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Editorial

Mind-Body Medicine: AI, Quantum Computing, and the New Frontier of Personalized Healing

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Mind-body medicine stands at the brink of revolution with the convergence of artificial intelligence (AI), quantum computing, and nanotechnology already beginning to offer precision, individualization, and predictive care as never before imaginable. Such breakthroughs are not future abstraction, they already offer workable tools to extend clinical insight and therapeutic force at both cellular and systemic levels.

It is now able to process vast and very complex data sets, including neuroimaging, genetic phenotypes, wearable sensing, and patient self-reporting and automatically distinguish subtle patterns reflecting disease initiation, response to therapy, or behavior change long before signature symptoms become manifest. As an example, AI algorithms can distinguish the first sign of stress disorders or neurodegeneration through heart rate variability, cortisol output, or facial appearance during remote consultations and enable rapid and personalized therapies of a mind-body type.

Quantum computing could revolutionize metabolic modeling and drug discovery based on computer simulation of protein folding, the functioning of the neurotransmitters, and receptor ligand binding at the level of the atoms, which is currently the territory of Earth's fastest supercomputers. Such is their possible bearing on the main mental afflictions, depression, anxiety, and dementia, that an understanding of the energy dynamics of synaptic transmission, say, or mitochondrial disease, might forge new therapeutics. Quantum-enabled models may equally offer the molecular level verification of the biophysical substrate of the practice of the mind-body therapies, the effect of meditation, say, or breathwork, on the synchrony and energy metabolism of the brain networks.

The nanotechnology, alone, introduced physical agents to work precisely where and when needed. Nanoparticles may selectively administer molecules of the psychotropic or anti-inflammatory type directly to the central nervous system, crossing the blood-brain barrier, minimizing the chances of undesirable side effects, and enhancing the effectiveness of treatments like mindfulness or psychotherapy. Nanosensors, placed in wearable devices or in capsules that may be ingested, continuously measure the neurochemical biomarkers like serotonin, dopamine, or cytokines, providing real-time information about the states of mental health and the body effects of treatments like psychotherapy or acupuncture.

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Regenerative nanomaterials that replicate the natural forms of the extracellular matrix might one day help repair neurons after injury or degenerative disease, and help achieve the repair goals of the integrative approach to medicine.

Integrated wearables or dermal patches already offer real-time output of variables like glucose, oxygen saturation, or sleep configuration, and enable clinicians and patients to adjust daily behavior (diet, breath patterns, exercise) in real-time to achieve best autonomic balance and mitochondrial function. Data thus obtained in real-time is available to be processed instantly on AI platforms and used to offer adaptive guidance sensitive to the individual user's current physiology, as well as psychology.

Even at the systems level, telemedicine and robots are expanding and concentrating the reach of mind-body medicine. Robot-assisted therapy delivers individually customized physical therapy for stress injury or chronic pain with precision to the level of the micrometer, and online real-time virtual consultations with AI-aided systems of triage allow practitioners to track mood, inflammation, and sleep online in real-time, regardless of geographics. Technologically enabled, smaller centers of wellness based on centers of integrative care are replacing the large centers, with lean, cheap venues where treatments might be individualized, tracked, and iteratively refined with the assistance of online real-time digital feedback.

While the coming convergence of AI, quantum computing, and nanotechnology promises paradigm-changing innovations in the practice of mind-body medicine, it poses serious challenges, as well. By developing the capability of monitoring in real time anything from brain wave patterns to indicators of stress, we must, too, ensure the privacy of such highly personal data. Without affirmative protection, sensitive information may be compromised or sold to the patient's disbenefit. There is an attendant risk that systems of AI, educated in biased information or lacunae in the information, themselves, may misread signals or perpetuate health inequities, disproportionately on the disadvantaged minorities. Over-reliance, however, may dissolve the human relationship at the very center of healing. Mind-body practices are based on empathies, presence, and relational trust, values that algorithms have yet to match. Further, sequential data feedback along wearable biosensors may overwhelm individual persons, inducing anxiety, rather than equilibrium. As the technology itself evolves, it must supplement/facilitate and not replace clinical intuition, human relationships, and individualized care. Consumed with care, the technology may extend the reach of that which we may heal. But consumed en masse without regard, it may reach with the very strengths which underlie the practice of mind-body medicine.

Conclusion

This intersection of brain-wave intelligences and micron-scale precision does not replace the values of mind-body medicine but enhances them. By demonstrating, down to the level of molecules and of network, the way the psychology affects the physiology (and the physiology back again), the instruments verify, yet again, the vital doctrine that the mind and the body are not two, separate entities, but an inseparable whole. And, finally, it is feasible to measure the relationship, back and forth, in real time, and to apply it to individualize healing specific to the individual. Mind-body medicine's future is no longer the topic of speculation. It is taking shape, and it is highly, exactly, and empathetically individualized.

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The intention of this editorial is not to claim expertise, but rather to highlight the depth of engagement and familiarity within our group concerning the issues discussed. Our involvement provides us with the appropriate perspective and criteria to thoughtfully contribute to the discourse in this area.

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Narrative Essay

Evolution of Mind-Body Medicine: A Clinician's Perspective

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As a clinician with thirty-five years of experience teaching the practical applications of mind-body medicine, I am deeply grateful to the scientists whose work has illuminated the intricate connections among mind, brain, and body—many of whom I have had the privilege to work alongside. Their discoveries have advanced our understanding of stress, adaptation, and resilience, establishing self-care as a vital component of health. Once a marginalized field, mind-body medicine is now recognized as an essential dimension of healthcare. This review highlights key scientific discoveries that have informed my practice—meditation and mindfulness, adaptive cognitive strategies, restorative sleep, and nutrition—underscoring their central role in the field's evolution.

Relaxation Response and Attention Regulation

In the late 1960s, Harvard cardiologist Herbert Benson, while studying hypertension and metabolism, discovered that self-directed mental focus could shift physiology into a hypometabolic state—characterized by reduced blood pressure, heart rate, respiratory rate, and oxygen consumption—which he termed the *relaxation response*, a functional counterpart to the stress response. Early research demonstrated that this response could be elicited through various mental focus techniques such as yoga, mindfulness, and prayer, each producing distinct brain oscillations and regional activations. The reproducibility of these findings marked the emergence of mind-body medicine at Harvard in the late 1970s (Wallace et al., 1971).

Allostasis and Allostatic Load

In the late 1980s, the concept of allostasis advanced the understanding of stress physiology from an acute response to a dynamic process central to adaptation and resilience. Building on this foundation, Bruce McEwen introduced the term *allostatic load* to describe the cumulative "wear and tear" of stress that leads to multisystem dysregulation and increased disease vulnerability. Within this broader framework—shaped by factors such as sociodemographic pressures, early adversity, trauma, and major life events—stress and mind-body interactions began to gain scientific legitimacy within modern medicine (McEwen & Stellar, 1993; McEwen, 1998).

Systemic and Neural Inflammation

In the early 2000s, advances in molecular biology and neuroimaging deepened understanding of the blood–brain barrier (BBB), primarily formed by capillary endothelial cells joined by tight junctions containing signaling proteins that respond to endogenous and exogenous threats. A key modulator of these responses is the inflammasome—an intracellular protein complex that detects pathogens or cellular damage and initiates inflammatory responses. Systemic inflammatory responses triggered by psychological stress can cross or signal across the BBB, activating microglia and astrocytes that further amplify neuroinflammatory processes. Chronic stress also elevates glucocorticoid levels, inducing oxidative stress and activating NF-κB signaling and inflammasomes, resulting in BBB dysfunction and neuroinflammation that underlie many psychiatric, neurodegenerative, neuroimmune, metabolic, infectious, and acute CNS disorders (Acioglu & Elkabes, 2025; García-Bueno et al., 2008; Wozny-Rasala & Oglodek, 2025).

Epigenetics

In the early 2000s, landmark work by Michael Meaney and colleagues demonstrated that variations in maternal care produced lasting changes in DNA methylation of the glucocorticoid receptor gene in offspring, altering stress reactivity across the lifespan. Notably, these epigenetic modifications were transmissible across generations, providing the first direct evidence of transgenerational inheritance of stress effects in mammals. Epigenetics has since transformed our understanding of biology—moving beyond the nature-versus-nurture debate toward a more integrated view of how inheritance, experience, environment, and behavior dynamically shape biology and behavior (Champagne et al., 2009; Weaver et al., 2002; Weaver et al., 2004).

Stress Signaling and Neurogenesis

By the early 2000s, chronic stress was shown to reduce hippocampal plasticity while enhancing amygdala growth—changes associated with reduced levels of neural brain-derived neurotrophic factor (BDNF). Current research provides a systems-level understanding of how neuroplasticity and synaptic transmission mediate adaptive versus maladaptive responses to stress, with BDNF recognized as a central regulator of neurogenesis, synaptic plasticity, and neuronal survival—key determinants of resilience and vulnerability across neuropsychiatric and neurodegenerative conditions. Self-care behaviors such as regular exercise, meditation, yoga, cognitive engagement, social connection, and dietary moderation have been shown to elevate BDNF and strengthen neural resilience (Notaras & van den Buuse, 2020; Zhou et al., 2022).

