Allostatic Load Theory (ALT) (McEwen, 2017), offering significant implications for OHP. For CRT, analyzing workplace environments and neuroplasticity mechanisms can help develop strategies to enhance cognitive resilience and implement targeted interventions that strengthen cognitive reserve in professional settings. For ALT, incorporating biomarkers to measure cumulative physiological strain and exploring the effects of chronic workplace stress on neural networks can inform interventions to alleviate stress and support cognitive performance. Advancing both theories with neuroscience insights can foster biologically-informed approaches to enhance worker well-being and cognitive health.

5.9. Topic 9: Neurocognitive tasks and disabilities (proportions: 4.95%)

This topic, focused on neurocognitive tasks and in relation to disabilities, utilizes various methods to gain a deeper understanding of brain function and cognitive performance. For instance, researchers employ EEG to monitor brain activity during cognitive tasks, providing insights into neural processes underlying cognitive functions. Additionally, studies conduct disability assessments to evaluate how cognitive impairments impact daily functioning and work performance. These assessments are crucial for developing tailored interventions and accommodations to support individuals with cognitive disabilities, promoting inclusivity and optimizing cognitive abilities in diverse settings.

This topic could advance OHP-related theories like Cognitive Compensation Theory (CCT) (Stern et al., 2003) and Cognitive Load Theory (CLT) from a neuroadaptive perspective (van Merriënboer & Sweller, 2010; Sweller et al., 2019). For CCT, exploring neuroplasticity mechanisms and compensatory neural pathways can guide interventions that enhance cognitive adaptability for individuals with disabilities. For CLT, real-time neuroimaging and EEG assessments can provide insights into cognitive load and neural resource allocation, supporting adaptive workplace environments tailored to diverse cognitive abilities. Together, these approaches can inform personalized accommodations, improve cognitive performance, and support employees with neurocognitive challenges.

5.10. Topic 10: Reaction time and processing speed (proportions: 4.07%)

Cognitive tests in this topic explore cognitive tests that measure reaction time and processing speed as indicators of cognitive performance. Researchers utilize tasks such as reaction time tests, including simple and choice reaction tasks, to assess how quickly individuals process and respond to stimuli. Furthermore, automated testing tools like the Cambridge Neuropsychological Test Automated Battery (CANTAB) are employed to quantify cognitive processing speed across different cognitive domains. These assessments are instrumental in identifying individuals who may benefit from interventions aimed at improving speed and accuracy in cognitive tasks, thereby enhancing overall cognitive performance in professional and everyday contexts.

This topic has notable implications for OHP theories like Cognitive Control Theory (CCT) (Miyake & Friedman, 2012) and the Neural Efficiency Hypothesis (NEH) (Neubauer & Fink, 2009). For CCT, understanding neural mechanisms in the prefrontal cortex and basal ganglia can help identify factors affecting reaction time and performance variability, enabling strategies to reduce errors and improve decision-making in high-stakes environments, enhancing workplace safety. For NEH, analyzing brain activation patterns and metabolic efficiency can provide biomarkers for processing speed, supporting interventions to prevent cognitive overload and promote sustained attention in demanding tasks. These neuroscience-based applications offer practical solutions to mitigate workplace risks and foster a healthier, more efficient workforce.

Overall, these topics illustrate the diverse approaches used in neurocognitive function assessments and their varying emphasis on different cognitive domains. The identification of these topics provides a comprehensive overview of current research trends and methodologies in the field of neurocognitive assessment. These insights are particularly relevant for OHP, offering valuable information to enhance employee well-being, performance, and organizational effectiveness. Table 3 offers a summary of the identified 10 topics of the neurocognitive function measures adopted in the 96 studies.

In the following sections, we offer an analysis of three studies chosen from the 96 included in the final review, highlighting their distinctiveness compared to traditional OHP research. These studies were not selected based on formal quality appraisal or risk of bias assessment, but rather for their strong illustrative value in demonstrating how neuroscience methodologies can be integrated into OHP. Each study serves as

Table 3
Results of structural topic modeling and top ten topics (based on 96 studies for final review).

