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Theoretical proposal for an interoceptive empowerment protocol for organizational interventions on mitigating work-related stress risk

Gianluca Viviani[1] - Massimo Servadio[2]

[1] Department of Educational Sciences, Psychology Unit, University of Genoa, Genoa, Italy
[2] Department of Psychology, Università Cattolica del Sacro Cuore, Milan, Italy

DOI: https://doi.org/10.7358/neur-2025-037-vivi gian.viviani@virgilio.it

Abstract

Work-related stress (WRS) and burnout represent significant challenges to individual well-being and organizational productivity. Although the neurophysiological effects of chronic stress are well documented, the effects of interventions based on interoception and the ability to perceive internal physiological states remain underexplored as a tool to attenuate WRS. This article provides a theoretical overview of the constructs and proposes a neuroscientific protocol based on interoception for organizational stress management. The protocol integrates phases of neuro-assessment with interoceptive brain training exercises, neurophysiological feedback techniques, and metacognitive discussions to enhance individual and group awareness and resilience. The goal of the protocol is to activate key brain areas, such as the prefrontal cortex and anterior insula, which are related to interoception, to improve the ability to detect and manage stressful stimuli. This work aims to lay the groundwork for innovative and adaptable interventions, bridging the gap between neuroscientific research and organizational applications.

Keywords: interoception; neuro-biofeedback; burnout; work related-stress; organizational wellbeing

1. Introduction

Work-related stress (WRS) and burnout are significant challenges in modern organizations, impacting individual and organizational performance (Salvagioni et al., 2017). While the effects of chronic stress on the body and mind are well-documented (Miller et al., 2007; Lupien et al., 2009), the connection between these effects and interoceptive abilities in stress relief strategies is not thoroughly explored. Interoceptive accuracy shows promise for improving emotional regulation and stress resilience; however, its application in organizational settings is mainly unexplored. The existing literature highlights essential gaps in utilizing neuroscientific findings for workplace interventions.

This work aims to close these gaps by establishing a theoretical framework that links the relevant constructs in organizational contexts. It proposes a structured, neuroscientifically-informed protocol to enhance interoceptive abilities and stress management, ultimately improving organizational well-being.

2. Stress, work-related stress and burnout

Stress often represents a heterogeneous construct that is challenging to categorize. Selye (1976) defines stress as a non-specific response to any demand that can affect physiology and emotions. Two types of stress can be distinguished: eustress, which is a temporary demand within a person's ability to cope, and distress, which occurs when prolonged demands exceed those abilities, leading to a sense of loss of control. This balance relates to allostasis, the process that maintains stability while adapting to change. Prolonged stress leads to allostatic load, marked by the inability to deactivate stress-response systems, which can result in psychophysiological decompensation (McEwen, 2007). The autonomic nervous system (ANS) plays a key role in mediating stress responses, triggering fight-or-flight reactions through sympathetic nervous activity, increased heart rate, pupil dilation, and redirection of blood flow to muscles. Chronic stress disrupts the ANS and hormonal systems, leading to increased glucocorticoid levels that impair brain function over time (Lupien et al., 2009; Schulz & Vögele, 2015).

Despite the extensive literature on stress, gaps remain in our understanding of how individuals transition from acute to chronic stress and the differences in their adaptive responses. Chronic stress in workplace settings lacks sufficient attention, limiting the effectiveness of targeted interventions.

WRS results from psychosocial factors like inequalities, organizational climate, leadership, and role ambiguity. These issues negatively impact individual health and overall societal productivity (Hassard et al., 2018). Chronic WRS often leads to burnout syndrome, which is characterized by feelings of inefficacy, cynicism, detachment, and exhaustion, frequently manifesting as chronic fatigue and overwhelming stress (Maslach & Leiter, 2016). Neurocortical issues include decreased modulation capacity in the dorsal anterior cingulate cortex (Bärtl et al., 2024) and reduced neurogenesis in the medial prefrontal cortex and hippocampus, particularly in the C3 region (McEwen et al., 2012). These changes contribute to difficulties in attention and working memory (Sokka et al., 2017). Additionally, excessive dendritic growth in the basolateral amygdala is linked to increased anxiety (Roozendaal et al., 2009), unlike acute stress, where the amygdala supports adaptive strategies (Berretz et al., 2021).