Meditation and Neuroplasticity

The first fMRI study examining brain changes associated with the relaxation response revealed desirable changes in the dorsolateral PFC, hippocampus, pregenual anterior cingulate cortex, and striatum, indicating that meditation engages neural structures involved in attention and autonomic regulation (Lazar et al., 2000). Maintaining the relaxation response requires sustained mental focus that competes with the pull of the internal narrative. In 2001, this internal narrative was characterized as self-referential thinking, with its neural correlates identified in the medial prefrontal cortex (mPFC) and posterior cingulate cortex (PCC)—regions collectively known as the default mode network (DMN) (Raichle, 2001). A decade later, research on experienced meditators showed reduced activation in key DMN hubs (mPFC and PCC) and strengthened functional connectivity between the DMN and the dorsal anterior cingulate cortex), insula (supporting interoceptive awareness), and the dorsolateral prefrontal cortex (DLPFC), linking interoceptive and executive control processes (Brewer et al., 2011; Christoff et al., 2009).

Meditation and Stress Regulation (NF-kB)

Advances in gene expression analysis in the early 2000s demonstrated that the relaxation response downregulates NF-κB, a key pro-inflammatory transcription factor responsible for the expression of cytokines such as IL-6, IL-17A, and TNF-α, while upregulating genes involved in mitochondrial energy production, insulin secretion, and telomere maintenance (Bhasin et al., 2013; Black et al., 2013; Dusek et al., 2008). Multiple systematic reviews and meta-analyses now confirm that mind-body interventions consistently suppress NF-κB signaling, producing effects opposite to those of chronic stress—and suggest a potential role in reducing allostatic load and the risk of inflammation-related disease (Bower et al., 2016; Buric et al., 2017; Diaz et al., 2021; Lindsay et al., 2024).

Telomeres

Elizabeth Blackburn's discovery of telomerase transformed our understanding of cellular aging, revealing how stress, inflammation, and oxidative imbalance can erode telomere integrity over time. Chronic psychosocial stress accelerates this process, shortening telomeres and reducing telomerase activity (Epel et al., 2004; Steptoe et al., 2017). In contrast, a growing body of research links meditation to slower cellular aging. A meta-analysis found meditators had significantly longer telomeres than controls, with greater effects observed in those with longer practice duration—suggesting that meditation may promote telomere maintenance through stress regulation, telomerase activation, and immune modulation (Schutte et al., 2020).

Adaptive Processing: System Recalibration

In early 2000s, the neural basis of emotion was linked to somatosensory regions and the insula, and shown to be modulated by top-down cortical control (Damasio et al., 2000). As understanding of neuro-affective processes advanced, interoception was conceptualized as a predictive process—relying on past experience and subject to prediction error (Farb et al., 2015; Seth & Critchley, 2013; Tops et al., 2014). Research in behavioral science, computational psychiatry, and network connectivity suggests that emotions are constructed from interoceptive signals and can be reshaped through higher-order cognitive processes (Barrett et al., 2025; Seth & Friston, 2016). By linking sensory cortices with prefrontal regions, predictive coding models can be updated in real time, allowing recalibration through higher cognition and context-appropriate responses. Comprehensive reviews show that a variety of mind-body techniques strengthen connectivity between interoceptive and top-down networks, thereby enhancing adaptive cognitive processes such as self-reflection, learning and memory, perspective taking, emotion regulation, cognitive control, motivation, and reward (Han et al., 2023; Perez-Diaz et al., 2025; Sezer et al., 2022).

Repetition Harms vs. Repetition Heals

By the early 2000s, research had shown that chronic stress disrupts prefrontal cortex (PFC) regulation of emotion and attention, shifting control from top-down executive networks to bottom-up threat circuitry. This remodeling of the cingulate cortex, insula, hippocampus, and amygdala heightens reactivity and impairs adaptive processing, while dysfunction of the dorsolateral PFC—highly sensitive to stress and disruption, increase the risk of cardiometabolic disease, neuropsychiatric disorders, cancer, immune dysregulation, and reproductive and metabolic syndromes (Allada & Bass, 2021; Meyer et al., 2022). Chronic stress alters hypothalamic–pituitary–adrenal (HPA) axis function at multiple levels, likely through epigenetic mechanisms linking perinatal stress to lifelong sleep disturbances (Christensen et inflammation—contributes to the cognitive and emotional deficits observed in depression, schizophrenia, long COVID, and Alzheimer's disease (Joyce et al., 2025). As neuroscience continues to reveal the brain's vast computational and integrative capacities, it underscores how cognitive reappraisal can transform threat perceptions into opportunities for learning and growth. Recent evidence also links long-term meditation to neural changes that integrate self-compassion and higher ego development with regions supporting advanced emotional and cognitive functioning (Singleton et al., 2021).

Empathy, Theory of Mind, and Compassion

A systematic review of 26 studies (85% randomized controlled), encompassing 1,714 participants, found that compassion and loving-kindness meditation increased empathy, compassion, and prosocial behavior (Luberto et al., 2019). A meta-analysis of eight fMRI studies involving 400 participants showed that compassion-based interventions enhance mesolimbic and fronto-striatal connectivity associated with positive affect and reward processing, along with prefrontal-parietal activation linked to attention and cognitive control (Mekelburg et al., 2025). Widespread implementation of these approaches hold promise for advancing global health and social cohesion (Singer, 2025).

Circadian and Glymphatic System

The discovery of the brain's glymphatic system revolutionized understanding of sleep's role in brain metabolism and homeostasis, providing new insight into its restorative and neuroprotective functions (Nedergaard, 2013; Xie et al., 2023). Sleep disturbances, associated with elevated allostatic load and circadian

al., 2022; Lo Martire et al., 2020). A recent review found that mindfulness-based interventions significantly improve sleep quality, while cognitive behavioral therapy for insomnia and self-hypnosis also demonstrate strong efficacy (Chamine et al., 2018; Champetier et al., 2025; Morin & Buysse, 2020; Rusch et al., 2019).

Microbiome

With advances in molecular assays in the 2000s, the Human Microbiome Project revealed the microbiome's central role in human health (Lynch & Pedersen, 2016; Peterson, et al., 2009). All diets influence gut–brain communication pathways that regulate the enteric nervous system, gut barrier integrity, and systemic homeostasis (Ross et al., 2024). Chronic stress disrupts this balance by reducing microbial diversity that supports neuroimmune stability and by increasing intestinal permeability, allowing pathogen-associated molecular patterns to enter circulation and trigger pro-inflammatory responses—adding to allostatic load (Cryan et al., 2019; Gershon, 2021). Emerging evidence shows that both the composition and timing of dietary intake affect brain–cellular energy metabolism and gut-derived anti-inflammatory signaling. Ketone metabolism, in particular, enhances mitochondrial efficiency, reduces oxidative stress, and modulates neuro inflammation. Even short-term ketosis has been shown to increase cerebral blood flow, improve executive function, and upregulate BDNF, supporting measurable cognitive and emotional benefits within three weeks (Luong et al., 2025).

All truth passes three stages.
First, it is ridiculed; second, it is violently opposed,
and third, it is accepted as self-evident
Arthur Schopenhauer

From Nonsense to Norm

In its early years, mind-body medicine was often overlooked as "complementary" or worse yet, "alternative"―a term long synonymous with quackery. Many patients came to us frustrated or ashamed after having their symptoms dismissed as "just stress." Some expressed relief upon receiving a serious diagnosis, if only to escape being labeled a hypochondriac or neurotic. In medicine, new concepts earn acceptance only after rigorous, cumulative evidence, a safeguard against harm that often slows innovation. The legitimization of mind-body medicine was further complicated by the complexity of mind-body interactions, which require investigation across multiple disciplines and often involve subjective symptoms. Thanks to decades of growing research, I have had the privilege of working in a mind-body medical department that is fully integrated within the largest Harvard-affiliated hospital network. Interdisciplinary research and patient referrals are now routine, and other disciplines recognize the importance of meditation and lifestyles behaviors grounded in mind-body science. Cost-offset studies, including our own single-site analysis, demonstrate that mind-body approaches can substantially reduce healthcare utilization at relatively low cost (Stahl, et al., 2015). After decades of persistence, mind-body medicine now holds a secure and respected place in academic medicine―honoring its pioneers while continuing to advance the science of healing.

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Research

Virtual Reality for Stress Reduction: Evaluating Strategies and Challenges in Coburg

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Abstract

With the emergence of new technologies, numerous options for stress management are becoming available. One promising approach to support individuals in coping with stress is virtual reality (VR). A variety of relaxation techniques, such as guided imagery and breathing meditation, have recently been translated into virtual environments, providing easily accessible alternatives to traditional approaches. As studies suggest that VR interventions are effective in reducing stress, the consortium project *AI4Coping* aims to develop a toolbox for individually adaptive, digitally supported coping strategies. Furthermore, the project evaluates the efficacy of VR interventions across various application fields and addresses the societal, ethical, and economic dimensions that determine its use in the general population.

Keywords: virtual reality, stress reduction, digital health, technology acceptance, mental well-being.

Digital health devices, intelligent virtual assistants, and service robots – new technologies have given rise to a plethora of opportunities to enhance the quality of life and facilitate daily living. On the one hand, digitalization has been shown to engender additional mental stress in some individuals. Constant availability or sensory overload for example have been demonstrated to result in a state of perpetual stress. On the other hand, technological advancements have given rise to numerous strategies for stress management, which are tailored to suit individual needs and preferences. In addition to wearable technology or relaxation apps, virtual reality (VR) emerges as a promising approach for mental health promotion and stress reduction.