Topic	General description	Examples	Relevant theories
1. Attention and Neurocognitive Functioning (proportions: 14.30%)	Evaluations focusing on attention/distraction and overall neurocognitive functioning, often using various measures to assess different cognitive capacities.	– Attention Tests: Visual attention and concentration tasks. – Counting Tasks: Assessing attentional capacity through counting exercises.	– Conservation of Resources (COR) Theory (Hobfoll, 1989) – Cognitive Activation Theory of Stress (CATS) (Ursin & Eriksen, 2004)
2. High-Risk Cognitive Tasks (proportions: 13.03%)	Studies focusing on cognitive tasks in high-risk situations and the associated neurocognitive responses.	– Event-Related Potentials (ERP): Measuring brain responses to specific stimuli. – Vigilance Tasks: Assessing sustained attention in high-risk environments.	– Multiple Resource Theory (MRT) (Wickens, 2002) – Organizational Safety Climate Theory (Zohar, 2010)
3. Memory and Cognitive Tasks (proportions: 12.23%)	Memory and cognitive tasks assess different aspects of memory and cognitive abilities, often involving specific tasks to measure these functions.	– Digit Span Tasks: Measuring working memory capacity. – Episodic Memory: Tasks evaluating the recall of specific events or experiences.	– Job Demands-Resources (JD-R) Theory (Bakker & Demerouti, 2017) – Cognitive Failure Theory (Wallace & Chen, 2005)
4. Neurobehavioral Testing (proportions: 11.19%)	Neurobehavioral testing assesses the interaction between the nervous system and behavior, often to evaluate the impact of various factors on cognitive performance.	– Simple Tests: Color-word tests, postural stability tests. – Performance Assessments: Evaluating cognitive performance after exposure to substances like alcohol.	– Person-Environment Fit (P-E Fit) Theory (Edwards et al., 1998) – Neuroergonomics Theory (Parasuraman & Wilson, 2008)
5. Executive Functioning and Intelligence (proportions: 10.66%)	Assessments that focus on executive functioning and general intelligence, often using standardized intelligence scales.	– Wechsler Intelligence Scale: Tests for assessing different aspects of intelligence and cognitive function. – Learning and Intelligence Quotient (IQ) Tests: Standardized tests measuring learning ability and IQ.	– Action Regulation Theory (ART) (Hacker, 2003) – Trait Activation Theory (TAT) (Tett & Burnett, 2003)
6. Cognitive Measures in Sleep Studies (proportions: 8.82%)	Studies using cognitive measures to assess the impact of sleep and sleepiness on cognitive performance.	– Driving Errors: Evaluating the impact of sleepiness on driving performance. – EEG: Using EEG to monitor sleep patterns and cognitive errors.	– Effort-Recovery Theory (E-R Theory) (Zijlstra & Sonnentag, 2006) – Compensatory Control Theory (Hockey, 2013)
7. Cognitive Functioning (proportions: 8.50%)	Cognitive functioning refers to the mental processes by which individuals acquire knowledge and understanding through thought, experience, and the senses.	– Memory Tests: Mini-Mental State Examination (MMSE), episodic memory tasks. – Fluency Tasks: Verbal fluency tests. – Screening Tools: Cognitive screenings for health assessments.	– Cognitive Load Theory (CLT) (van Merriënboer & Sweller, 2010; Sweller et al., 2019). – Sociotechnical Systems Theory (STS) (Clegg, 2000)
8. Comprehensive Cognitive Functioning (proportions: 8.25%)	Overall assessment of cognitive functioning, including various aspects of cognitive and physical health.	– Fatigue Assessments: Measuring the impact of fatigue on cognitive performance. – Emotional and Physical Health: Evaluating the emotional and physical aspects that influence cognitive functioning.	– Cognitive Reserve Theory (CRT) (Stern, 2009) – Allostatic Load Theory (ALT) (McEwen, 2017)
9. Neurocognitive Tasks and Disabilities (proportions: 4.95%)	Using neurocognitive tasks to gain insights into brain function and cognitive performance.	– EEG: Monitoring brain activity during cognitive tasks. – Disability Assessments: Evaluating the cognitive impact of disabilities.	– Cognitive Compensation Theory (CCT) (Stern et al., 2003) – Cognitive Load Theory (CLT) (van Merriënboer & Sweller, 2010; Sweller et al., 2019)
10. Reaction Time and Processing Speed (proportions: 4.07%)	Cognitive tests that measure reaction time and processing speed as indicators of cognitive performance.	– Reaction Time Tests: Simple and choice reaction time tasks. – Automated Testing: Using tools like the Cambridge Neuropsychological Test Automated Battery (CANTAB) to assess cognitive processing speed.	– Cognitive Control Theory (CCT) (Miyake & Friedman, 2012) – Neural Efficiency Hypothesis (NEH) (Neubauer & Fink, 2009)