Virtual Reality (VR) as a Tool for Stress Reduction

Defining and understanding VR is as complex as the technology itself. Abbas et al. (2023) synthesized prevailing definitions and characterized VR as “a three-dimensional computer-generated simulated environment, which attempts to replicate real world or imaginary environments and interactions, thereby supporting work, education, recreation, and health” (Abbas et al., 2023, p. 7) The potential of VR for mental health has already been evaluated in the treatment of mental disorders, such as through virtual reality exposure therapy for anxiety disorder and posttraumatic stress disorder (Van Loenen et al., 2022; Tan et al., 2025; Deng et al., 2019). Moreover, there is evidence supporting the efficacy of VR interventions in mitigating stress levels in individuals with mental health disorders (Riches et al., 2023) and in the general population (Riches et al., 2021; Velana et al., 2022).

In the context of stress reduction, a range of approaches have been developed for adapting relaxation techniques and coping mechanisms in virtual environments. Among these approaches, guided imagery as well as breathing and meditation exercises have gained notable popularity in recent years (Ladakis et al., 2024).

AI4Coping: Creating Methods for individual Stress Management in Coburg

The consortium project "Artificial Intelligence for Sustainable Support in Stress Management" (*AI4Coping*) aims to investigate the potential of new technologies, particularly VR, to reduce stress and improve well-being. In addition to assessing effectiveness, the project also addresses the societal, ethical, and economic dimensions of such interventions, with a particular focus on acceptance. Furthermore, the project aims to provide evidence-based recommendations for the sustainable and responsible implementation of VR-driven health applications. The overarching aim of *AI4Coping* is to develop a toolbox providing individually adaptive, digitally supported coping strategies to foster and facilitate the sustainable and responsible use of emerging health technologies.

The project is divided into five work packages. Firstly, there is the technical part, which includes developing a toolbox containing multimodal XR- and VR-based health applications to help people cope with stress. The second package involves evaluating a VR-based intervention for reducing Public Speaking Anxiety. The third work package is related to virtual forest bathing for people with restricted mobility, with the aim of reducing their stress levels and increasing their sense of well-being. The fourth working package concentrates on kitchen hygiene training using VR-based instruction to increase competence and reduce the fear of contamination. The fifth work package focuses on social and ethical aspects as well as acceptance levels in the society regarding VR-based health applications. Fig. 1 provides an overview of the work packages of *AI4Coping*.

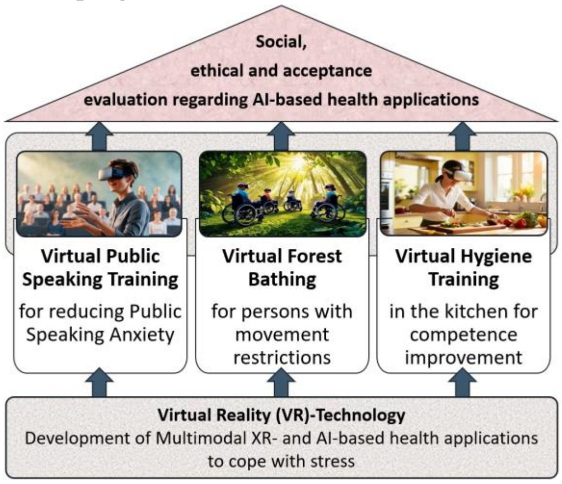

Fig. 1. The project *AI4Coping*. This figure provides an overview of the work packages included in the *AI4Coping* project at the Coburg University of Applied Sciences and Arts, which investigates the use of virtual reality for stress reduction.

Initial findings have already been obtained. To identify potential predictors of the stress-reducing effects of VR interventions, a systematic review and meta-analysis of 41 Randomized Controlled Trials (RCT) has been conducted (Strauch et al., submitted). The most commonly used VR intervention in the RCTs was nature exposure. The meta-analysis, which included 29 RCTs, demonstrated the significant benefits of VR interventions on stress levels, positive affect, and symptoms of anxiety and depression (all *p-values* $<.001$). No significant intervention effects were found for physiological stress parameters. In addition, the meta-analysis identified a higher age of the target population, a repeated application of VR sessions, and a higher immersion level in VR as key predictors of the intervention effectiveness in reducing stress.

The first intervention study of AI4Coping has also been finalized. The main objective of this randomized controlled trial (RCT) was to examine whether olfactory stimulation enhances the stress-reducing effects of virtual forest bathing (Schuil et al., submitted). Results showed that questionnaire-based psychological stress parameters improved significantly through the VR forest bathing intervention compared to the active control condition (2D forest bathing) and the passive control (grey screen). However, olfactory stimulation did not demonstrate an additional stress-reducing effect.

The Potential of VR interventions

The presented results align with recent research highlighting the great potential of VR interventions in reducing stress (Ladakis et al., 2024; Lee et al., 2022; Xu et al., 2024). As shown in our systematic review and meta-analysis, nature-based VR experiences are frequently used and have proven effective in stress reduction. Moreover, the almost limitless possibilities for creating immersive virtual environments, combined with their accessibility regardless of location, make VR a particularly powerful and scalable component of future digital health strategies. By offering immersive and controllable environments, VR allows users to disengage from real-world stressors, immerse themselves in diverse virtual settings, and engage in guided relaxation, mindfulness, or exposure-based exercises. Especially for hospital patients and older adults, VR may represent a valuable therapeutic tool. In a subsequent study within the *AI4Coping* project, the effectiveness of a VR forest-bathing intervention enriched with mindfulness exercises will be evaluated among neurological patients in early-stage rehabilitation in an acute-care hospital setting. In the long term, if the mindfulness-based VR intervention proves effective in reducing stress and improving well-being, it could be implemented across various target groups, including patients undergoing surgery or chemotherapy, older adults, and people without access to real natural environments.

Within the *AI4Coping* project, VR will also be used for presentation training to potentially reduce public speaking anxiety. The objective of this study is to examine the efficacy of an immersive, VR-based visualization intervention in reducing public speaking anxiety and enhancing performance, while also exploring the role of VR-induced presence in its effectiveness. The intervention, which involves a VR visualization of a successful speech in front of a virtual audience combined with positive affirmations, represents a novel approach in this field and holds considerable potential for applications in clinical and non-clinical settings.

A distinct part of the project focuses on kitchen hygiene training using a VR intervention. The aim of this study is to evaluate whether VR-based hygiene training is more effective in improving hygiene competence than conventional training and to identify potential influencing factors.

The Challenge of Providing, Acceptance, and Intention of Use

The application areas of VR interventions to reduce mental stress and promote well-being are wide-ranging. In order to fully exploit the potential of VR for individual stress reduction, it is crucial to make this technology accessible and to promote its use. Beyond effectiveness, the application and use of VR interventions for stress reduction are driven by acceptance and willingness to use among providers and end users. While studies suggest the acceptance of VR in therapeutic contexts (Waldmann & Seidel, 2019), the factors determining its use for stress reduction in private settings remain largely unexplored (Janzik, 2022). According to theoretical technology acceptance models such as TAM (Davis, 1987) and UTAUT (Venkateh & Davis, 2022), factors such as perceived usefulness, ease of use, and general attitudes toward using VR may determine the level of acceptance and, consequently, its use for stress reduction. On the one hand, a lack of personal, financial, or time resources to acquire VR technology, insufficient experience and knowledge, or doubts about its effectiveness constitute barriers at the provider level. On the other hand, there are certain barriers on the part of end users, such as limiting health conditions, individual needs, or personal values and attitudes (Kouijzer et al., 2023). Moreover, ethical issues, such as the risk of manipulation, questions of equity, and other related concerns, are crucial for the application of new technologies, especially in the field of health care and promotion (Halbig et al., 2022).

Therefore, the acceptance, intention to use, and potential barriers for the application of VR in stress reduction are also being examined within the context of the *AI4Coping* project. In a first step, the levels of acceptance, intention to use, and their determinants are investigated in the German population through a representative online survey. In a second step, qualitative interviews and focus groups will be conducted to explore ways to alleviate concerns and facilitate the implementation of VR technologies for individual stress reduction.

Conclusion and Outlook

As new technologies are increasingly integrated into health care and health promotion, their potential for improving individual well-being is substantial. The benefit, especially for reducing perceived stress, could be enhanced by providing targeted solutions that consider individual needs and conditions, while also addressing current concerns and barriers to use. However, further research is warranted. The project *AI4Coping* in Coburg seeks to contribute to this effort by advancing innovative approaches to strengthen overall mental health.

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Research

Medicine at the Crossroads of Artificial Intelligence and Human Judgment

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Abstract

The infusion of artificial intelligence (AI), supercomputing, and quantum computing into the field of medicine has accelerated the speed of diagnostic accuracy and therapeutic development. Companies like IBM, Apple, and Google are putting biosensing and analytic technologies into mass-market devices such that health data is democratized and delivered through channels bypassing the old medical gatekeeping. This development creates both opportunity and disruption: biosensor-pushed self-surveillance promotes earlier detection and individually adapted intervention, but can also undermine the old physician's authority and violate privacy with the harvesting of corporatized data. Telemedicine and the power of AI merge within the hybrid ecosystems of the new clinics, such that the role of the physician must be transformed from sole diagnostician to the unifying interpreter of algorithmic findings. Pre-serving trust and professional integrity within this changing landscape will depend on transparent data stewardship, mutual decision-making, and regulation that ensures the human judgment remains the axis of medical attention.

Keywords: Telemedicine, Artificial Intelligence, Augmented Intelligence, super- & Quantum Computing, Biosensors, health care, commercial medicine

The Evolving Role of Computing and AI in Medicine

Supercomputing and quantum computing advances have converted medicine from many reactive fields to predictive and precision medicines (Stefano, 2024; Stefano & Kream, 2017). Technologies like IBM Watson Health exemplify how deep-learning models can assimilate genomic, clinical data with behavioral data to improve diagnosis and treatment suggestions beyond human cognitive potential (Obermeyer & Emanuel, 2016; Rajkomar et al., 2019). Quantum computing extends this potential by simulation of the probabilistic biology of protein folding and neuronal impulses at an unattainable classical computational scale (Biamonte et al., 2017; Stefano, 2024). These developments exemplify what Stefano and Kream (2015, 2023) refer to as the transition to the era of "One Medicine," in which human and technological fields of knowledge are harmonized under the unifying framework of bioinformatics into the continuum of therapy.

Biosensors and the Consumerization of Medical Insight

The mass commercialization of biosensors—miniaturized devices that can monitor physiological parameters in real time—has placed in the hands of the consumer clinical-grade diagnostics (Stefano & Fernandez, 2017). The Apple Watch and Fitbit now track heart-rhythm irregularities, oxygen saturation levels, and even biomarkers for stress with the aid of AI algorithms (Heikenfeld et al., 2018; Topol, 2015). Although this democratization of data places the power in the hands of the people to be in charge of their own bodily commodity, it also bypasses the physician's role of interpretation and creates a new interface in which the industry comes between the patient and the professional (healthcare professional), with such developments signifying the new paradigm in which the health data moves directly from the person to the cloud and not directly from the patient to the doctor (Price & Cohen, 2019; Schwab, 2022).

Telemedicine and the Transformation of Clinical Practice

Telemedicine, spurred on by 5G networks and the integration of AI, illustrates how technologies can re inserts the physician back into the informational loop (Stefano, 2017; Stefano & Kream, 2018). Remote robotic procedures and micro-hospital infrastructure illustrate how digital connectivity can expand the reach of rather than supplant medical expertise (Mehta et al., 2021). Here, biosensor data streams could allow doctors to offer real-time interpretation and intervention, translating raw data into clinical action. This ideal nonetheless hinges on clinicians holding interpretive authority over the insights provided by AI—a dynamic that necessitates new skills in digital literacy, data science, and moral discernment (Topol, 2019; Coiera, 2019).

The Expanding Commerce and the Problem of Professional Degradation

Fears that commercialized AI systems will infiltrate the medical domain are justified. Technology corporations, motivated by the prospect of gain and the acquisition of data assets, may favor algorithmic fine-tuning rather than comprehensive care (Froomkin et al., 2019; Parikh et al., 2019). This process has the potential to sideline clinical judgment and reframe health as a product commodity. The threat is neither the potential of AI but the unmediated commercial brokerdom that exchange professional competence for technological assurance. Stefano (2023) cautions that the entry of AI in the area of diagnostic and neurodegenerative research must be grounded within humancentric oversight and the ethics of medicine. Should clinicians become passive off-takers of machine output, the epistemological basis of the human science of caring known as medicine could be compromised (Cascella et al., 2023; Marcus & Davis, 2020).

Towards Human–Machine Symbiosis in Medicine

The best trajectory is in augmentation of intelligence rather than automation. Following the suggestion of Stefano and Kream (2017), we can consider the potential role of AI to act as an extension of human seeing, similar to molecular mimicry in biology—where functional similarity facilitates complementary rather than replaceable interaction. By the same token in medical care, biosensors and AI must enlarge the cognitive reach of doctors without taking away their interpretive power. Quantum computing's probabilistic simulation and biosensors' real-time sensing create the new epistemic substrate upon which clinical reasoning can be updated dynamically and in the personalized mode (Stefano, 2024; Biamonte et al., 2017). That this development remains ethically framed will be ensured by multidisciplinary regulation involving the combination of computer science, medicine, and philosophy of mind (Floridi & Cowls, 2019; Topol, 2023).

Conclusion and Future Outlook

The introduction of commercialized AI platforms and biosensors into health care is a double-bladed evolution. Whilst it promises new levels of personalization and availability, it also threatens to commodify health and dilute professional judgment. The physician of the future must in turn become a hybrid cognitive agent—part clinician, part data scientist—that includes the ability to integrate algorithmic and experiential knowledge (Topol, 2023; Esteva et al., 2019). Whilst Stefano (2024) and colleagues insist that the intersection of AI, quantum computing, and telemedicine must result in the enlightenment rather than diminution of medicine, it must become an ever more integrated, anticipatory, and patient-centered science.

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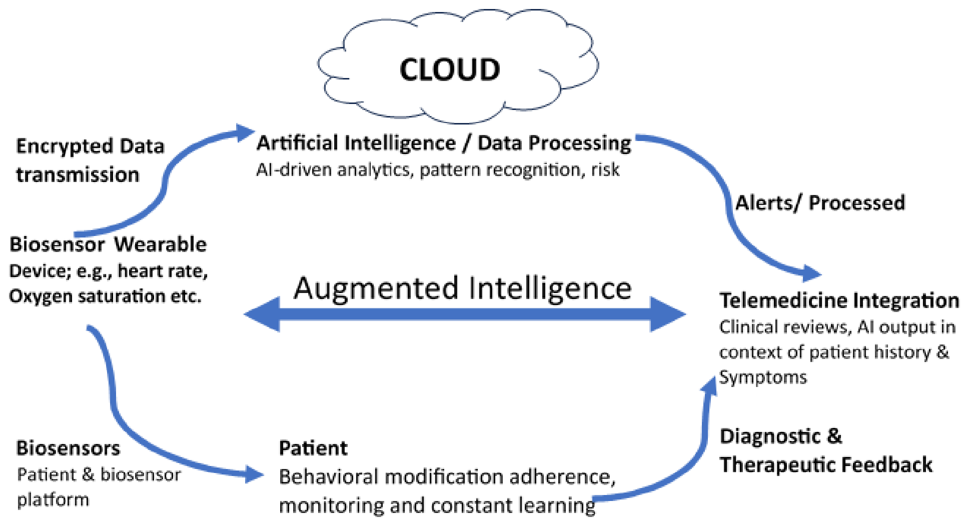

Fig. 1. Conceptual model illustrating the hybrid flow of medical information and decision-making in an augmented intelligence ecosystem. Data originating from biosensors and wearable devices are continuously transmitted to cloud-based artificial intelligence (AI) platforms that perform real-time analysis, pattern recognition, and predictive modeling. These AI-derived outputs are then integrated into telemedicine systems, where physicians interpret results in the context of individual patient histories and physiological trends. Clinical insights and treatment recommendations are communicated back to the patient, completing a continuous feedback loop that enables personalized, dynamic health monitoring. The cyclical architecture underscores the principle of *augmented intelligence*, in which human expertise, AI computation, and patient participation operate as co-regulatory components of a unified medical ecosystem

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Research

Mind-Body Approaches to Physician Well-Being: A Talk by Dr. Michelle Dossett

by Dr. Michelle Dossett[1]

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On a recent occasion, colleagues gathered at Witten/Herdecke University as part of an MBMRC guest lecture to hear from Dr. Michelle Dossett, Associate Professor of Internal Medicine at the University of California, Davis and Associate Director of Physician Wellbeing. Tobias Esch introduced her warmly, noting her extensive background in medicine, immunology, mind-body practices, and physician wellness; they had been working together in the past as colleagues at Harvard. Dr. Dossett trained at Harvard and Beth Israel Deaconess Medical Center in Boston, has an MPH from Harvard School of Public Health, and is also a certified yoga teacher. Her career bridges basic science, clinical medicine, complementary practices, and organizational well-being. The audience welcomed her to share her work, particularly in the area of stress management and resiliency for healthcare providers.

The Scope of the Problem

Dr. Dossett began by grounding the discussion in scientific data on physician wellbeing. Burnout among physicians has been tracked for more than a decade in the United States, with rates rising significantly, especially during the COVID-19 pandemic. Surveys conducted by Dr. Tait Shanafelt and colleagues show that physician burnout peaked around 18 months into the pandemic before returning somewhat toward pre-pandemic levels. Yet, burnout remains far higher among physicians than in the general working population. Similarly, satisfaction with work-life integration is significantly lower for physicians compared to other professions.

In Europe, the picture looks remarkably similar. A systematic review of 56 studies across 41 countries found an average burnout prevalence of 43%, very close to U.S. data. These figures underscore that burnout is not confined to one country or health system, but rather represents a widespread challenge in modern medicine.

Recognizing this, the U.S. National Academy of Sciences, Engineering, and Medicine convened a working group in 2017 to conceptualize clinician well-being. Their model highlighted the complex interplay of individual factors (personal traits and skills), organizational factors (workplace structures and support), and systemic factors (societal and regulatory conditions). Burnout is not simply a matter of individual weakness but reflects multi-layered pressures that demand multi-layered responses.