Notes. Proportions indicate the expected topic prevalence represented by the conditional probability of each topic across the corpus. For instance, the approach in Topic 1, focusing on memory assessment, was found in over 14% of the 96 reviewed studies.

an exemplar to illuminate how methods and frameworks from neuroscience research in workplace safety and health promotion can advance OHP. They represent methodologically diverse yet complementary approaches, showcasing different techniques (e.g., neuroimaging, electrophysiology, psychophysiological measures), addressing a range of safety-relevant factors (e.g., stress, cognitive load, fatigue, attention, decision-making, risk perception), and offering clear links between neural mechanisms and practical applications. This selection approach prioritizes demonstrative utility and conceptual relevance over formal quality rankings, providing readers with concrete examples of how neuroscience can enhance the understanding and prevention of safety–critical human errors across diverse occupational contexts.

5.11. Xing et al.'s (2020) study on the effects of physical fatigue on the induction of mental fatigue of construction workers

This study stands out in OHP due to its innovative use of objective neurocognitive function measures with a mobile EEG system that is wearable in work environments. This study highlighted that construction workers experience significant impacts from both physical and mental fatigue, which adversely affects their work performance. Using EEG data, the study found that high physical fatigue accelerates mental fatigue during risk identification tasks. The findings stress the importance of implementing targeted fatigue management strategies to improve safety and cognitive performance on construction sites.

A notable strength of this study is its reliance on objective fatigue measurements. EEG sensors provide quantitative data on brain activity, offering a more reliable alternative to subjective self-reported measures, which are often biased. Several basic human neuroscience studies have demonstrated that the strength of EEG oscillations in the 4——8 Hz (theta), 8——13 Hz (alpha), and beta (13——30 Hz) bands can be related to fatigue (for review, see Tran et al., 2020). Xing et al. (2020) took advantage of the real-time monitoring capability of EEG sensors to enable the quick objective identification of mental fatigue using these

EEG features. The study employs controlled manual handling tasks to induce physical fatigue, followed by cognitive tasks to assess mental fatigue, thereby creating a robust experimental framework. These findings have significant implications for fatigue management on construction sites. By elucidating the relationship between physical and mental fatigue, the study paves the way for developing more effective fatigue management strategies to enhance safety and performance.

In contrast, most conventional OHP studies rely on self-reported measures of fatigue, stress, and cognitive function, which are prone to bias and response distortion. These studies often lack integration of objective measures like EEG, limiting their ability to provide precise insights into the physiological aspects of mental fatigue. Additionally, without adequately considering the physiological interplay between physical and mental demands, the exact mechanisms of occupational fatigue and its impact on cognitive functions and performance remain unclear.

The study has several limitations, though. As a pilot with a small sample size (n = 9), its findings have limited generalizability, requiring larger studies for validation across diverse populations. The controlled experimental setup may not fully capture the complexity of real-world construction environments, and the tasks used may not reflect the full range of physical and cognitive demands faced by workers. Implementing EEG sensors in construction settings poses technical challenges, including the need for expertise, worker discomfort, and potential equipment damage. Analyzing EEG data also demands specialized knowledge, with variability in interpretation potentially affecting reliability. Ensuring consistent and accurate analysis is critical. Additionally, the study focuses on the immediate effects of physical fatigue on mental fatigue, leaving the long-term impacts of chronic physical exertion on cognitive performance unexplored. Finally, while the findings offer insights into fatigue management, they do not address the long-term sustainability or practicality of implementing these measures in construction environments.

In conclusion, Xing et al. (2020) significantly contribute to OHP by using a mobile EEG system to objectively measure the interplay between physical and mental fatigue in construction workers. This approach offers a more reliable alternative to subjective self-reports and provides actionable insights for developing effective fatigue management strategies. Future research should expand on these findings with larger sample sizes and explore long-term impacts to ensure the practical application of these measures in diverse real-world settings.