Mind-Body Approaches: Why They Matter

Despite the complexity, Dr. Dossett argued that mind-body practices are a vital piece of the solution. Stress, she explained, has profound neurobiological consequences. When stress activates the amygdala, it suppresses the prefrontal cortex, impairing memory, decision-making, empathy, and self-regulation. Clinicians under stress are more likely to make errors, struggle with complex tasks, and experience cynicism and disengagement.

Mind-body practices such as meditation and yoga help restore prefrontal regulation, enhancing clarity, compassion, and self-control. Beyond the brain, stress also affects cellular biology. High stress accelerates telomere shortening—a marker of cellular aging. Studies show that medical trainees, especially interns working long hours, experience telomere loss six times greater than expected for their age. Encouragingly, meditation has been linked to increased telomerase activity, suggesting a potential buffer against stress-induced biological wear.

Evidence for these benefits is steadily accumulating. Meta-analyses of mindfulness-based interventions in physicians show moderate reductions in stress and small-to-moderate reductions in burnout. While many studies are small and short-term, the consistency of results points to real promise. Moreover, mind-body practices appear to enhance empathy, prosocial behavior, and even reduce implicit bias—factors with direct relevance to patient care and health equity.

Healing the Culture of Medicine

Dr. Dossett then turned to the cultural dimensions of medical practice. She highlighted the concept of "moral distress," long discussed in nursing but increasingly recognized across medicine. Moral distress arises when clinicians feel unable to deliver the care they know patients need, leading to anger, guilt, and frustration. Cynthia Rushton and others have advanced the idea of "moral resilience" as an antidote—defined as the ability to sustain integrity in the face of moral complexity. Key characteristics of moral resilience—self-regulation, self-awareness, discernment—are precisely the skills cultivated through mind-body practice.

She also noted that medicine's noble ideals—service, compassion, excellence—can become distorted under extreme demands. A relentless focus on self-sacrifice can lead to burnout, compassion fatigue, or entitlement. Practices like gratitude, mindful self-compassion, and cognitive reframing can help restore balance, allowing physicians to serve others without depleting themselves.

The SMART Program

Central to Dr. Dossett's work has been the development and adaptation of the **SMART program—Stress Management and Resiliency Training**. Originally designed for patients, the program includes eight sessions teaching a wide range of tools: meditation (mindfulness, mantra, imagery, loving-kindness), yoga, breathing techniques, gratitude practices, cognitive-behavioral skills for reframing thoughts, sleep hygiene, physical activity, nutrition, humor, and social support. The breadth of approaches allows participants to find practices that resonate with them.

Beginning over a decade ago at Massachusetts General Hospital, Dr. Dossett and colleagues adapted SMART for clinicians. Sessions were shortened and spread out to accommodate busy schedules. Three pilot groups demonstrated promising outcomes: reductions in perceived stress, improvements in mental and physical health, and increased job satisfaction. Qualitative feedback highlighted the value of community, safe space, and ripple effects on patient care and personal relationships. Some physicians even reported profound changes in their lives, such as resolving marital challenges, discontinuing unnecessary medication, or approaching medical errors with greater composure and compassion.

During the pandemic, the program was further adapted for online delivery. At Mass General, 17 online groups reached more than 100 frontline clinicians in a matter of months. Despite condensed sessions, participants reported meaningful reductions in stress, distress, and loneliness, along with increased mindfulness and self-compassion.

At UC Davis, Dr. Dossett implemented a weekly online format open to multiple specialties. This version showed significant improvements in well-being, stress, resilience, and self-compassion, with many benefits persisting at six months. Importantly, two-thirds of participants continued practicing meditation or mini-relaxations months after the program, demonstrating durable uptake of skills.

Challenges and Realities

Despite these successes, challenges remain. High dropout rates are common, largely because physicians are not given protected time to participate. Those most in need often lack the bandwidth to attend. Additionally, some clinicians resist such programs, viewing them as attempts to "fix doctors" rather than fix broken systems. Dr. Dossett acknowledged these concerns but emphasized that mind-body practices are not substitutes for systemic reform. Instead, they are akin to survival gear for a climber facing harsh mountain conditions. While the weather (the system) cannot be changed instantly, having proper tools can mean the difference between despair and resilience.

Conclusion

Dr. Dossett closed by summarizing key takeaways:

- **Mind-body tools** reduce stress, support resilience, and enhance well-being in clinicians.
- **Effect sizes vary**, but evidence shows real benefits, including improved empathy, patient care, and reduced bias.
- These practices are **not about fixing people**, but equipping them with tools to sustain their inherent resilience while broader cultural and systemic changes evolve
- The **SMART program** offers a comprehensive, evidence-based framework that has demonstrated durable impact in multiple settings.
- Challenges include high dropout rates and limited institutional support, highlighting the need for both individual and systemic solutions.

Ultimately, she argued, physician wellness requires a dual approach: systemic reforms to reduce unnecessary burdens, and personal tools to enhance adaptability and resilience. Mind-body practices are not a cure-all, but they are a valuable, evidence-based component of a broader strategy to heal clinicians and the culture of medicine itself.

With that, Dr. Dossett invited questions and discussion, leaving her audience with both scientific evidence and a vision of hope: that healing is possible not only for patients, but for those who care for them.

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Report

Precision breathing: AI-personalised MBM microinterventions for sleep and stress in adolescence

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Abstract

With the onset of puberty, the internal clock shifts backwards, creating a structural mismatch with early school hours. This conflict results in reduced sleep duration, daytime fatigue and a decline in mood and performance. Structural reforms such as later start times alleviate the burden, but leave the evening self-control bottleneck intact. This is precisely where low-threshold, immediately effective help is needed. Precision breathing offers such micro-interventions: ultra-short, inconspicuous breathing sequences that young people can use independently during transitions. Because slow, exhalation-focused and resonance-oriented breathing promotes vagal regulation, it reduces arousal and facilitates the transition to sleep readiness. To ensure that the effect is not left to chance, these micro-interventions are designed as Just-in-Time Adaptive Interventions (JITAI): AI personalises the timing, dose and technique to the condition, context and progression. This requires data minimisation, transparency, opt-out options and fairness audits to ensure autonomy and justice. In this way, precision breathing combines structural and subjective logic. The next step is methodologically robust micro-randomised studies with valid measurement and school-based implementation.

Keywords: Adolescence; Precision Breathing; Micro-interventions; Sleep Regulation; Stress Regulation; Just-in-Time Adaptive Interventions (JITAI)

Why Breathing Micro-Interventions in Adolescence?

The circadian rhythm systematically shifts backwards during puberty, leading to a structural discrepancy between biological sleep tendencies and early school hours. This has well documented consequences: less sleep, more tiredness during the day, and a drop in mood and performance (Yip et al., 2022; Minges & Redeker, 2016). Delayed school start times have demonstrated benefits in alleviating these conditions by extending sleep duration and improving well-being (Barlaan et al., 2022; Yip et al., 2022) – however, they are not implemented across the board, nor do they eliminate the second bottleneck of daily life that occurs in the evening: High screen exposure, homework and social-emotional activation increase arousal making it difficult to ‘switch off’ (Crowley et al., 2018). This is consistently associated with poorer sleep in cohort and review studies (Brosnan et al., 2024; Drumheller & Fan, 2022).

Here is where micro-interventions for breathing fill the gap: ultra-short, low-impact exercises lasting three to five minutes that young people can implement independently during transitional phases (after learning phases, before exams, in their evening routine). Young people need easy-to-use and effective self-regulation tools and precision breathing is exactly that. Slow, steady breathing at a rate of approximately 4.5–7 breaths per minute increases respiratory sinus arrhythmia, strengthens baroreflex dynamics and promotes vagal activity (Bentley et al., 2022). These effects have been consistently associated with calmed physical arousal, improved emotional control, and benign cardiovascular modulation (Laborde et al., 2022; Russo et al., 2017).

Exhalation-oriented approaches such as cyclical sighing show significant improvements in affect and reductions in tension after just 5 minutes daily in a randomised study (Balban et al., 2023). Kramer et al. (2023) showed that effectiveness is context-dependent, as breathing exercises are most effective when they are offered just-in-time on moments of anxiety or high stress (Nahum-Shani et al., 2018). At the same time, the individual frequency at which people resonate with such interventions is not rigid but variable, so that maximum benefit is achieved with a personalised target frequency rather than a 'one-size-fits-all' approach (Yoo et al., 2022; Lehrer & Gevirtz, 2014). For use before bedtime, polysomnographic pilot data support the use of slow breathing to reduce alertness and promote sleep-inducing states (Kuula et al., 2020). In addition, school-based cluster pilot studies demonstrate feasibility, acceptance, and stress reduction in real-world settings (Bentley et al., 2022). Furthermore, micro-randomised, digitally supported sleep Just-in-Time Adaptive Interventions (JITAIs) show improvements in sleep stability and daytime well-being under field conditions, indicating the feasibility of context-sensitive, micro-dosed sleep interventions (Takeuchi et al., 2024).

Microinterventions as shown in Table 1 for breathing thus combine structural and subjective logic, as they complement the (as-yet unevenly implemented) structural reform of later school start times by offering young people a concrete, immediately effective coping strategy for self-regulation, especially in the evening and during stressful times of the day. In short, educational policy-based prevention can create more opportunities for adequate sleep, while micro-interventions help to make the most of these opportunities.