5.12. Ramírez-Santana et al.'s (2015) study on neurocognitive implications of chronic pesticide exposure

The study by Ramírez-Santana et al. (2015) offers valuable insights into the chronic health effects of pesticide exposure, with important implications for OHP. While acute pesticide poisoning can be diagnosed with biomarkers like plasma cholinesterase (ChE) and erythrocyte acetylcholinesterase (AChE), chronic exposure leads to subtle, long-term neuropsychological issues. The researchers evaluated acylpeptide-hydrolase (ACPH) as a novel biomarker for chronic exposure to organophosphate pesticides (OPP), hypothesizing it could better reflect neuropsychological decline than traditional markers. Conducted over three years (2011–2013), the study involved three groups: (1) individuals with no pesticide exposure in coastal areas (Group I, External Control), (2) individuals in rural farming areas without occupational pesticide exposure (Group II, Internal Control), and (3) agricultural workers with over five years of pesticide contact (Group III, Exposed Group). Blood samples and neuropsychological evaluations were collected once for the External Control group, twice (before and during fumigation) for the Internal Control group, and three times (before, during, and after fumigation) for the Exposed Group. Biomarkers measured included ChE, AChE, and ACPH, with assessments of cognitive functions, affectivity, and psychomotor activity.

Similar to Xing et al. (2020), who used EEG sensors, Ramírez-Santana et al. (2015) prioritize objective biomarkers over subjective self-reports. Traditional OHP studies often rely on self-reported data, which can be biased and distorted. By using ACPH as an objective biomarker, the study offers more accurate insights into the physiological effects of chronic pesticide exposure, reducing the limitations of unreliable self-assessments.

The researchers employed a rigorous longitudinal design, recruiting subjects with at least five years of pesticide exposure and monitoring them over three years, across various seasons and exposure periods. This approach contrasts with typical cross-sectional studies that only provide snapshots of workers' health. Longitudinal data collection offers a clearer understanding of how chronic exposure affects workers over time, essential for developing effective long-term intervention strategies.

The study also highlights how OHP principles can identify behavioral and managerial factors linked to hazard exposure. Researchers assessed factors such as workers' personal protective equipment (PPE) use, safety protocol adherence, administrative controls, and management practices regarding chemical handling, training, and risk mitigation. This systematic analysis helps to determine how organizational culture, leadership, and individual behaviors influence occupational health risks. Objective measures from longitudinal monitoring provide empirical evidence for these interventions.

In conclusion, Ramírez-Santana et al. (2015) emphasize the value of objective biomarkers and longitudinal monitoring in understanding the chronic effects of occupational hazards. These advanced methodological approaches can lead to more accurate, actionable insights, ultimately improving worker health and safety.

5.13. Kim et al. 's (2023) study on the virtual reality (VR) training for mitigating sensory habituation to warning signals

This study explores the efficacy of virtual reality (VR) training in mitigating sensory habituation to warning signals in high-risk work environments. Workers often become habituated to frequently encountered hazards, a phenomenon termed "risk habituation," leading to underestimating risks and engaging in unsafe behaviors. This study investigates whether experiencing an accident in a VR environment can reduce risk habituation and improve safety behaviors. The study used EEG to examine sensory-level risk habituation. Specifically, known sound evoked responses in the EEG (for review, see Näätänen & Picton, 1987) could be used to characterize the brain's changing sensitivity to warning sounds over time, and their relationship to prior accident events in a virtual work environment. Workers were exposed to a VR environment where they experienced a simulated accident. Pre- and post-treatment analyses assessed changes in risk habituation behaviorally and at the sensory level. Results indicated that experiencing a virtual accident significantly reduced risk habituation. Both behavioral and EEG data showed a decrease in habituation for warning sounds, suggesting that VR training could be an effective intervention for improving occupational safety.

Kim et al. 's (2023) study provides a neuroscientific approach to understanding and mitigating risk habituation, contrasting with conventional OHP methods that primarily focus on behavioral interventions and self-reported data. Traditional OHP research often addresses risk perception and safety behaviors through training programs, policies, and organizational culture interventions. The use of EEG to measure sensory-level changes provides insights into the underlying mechanisms of risk habituation. This neuroscientific approach enables a deeper understanding of how workers perceive and react to hazards, beyond behavioral observations. VR training represents a novel intervention that can simulate realistic hazardous scenarios without actual risk. This method enhances traditional safety training by providing immersive and experiential learning, which can lead to more effective behavior change. Also, the study offers empirical evidence supporting the use of VR training to reduce risk habituation. This addresses a gap in conventional

OHP research, where interventions often lack rigorous empirical validation. Integrating VR-based interventions can strengthen safety culture by continuously engaging workers in safety practices. This approach can complement existing safety programs, making them more dynamic and responsive to worker needs.

Kim et al.'s (2023) study exemplifies how incorporating human neuroscience into OHP can advance the field by providing novel insights and effective interventions. The use of VR training to mitigate risk habituation highlights the potential for human neuroscience to enhance traditional OHP practices, ultimately leading to safer work environments. This interdisciplinary approach paves the way for more comprehensive and empirically supported strategies in occupational health and safety.

6. Discussion

This study delves into the neurocognitive correlates of work-related factors, emphasizing their critical role in advancing occupational safety and health. Recognizing a significant gap in integrating neuroscience and OHP, it highlights promising developments such as the rise of "health neuroscience" and "neuro-safety science," increased interdisciplinary research funding, and innovations in neurocognitive assessment technologies. By reviewing 96 studies at the intersection of human neuroscience and OHP, this research introduces a collaborative framework to enhance workplace safety, well-being, and organizational effectiveness through the integration of psychological and neurobiological insights.

The topic modeling results further underscore the importance of this integration, revealing diverse cognitive domains such as attention, memory, executive functioning, and reaction time as critical to understanding workplace behaviors. These findings bridge traditional psychological theories with neurobiological insights, advancing frameworks like Cognitive Load Theory, Job Demands-Resources Theory, and Allostatic Load Theory. Leveraging neuroscience methods such as EEG, fMRI, and neurobehavioral testing enables precise identification of cognitive and neural markers, facilitating targeted interventions like neurofeedback and cognitive resilience training. Such interventions mitigate stress, enhance cognitive capacity, and optimize performance, particularly in safety–critical and high-stress environments.

This neuroscience-informed approach complements traditional OHP methods by offering objective measures of neural processes that contrast with self-reported survey data. For example, examination of the neural mechanisms underlying decision-making during such situations can inform interventions aimed at improving cognitive processes crucial for accident and injury prevention (Pan et al., 2019; Williams & Lewis, 2020). Also, studying neural responses to stress using techniques like EEG and fMRI provides insights into physiological manifestations of psychological stress, influencing factors like alertness, reaction times, and decision-making (McEwen, 2009; Morales et al., 2019), addressing the potential limitations of OHP's reliance on self-reported survey data to assess workplace stress (Ahn et al., 2016). These insights inform interventions targeting both psychological well-being and physiological states crucial for workplace safety and health.

The integration of neuroscientific methods into OHP also fosters a holistic understanding of how work-related factors influence employee performance. For instance, identifying neural correlates of attention lapses or safety–critical errors supports focused interventions to prevent workplace accidents (Fan et al., 2005; Mao et al., 2011). Advancing neurobehavioral testing, including assessments of reaction time and processing speed in high-risk environments, enhances our understanding of safety–critical human errors and guides preventive measures (Linden et al., 2005; Rogers & Franklin, 2021; Turcotte & Oddson, 2022). Moreover, assessments of cognitive functions under varied work conditions and advancements in wearable sensor technology (Wang et al., 2017; Xing et al., 2020) enhance real-world applicability, addressing methodological challenges in OHP research. By linking neurobiological processes to occupational behaviors, this study lays the groundwork for a neuroscience-informed paradigm, offering transformative insights into enhancing employee well-being, safety, and organizational effectiveness.

6.1. Future Directions: Advancing OHP-Neuroscience integration with objective methodologies

The integration of OHP and human neuroscience offers powerful opportunities to develop evidence-based interventions that enhance workplace safety and well-being. Building on our literature review, several key research directions emerge that emphasize methodological rigor, technological innovation, and real-world applicability.