From breathing exercises to MBM micro-interventions

When there is an acute need for relaxation, sequences focused on exhalation are recommended. In a randomised study, just 5 minutes daily showed a noticeable improvement in mood and reduction in tension (Balban et al., 2023). For periods of rest, such as during longer school breaks, steady, slow breathing stabilises the parasympathetic nervous system. And in the evening routine, 5–10-minute presleep protocols act as a ritualised 'gateway' to sleep readiness (Kuula et al., 2020). A three-part administration format is therefore required: (1) rapid effect during peaks of stress, (2) longer-lasting regulation during the day, and (3) to accompany sleep in the evening.

This logic does not end in standardised administration. Young people differ significantly in terms of physiology, temperament, chronotype, fitness level and contexts, and the individual resonance frequency of their breathing also varies. Precision breathing is therefore not a one-size-fits-all solution, but requires a short, learning calibration: Initial breathing pacing (3–5 minutes) with heart rate variability (HRV) feedback determines a personalised target frequency, which can be fine-tuned as the situation requires (e.g. slightly slower in the evening, minimally higher before exams) in order to make optimal use of Respiratory Sinus Arrhythmia (RSA) resonance (Lehrer & Gevirtz, 2014).

Methodological care is required: many wearables estimate HRV photoplethysmographically as pulse rate variability (PRV). PRV is sufficiently meaningful during rest and sleep phases, but not identical to Electrocardiography (ECG) HRV.

Decision rules should therefore provide for quality filters, artifact checks and rest reference windows to avoid false triggers and ensure reliability (Kantrowitz et al., 2025).

Table 1. Breathing micro-interventions

Protocol	Duration	Target state	Ideal Context	Contraindications/ Notes	Evidence note
Exhalation emphasis (e.g. 3-6)	2-5 min	Rapid de-arousal	Pre-exam, post conflict	Avoid if dizzy/panic, seated posture	5-min/day → mood↑, tension↓ (Balban et al. 2023)
Resonance breathing (~6/min)	3-5 min	Calm, focus, vagal upshift	Between classes, afternoon reset	Gentle nasal/diaphragmatic pattern	HRV↑; parasympathetic tone↑ (Laborde et al., 2022)
Pre-sleep slow breathing	5-10 min	Sleep readiness	Bedtime routine	Dim light; stop if uncomfortable	PSG pilot: N3 delta ↑ (Kuula et al. 2023)
Physiological sighs (cycles)	1-2 min	Acute arousal dip	High arousal moments	Brief set; no holds if intolerant	Rapid down-regulation (Balban 2023)
Box breathing (4-4-4-4)	1-3 min	Composure & focus	Pre-performance	If holds activating → remove holds	Traditionally used; adaptable pacing

AI personalisation as JITAI: decision architecture

In order to join structural and subjective logic, young people should acquire self-management skills in the micro-rhythm of everyday life. A Just-in-Time Adaptive Intervention (JITAI) with AI personalisation is an approach that bridges this gap. Its basic principle is simple but difficult to implement: not ‘more intervention’, but the right intervention at the right time is needed. First, the framework defines proximal target variables such as reducing anxiety or somatic tension within a ten-minute time window and alleviating physical and psychological stress reactions before falling asleep. This is followed by decision points as shown in Table 2 based on the daily rhythm of young people (school breaks, before exams, after homework, at the threshold of sleep). Tailored variables record situational stress experiences and contextual conditions such as subjective stress and rumination, time of day and day of the week, sleep history, the last intervention, and simple physiological short markers such as PRV-Root Mean Square of Successive Differences (RMSSD) from wearables. Based on this assessment, the system chooses between different intervention options (exhalation-focused relaxation, resonance breathing or consciously no intervention) according to clear decision rules that avoid overstimulation and respect autonomy (Nahum-Shani et al., 2018; Klasnja et al., 2015).

Table 2. Operational JITAI parameters for precision breathing

Parameter	Specification
Eligibility	Need: VAS-stress ≥ 6/10 or pre-sleep rumination; Receptivity: not in class/driving; quiet window; device unlocked
Tailoring variables	Time/day; time since last prompt; sleep history; subjective stress; PRV-RMSSD baseline (night)
Intervention arms	Exhale-emphasis 3′ | Resonance 5′ | Box 2′ | No-intervention
Soft constraints	≤ 3 prompts/day; quiet hours (22:00–07:00); 1-tap opt-out/snooze
Exploration/Exploitation	ε-greedy: ε=0.2 (week 1–2) → 0.1; keep ‘no-intervention’ arm for counterfactuals
Proximal outcomes	Δ stress (10′), Δ HR/BR (5′), prompt accepted?
Non-responder rule	Three consecutive null-effects → switch arm or adjust dose
Analysis (MRT)	Weighted centered least squares; time-varying moderation (evening window, exam days)

The learning logic should be adaptive. This is ensured by contextual bandit algorithms that strike a balance between exploration and exploitation. While initially testing cautiously which micro-intervention is effective in which context, the system prefers the option that is expected to provide the greatest immediate benefit for that person under these conditions as evidence increases. Micro-randomised designs provide the causal short-term effect for this, so that the strategy is based on empirical excursion effects rather than intuition. This creates a learning logic in care that does not smooth out heterogeneity but uses it productively (Tewari & Murphy, 2017; Liao et al., 2020; Greenewald et al., 2017). The practical design consists of a lean mix of sensors from passive contexts (time of day, simple calendar events), PRV references recorded at night as a stable baseline, economic digital usage indicators, and ultra-short self-reports (one question about stress or sleepiness).

From the receptivity (availability without distraction) and the necessity (increased stress level, rumination before bedtime), the AI derives tailored suggestions, such as three minutes of exhalation-focused breathing before an exam or five minutes of resonance breathing in the evening routine, embedded in soft constraints (maximum number of prompts per day, fixed rest periods, option to opt out at any time) (Klasnja et al., 2015; Nahum-Shani et al., 2018; Liao et al., 2020). The target architecture remains multi-layered: (1) in the short term, stress reaction, heart rate and respiratory rate decrease; (2) in the medium term, days with short sleep latency increase; (3) in the long term, sleep duration and daytime functioning stabilise, while (4) school stress and anxiety decrease. Engagement is measured objectively (traces of use, mini-Ecological momentary assessments (EMA)) to improve enabling conditions (Leong et al., 2023). In this way, the JITAI decision-making architecture as shown in Figure 1 combines educational connectivity with technical precision and strengthens young people's self-control without overforming their living environment.

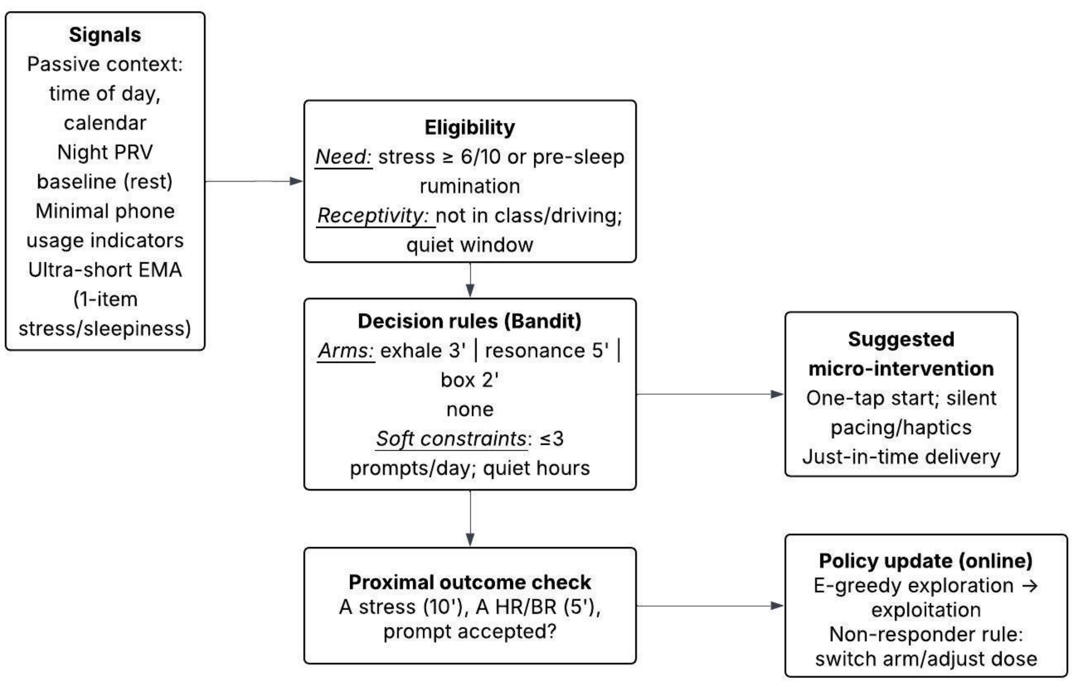

Figure 1. Just-in-time decision architecture for precise breathing in adolescence. The diagram links structural rhythms (school day, evening routines) with subjective self-regulation: Passive and minimal signals (time of day, calendar, nocturnal PRV baseline, ultra-short EMA) determine eligibility as a joint function of *need* (increased stress or rumination before bedtime) and *receptivity* (no competing demands). Decision rules operationalise a contextual bandit policy with a 'non-intervention' arm and soft constraints (≤3 prompts/day; rest periods) and select a microintervention (exhale 3′, resonance 5′, box 2′) that is discreet and executable with a tap of the finger. A proximal outcome check (Δ stress at 10'; Δ HR/BR at 5'; immediate acceptance) feeds into the policy update (exploration→evaluation; change/adjustment for non-responders).