Longitudinal Neural Biomarkers and Neuroplasticity Future research should prioritize the development of validated neurocognitive biomarkers of occupational stress, fatigue, and cognitive or emotional overload using longitudinal designs. Continuous EEG monitoring, combined with ecological momentary assessment (EMA), can capture real-time fluctuations in cognitive states across work shifts, particularly in safety–critical environments. This approach enables early identification of performance declines before behavioral signs become evident. At the same time, neuroimaging studies should investigate how prolonged exposure to job demands affects brain structure and function over time. Understanding which neural changes are reversible and which are enduring will inform timely interventions, support job redesign, and contribute to resilience-building efforts. These directions reinforce the preventive focus of occupational health psychology by enabling earlier and more precise detection and intervention for at-risk workers.

Multi-Modal and Mobile Neuroimaging A comprehensive understanding of the neural basis of occupational functioning requires the integration of multiple methods, including methods like EEG for high temporal resolution, fMRI for high spatial resolution, and functional near-infrared spectroscopy (fNIRS), which is suitable for mobile and field-based settings. This multi-modal approach allows for detailed mapping of cognitive processes while maintaining ecological validity. Advances in wearable neurotechnology now make it feasible to collect high-quality data during authentic work activities. Researchers should prioritize protocols that minimize motion-related noise and incorporate contextual data from Internet of Things (IoT) devices, such as workload, ambient conditions, and social interactions. Objective neural data can serve as empirical validation tools for widely used self-report surveys in occupational health psychology. Comparing neural activity with subjective reports of stress, cognitive and emotional workload, engagement, and performance can highlight gaps between perception and physiology. This, in turn, can enhance the precision of psychological scales and support the development of hybrid assessment models. These efforts directly contribute to improved measurement validity and more accurate evaluations of psychosocial risks in the workplace.

Real-Time Feedback and Personalized Interventions The emergence of real-time feedback systems powered by mobile EEG and advanced data processing techniques offers a major advancement in the application of neuroscience to occupational health. These systems can detect acute cognitive overload, stress responses, or lapses in attention and initiate adaptive interventions, such as rest breaks, task reprioritization, or workload adjustments, before safety or performance is compromised. Enhancing the reliability of these systems in dynamic and noisy environments, and validating neural indicators against relevant safety metrics, will be essential for practical deployment. In parallel, personalized neurocognitive interventions should be developed based on individual neural patterns and specific task demands. Evidence from empirical studies can inform the optimization of intervention strategies, whether through neurofeedback, cognitive training, or tailored job accommodations. This individualized approach reflects the principles of precision health and aligns with occupational health psychology's emphasis on worker-centered solutions. It marks a shift from generic safety programs to adaptive interventions that enhance both effectiveness and employee autonomy.

Methodological and Analytical Advancements To fully leverage the richness of neuro-behavioral data, future research must adopt advanced analytical approaches capable of modeling the complex and dynamic interactions between brain function and work behavior. Techniques such as dynamic causal modeling, machine learning, and neural network analysis can uncover subtle relationships that traditional statistical methods may overlook. Establishing best practices for handling multi-modal and high-dimensional datasets while ensuring adequate statistical power and minimizing false positives is essential. These methodological innovations will enhance the scientific rigor of occupational health research and support the translation of complex data into practical interventions that improve workplace safety and well-being.

7. Conclusions

In conclusion, integrating human neuroscience into OHP offers significant potential to enhance workplace safety, health, and organizational effectiveness. By understanding the neurobiological basis of work-related factors and their impact on cognitive functions, we can develop targeted interventions to mitigate risks and optimize employee well-being. Neuroimaging techniques like EEG and fMRI, coupled with wearable sensor technology, provide precise, objective insights into neural processes. These advancements enable the development of neurofeedback training, cognitive resilience programs, and real-time monitoring tools. By fostering interdisciplinary collaboration, we can bridge the gap between theory and practice, leading to impactful, evidence-based strategies that benefit both employees and organizations.

8. Data and analytic code availability

The data analyzed in this study, along with the codes used for topic modeling, are available at: https://osf.io/pefjk/files/osfstorage

Ethical approval

This study is based on a comprehensive literature review and does not require IRB approval.

CRediT authorship contribution statement

Jin Lee: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Jesica Luna:** Writing – review & editing, Writing – original draft, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Matthew Wisniewski:** Writing – review & editing, Writing – original draft, Resources, Methodology, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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