Security, Ethics & Fairness

Health promotion requires age-appropriate consent procedures, understandable information routes and a genuine freedom of choice. Young people need to know what data is being collected and for what purpose, and what rights they have, because only then can self-determination become a real option and not just an appeal (Agostino et al., 2023; Mathews, 2022). Technically, this leads to the principle of data minimisation and, where possible, edge processing, so that sensitive data remains on the device and only aggregated/purpose-specific information is processed. An opt-out without disadvantages is essential, as autonomy in adolescence must be structurally guaranteed for educational reasons (Agostino et al., 2023).

Digital prediction models are not neutral, as they easily reflect and reinforce existing inequalities when training data and decision chains contain demographic biases (Obermeyer et al., 2019). For youth-oriented applications, regular algorithm audits and fairness corrections are therefore imperative, e.g. through demographically informed reweighting or procedures to reduce disparate effects (Park et al., 2022; Ueda et al., 2023). The normative standard is that equal opportunities go hand in hand with effective support, regardless of gender, origin, socio-economic status or neurodiversity.

It is equally important that services for young people are developed together with young people. Co-design formats therefore highlight experiential knowledge, increase acceptance and accuracy, and reduce misjudgements based on adult-centred assumptions (Oetken et al., 2024). This includes transparency about the trigger logic (when, why and on what basis is a proposal made?) as well as maintaining the ability to act through inviting, moderate proposals that fit the rhythm of life, avoid disruption and can be rejected at any time (Nahum-Shani et al., 2018).

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Report

Body, Emotions and the Self: Complementary Mind-Body Approaches to Psychotherapy

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Abstract
The subjective experience of time is closely linked to emotional and bodily states. Psychopathological conditions such as depression and anxiety are associated with altered time perception, reflecting disruptions in interoceptive and affective processing. Recent neurophysiological findings implicate the insular cortex in integrating bodily signals that shape temporal experience. Altered states of consciousness (ASC) induced by meditation, psychedelics, and Floatation-REST reveal opposing effects to psychopathological distortions: diminished self-focus, relaxation, and temporal dissolution. Empirical studies demonstrate that Floatation-REST reduces anxiety and stress while inducing ASC characterized by body-boundary dissolution, suggesting its therapeutic potential and utility for consciousness research.

Keywords: time perception, interoception, insular cortex, altered states of consciousness, Floatation-REST

The subjective passage of time is closely linked to our state of mind and attention. When we are engaged in stimulating activities—especially in good company—we hardly notice time passing; an hour can fly by. In contrast, an hour of waiting, when we have no means of distraction, can feel painfully slow (Witowska et al., 2022). What is familiar to everyone as boredom can become unbearable in psychopathological syndromes. Qualitative and quantitative studies show that psychiatric patients experience time differently. For patients with depression, for example, the present feels unchangeable, they feel cut off from the future, and time flows uncomfortably slowly (Vogel et al., 2018). Although empirical findings from objective timing tasks are inconsistent (Thönes & Oberfeld, 2015), patients with depression sometimes overestimate the duration of intervals in the range of minutes (Bschor et al., 2004). A study involving oncology patients confirmed that a lower quality of life and higher anxiety levels were associated with a slower passage of time (Wittmann et al., 2006). Similarly, drug-dependent patients in a rehabilitation unit overestimated time intervals of several minutes (Wittmann et al., 2007). Psychopathological syndromes are now understood to involve impaired emotional regulation, with symptoms linked to altered internal temporality (Fuchs, 2013). Body, emotion, and time are mutually dependent. Importantly, altered states of consciousness (ASC), induced by meditation, Floatation-REST, or psychedelics, have an opposing effect on the overrepresentation of time and self (Fort et al., 2025). This idea will be the focus of this opinion paper in that certain psychiatric populations could benefit from mind-body induction methods to alter time consciousness.

Over the past decade, neurophysiological research has increasingly supported the view that subjective time is embodied and closely connected to neural networks in the insular cortex. The posterior insula represents the primary interoceptive cortex—the cortical region responsible for representing signals from the body (Craig, 2009). For the first time, we demonstrated that peripheral psychophysiology—especially measured by the heart rate—along with activity in the insular cortex, is involved in perceiving time intervals of several seconds' duration (Wittmann, 2013; Khoshnoud et al., 2024). Research led by Alice Teghil replicated and extended our findings, showing that sensitivity to bodily perception correlates with time estimation accuracy, and that time perception is related to resting activity in the posterior insula as measured by fMRI (Teghil et al., 2020). Thereafter, subjective time in ordinary states of consciousness is understood to be fundamentally embodied (Teghil & Wittmann, 2025). Time processing in psychiatric patients is closely tied to interoceptive function and insular cortex activation, as observed across various neuropsychiatric disorders (Vicario et al., 2020). Moreover, as will be discussed below, altered states of consciousness (ASC) act in opposition to the overrepresentation of time and self typically seen in psychiatric conditions, thereby offering therapeutic potential.

Throughout history, people have reported experiencing ASCs during meditative contemplation, while listening to music, during physical exertion, or under the influence of certain drugs—namely psychedelics (Wittmann, 2015, 2018). What ASC have in common is that the perceived passage of time initially slows down until, at the peak of the experience, it may seem to come to a complete standstill. This is accompanied by a profoundly altered sense of body and space, often culminating in ego dissolution. Because insights gained from altered experiences of time and self play a role in understanding psychiatric disorders, I will discuss methods of inducing ASCs, touching on meditation and psychedelics, but focusing especially on Floatation-REST.

Mindfulness meditation as practiced in the West today derives from the Theravada Buddhist tradition, which emphasizes nonjudgmental awareness of the present moment, thereby having the potential to leading to improvements in mental and physical well-being in the long run (Esch, 2021). Meditation practitioners often experience a slowing of subjective time, achieved through the body-centered focus of most meditation techniques (Matko et al., 2021). This increased bodily attention is associated with greater insular activity and reduced cingulate activity (within the default mode network related to the narrative self), as demonstrated by Farb and colleagues in an fMRI study of novice and moderately experienced meditators (Farb et al., 2007). For experienced meditators, however, the state of slowed perception of time changes, and it is often reported that the session felt much shorter than it actually lasted (Berkovich-Ohana & Wittmann 2017, Droit-Volet & Dambrun 2019). Novices also report that the meditation session feels shorter in retrospect (Sedlmeier et al. 2023). Since patients with depression exhibit increased self-focus accompanied by increased activity in the default mode network (Hamilton et al. 2015), meditation as a complementary therapy could interrupt the narrative circling around oneself and thus reduce symptoms. The reduction in mental rumination and a temporary increase in bodily awareness could be the decisive factors in why various meditation programs and related body-oriented techniques (yoga, tai chi, qi gong) are successful in people with mild to moderate depression and anxiety syndromes (Bringmann et al. 2021), as well as in mitigating stress-related health risks (Michaelsen & Esch, 2023): The rumination of the narrative self is reduced and a pleasant, relaxed bodily experience is accompanied by a faster subjective perception of time.

Taking psychedelics such as psilocybin, LSD, or ayahuasca induces profound and multifaceted changes in thinking, feeling, and perception (Fort et al., 2025). Individuals can undergo psychodynamic phases that alter self-concept and often carry spiritual dimensions (Nour et al., 2017; Ritchie, 2021). Subjective time becomes noticeably altered, as shown in systematic studies of time estimation and temporal control of motor performance (Wittmann et al., 2007). Different phases during drug experiences produce varying temporal experiences, including extreme time dilation. Peak experiences are often described as timelessness and ego dissolution—the self becomes one with the world, and distinctions between past, present, and future disappear (Shanon, 2001). Validated questionnaires have shown that these temporal distortions are accompanied by feelings of unity with the world and a sense of disembodiment (Studerus et al., 2010). The first successful studies have shown how psychedelics have a positive impact on patients with depression showing marked reductions in depressive symptoms for the first weeks after one-time exposure (Carhart-Harris et al., 2018; Erritzoe et al., 2024).

In Floatation-REST (Restricted Environmental Stimulation Technique), individuals float weightlessly in body-temperature salt water within a soundproof, light-free tank (Huber et al., 2025). The body is fully supported, and external sensory input is almost entirely eliminated. The boundaries of the body blur, leaving only inner bodily sensations—breathing, muscle tone, and internal processes. By focusing on bodily awareness and minimizing external stimuli, Floatation-REST creates conditions similar to deep meditative states typically reached only by experienced meditators (Pantazis & Wittmann, 2025). Along with profound relaxation, participants often underestimate session duration or lose their sense of time altogether (Kjellgren et al., 2008).

Justin Feinstein and colleagues (2018) exposed 50 patients with anxiety- and stress-related disorders—including PTSD, generalized anxiety, panic disorder, agoraphobia, and social anxiety—to a single Floatation-REST session. Most patients reported reductions in stress, muscle tension, pain, depression, and negative affect, alongside increased relaxation, happiness, and well-being. Given that these effects followed a one one-hour session, changes in consciousness were likely moderate compared to psychedelic-induced states. The effects are more comparable to those achieved through meditation, where bodily self-awareness and the sense of time gradually diminish.

In a recent study, my colleagues and I further explored the relationship between altered states of consciousness and affective changes induced by Floatation-REST (Hruby et al., 2024). Fifty participants experienced 60 minutes of Floatation-REST and, on a separate occasion, 60 minutes of Bed-REST—a control condition involving lying supine on a warm waterbed in a dark, quiet room. Both REST conditions reduced arousal, tension, anxiety, and stress, but Floatation-REST led to significantly greater relaxation and lower anxiety. Moreover, it induced stronger experiences of body-boundary dissolution and subjective time distortion. The loss of body boundaries was linked to decreased anxiety, suggesting a novel mechanism by which Floatation-REST exerts its anxiolytic effects.

Given the limitations of current treatments for depression and anxiety disorders, there is growing interest in complementary approaches. Floatation-REST may offer such an alternative, with minimal or no side effects. Floatation-REST is a safe method for inducing altered states of consciousness and provides a valuable tool for exploring the mechanisms underlying conscious experience (Schiffer et al., 2025). Extraordinary states of consciousness were long ignored or dismissed by mainstream science—but this is beginning to change. Moreover, as a scientifically validated method for inducing ASCs, Floatation-REST may become an established tool for studying the foundations of phenomenal consciousness.

To sum up, the experience of time is intimately tied to emotions and self-perception. Bodily processes shape our immediate experience of time passage in every moment. Understanding these connections helps explain why subjective time sometimes seems to pass quickly or slowly. ASCs, induced through psychological or pharmacological means, are characterized by a subjective loss of both self and time. The induction of ASCs may hold therapeutic potential for treating psychiatric conditions characterized by an overrepresentation of self and time

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Exercise Corner

Mantra Meditation

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Description

Mantra meditation is a mind-based relaxation technique whereby the mantra acts as an anchor to maintain focus during meditation. The word "mantra" has a long history in ancient systems such as yoga, Buddhism, Hinduism, and Ayurveda. It is derived from the old Sanskrit and has various meanings as "prayer" or "mystic formula" (Gonda, 1963). In its wider sense we can understand it as "song, chant, or hymn". Every syllable, word, verse, or phrase can be used as a mantra, though there are many traditional ones. The tone "om," which is a sacred sign and represents the primordial sound of the cosmos, is undoubtedly the most well-known mantra. These days, affirmations and positive phrases and statements are frequently used, such as "I am glad." It is repeated in the same beat, revealing the spiritual power and effectiveness. You can chant it, whisper it, or only say it to yourself (Carrington, 2007).

Mantra meditation can help to deepen relaxation and have beneficial effects on stress, anxiety, hypertension and immunity (Tseng, 2022). It is also helpful for depression therapy (Bringmann et al., 2021), may improve attention, awareness and stress coping (Lynch et al., 2018).

Exercise

You can do mantra meditation almost anywhere. While it is advised to look for a peaceful area and attempt to minimize distractions during this period, it is not required to be sitting in an upright position. To relax and establish a connection with yourself, start by concentrating on your breathing. Next, consider a word, phrase, or syllable that makes you feel good or evokes pleasant feelings. Attempt to establish your rhythm by repeating it multiple times. The mantra can be linked to your breathing. This facilitates understanding the flow.

As with all mindfulness meditations, you simply observe the present moment without passing judgment or setting any particular goals. The practice of meditation is neither "good" nor "bad." You just watch what happens, and when you catch yourself thinking about something else, gently remind yourself to return to your mantra. To finish your meditation, return your focus to your breathing and take one or two deep breaths.

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Announcements

MBMRC Guest Lecture with Leigh A. Frame, PhD, MHS[1] on November 19th at Witten/Herdecke University, 15:00h – 16:15h (CET)

We are excited to present the next speaker in our growing hybrid lecture series.
Happily, we welcome Leigh A. Frame from the [1]George Washington University (GW) School for Medicine and Health Science Washington, DC, USA, as a speaker for the MBMRC Guest Lectures on November 19st 2025, hosted by the Institute of Integrative Health Care and Health Promotion (IGVF).

Title: **Connecting the Gut to the Mind: The Microbiome-Gut-Brain Axis**
Time: 15:00h – 16:15h (CET)
Join online: Zoom-Link
Join on-site: Room 2.273 (Purkinje), Witten/Herdecke University, Alfred-Herrhausen-Straße 50, D-58448 Witten

The lecture will be followed by an open Q&A.
The participation will be free of charge.
For further information, please click here.

Additional dates of the guest lectures are
25th February 2026
20th May 2026
26th August 2026
04th November 2026

This new series aims to create a platform for exchange beyond institutional boundaries – and you're warmly welcomed to be part of it from the start! We invite all interested participants – students, researchers, and members of the public – to join us for this event. We look forward to welcoming you!

Save the date!

We look forward to the
2nd International Scientific Conference on Innovation in Mind-Body Medicine (ISC-MBM)
(hybrid) on 19th and 20th November 2026

Delve for the second time with international experts from diverse fields into the molecular mechanisms, neurobiological correlates, artificial intelligence in mind-body medicine, and integrative approaches to holistic health.

We are inviting abstracts on the following topics:

Topic 1: Mind-body medicine interventions
Topic 2: Modes of action of mind-body medicine, e.g., mitochondria and microbiome
Topic 3: Artificial Intelligence in Mind-body medicine research

Click here to see updates on the upcoming conference and information about the first one.

The Mind-Body Medicine Research Council (MBMRC)

At the present time, the council consists of the following members:
Tobias Esch, M.D. (Co-Chair) – Witten/Herdecke University
George B. Stefano, Ph.D. (Co-Chair) – Charles University, Prague/ Witten/Herdecke University
Maren M. Michaelsen, Dr. rer. oec. Dr. rer. medic. (Project Lead) – Witten/Herdecke University
Christoph Stueckle, M.D. – Niles-Stensen-Kliniken Osnabrueck
Pascal Büttiker, M.Sc. – Charles University, Prague

How to become a member of MBMRC

As the MBMRC has been founded in 2022, and due to its dedication to rigorous contributions on the basic research foundations of Mind-Body Medicine, the number of members is yet small. In the future, the council aims to invite outstanding researchers in the field to become MBMRC members. Membership implies no fee.

Acknowledgement

We thank Helena Müller-Peters, a student assistant at the Institute for Integrative Health Care and Health Promotion (IGVF), for the technical elaboration of this journal.

Recent Publications of MBMRC Members

Esch, T. & Stefano, G.B. (2025). The neurobiology of love and addiction: Central nervous system signaling and energy metabolism. *Cogn Affect Behav Neurosci* 25, 1225–1236. https://doi.org/10.3758/s13415-025-01333-w

Kavrakova, I., Haage, P. & Stueckle, C.A. (2025). Current State-of-the-Art 3D MRI Sequences for Assessing Bone Morphology with Emphasis on Cranial and Spinal Imaging: A Narrative Review. *RöFo - Fortschritte auf dem Gebiet der R* . https://doi.org/10.1055/a-2673-4339.

Kettler, C., Weber, R.M., Anand, C., Husain, S., Koeder, C., Schoch, N., Michaelsen, M.M., Esch, T. & Englert, H. (2025). Effect of a community-based lifestyle intervention on predictors of behavior change regarding a healthy plant-based diet—The Healthy Lifestyle Community Program (cohort 2). *Frontiers in Public Health* 13. https://doi.org/10.3389/fpubh.2025.1560376

Michaelsen, M.M., Uhl, J., Mindrup, L., Neumann, C., Langer, L. & Esch, T. (2025). Development of a (digital) mindfulness-informed intervention for older adults in nursing homes: description and reflection of a person-based co-design approach. *BMC Geriatr* **25**, 703. https://doi.org/10.1186/s12877-025-06223-x

Schmidt, C.M., Haage, P. & Stueckle, C.A. (2025). Volumetric measurement of herniated disc material as a predictor of outcome in periradicular therapy. *European Spine Journal* 34(10):4404-4414. https://dor.irg/10.1007/s00586-025-09324-8

Stefano, G. B. (2025). Adaptability Beyond Darwin: Microbial Evolution, Mitochondria, and the Thermodynamic Frontiers of Survival. *Frontiers in Bioscience-Landmark*, *30*(10), 45962.

Stefano, G.B., Büttiker, P., Weissenberger, S., Raboch, J. & Anders, M. (2025). Semaglutide and the pathogenesis pf progressive neurogenerative disease: the central role of mitochondria. *Frontiers in Neuroendocrinology* 79, 101217. https://doi.org/10.1016/j.yfrne.2025.101217

Uhl, J., Michaelsen, M.M. & Esch, T. (2025). Psychologische Sicherheit und Resilienz für einen besseren Umgang in der ambulanten Gesundheitsersorgung. *Interdisziplinäre Versorgungsforschung* 5 (4), 10–12.

Wrede, S.J.S., Esch, T. & Michaelsen, M.M. (2025). Mindfulness in the digital worlplace: an explorative study of the compatibility of mindfulness and technology. *BMC Digital Health* 3:45. https://doi.org/10.3389/fpubh.2025.1560376