Although the neurobiological effects of burnout are well-documented, most existing interventions focus on treating symptoms rather than addressing the underlying neurobiological mechanisms. Interoception, a physiological ability associated with the stress response, is not widely recognized as a viable option for reducing WRS.

3. Interoception and stress

Interoception refers to the ability to perceive internal physiological states (Craig, 2009) and includes sensations like mechanical, thermal, and osmotic inputs (Jarrahi et al., 2015). Schulz and Vögele (2015) identify three primary stages of interoception: the first stage involves transmitting information from the organs; the second stage focuses on directing attention to these internal sensations; the third stage consists of processing these signals for psychological representation.

The neural pathways underlying these stages can be described from a neuropsychological viewpoint. Afferent information travels via ascending autonomic fibers through two main pathways: medullary and extramedullary (Jarrahi et al., 2015). The C fibers transmit thermo-osmotic information, while Ad fibers convey mechanical information, forming the medullary pathway that ascends along lamina I to reach the thalamic nuclei. In contrast, the extra-spinal fibers include sensory components from the vagus and glossopharyngeal nerves. They project to the nucleus of the solitary tract and then to the parabrachial nucleus before connecting to the thalamus. The second and third stages in Schulz and Vögele's model primarily highlight the activation of cortical areas. The dorsolateral prefrontal cortex mainly facilitates attention toward internal sensations (Angioletti & Balconi, 2022). The prefrontal cortex (PFC), anterior cingulate cortex (ACC), and anterior insula cortex (aIC) are key areas that help integrate the received signals into mental representations (Adolfi, 2017; Balconi & Angioletti, 2023a; Terasawa et al., 2013). These regions process internal bodily, emotional, cognitive, and social stimuli, thus improving our understanding of their interconnected functioning. Emotional processing mainly involves activations related to interoception, especially concerning the precuneus (Terasawa et al., 2013). Additionally, the PFC plays a crucial role in cooperative social interactions (Balconi & Angioletti, 2023a) and works alongside the activations of the aIC and the temporoparietal junction, which are pivotal for social cognition (Adolfi, 2017).

When studying interoception, it is essential to focus on its key dimensions: sensitivity and accuracy (Schulz & Vögele, 2015). Sensitivity is often assessed through self-reports (Cabrera et al., 2018; Garner, 1991; Mehling et al., 2012), while accuracy can be measured through cognitive tasks (Brener & Kluvitse, 1988; Schandry, 1981) or psychophysiological methods.

The ability to recognize internal stimuli can sometimes become distorted, especially during psychological distress (Herbert, 2013; Terhaar et al., 2012). Interoception plays a key role in connecting stress and psychopathology, particularly in disorders that show significant somatic symptoms (Acheson et al., 2012; Furman et al., 2013; Herbert & Pollatos, 2018). This connection is not linear but forms a circular positive feedback loop reinforcing symptoms.

Schulz and Vögele (2015) present different scenarios within their model where interoception and stress affect each other: acute stress leads to altered interoceptive sensations that resolve once the stressor is removed; chronic stress causes ongoing changes in interoception, and altered interoception arises when internal sensations are misinterpreted, resulting in physical symptoms.

Although clinical literature discusses these relationships, their implications and applications in organizational contexts are still limited, leaving concepts like burnout WRS underexplored. Existing frameworks do not aim to combine neurophysiological processes with practical applications in organizations, which hinders the development of new assessments and interventions.

4. Interoceptive and stress neuro-assessment

Measurement is crucial for understanding stress and interoception phenomena. In neuroscience, various indices help detect how individuals manage stress and the WSR load. ANS can be measured based on its flexibility to activate at the ortho-sympathetic level and return to a new equilibrium by the parasympathetic system (Weissman & Mendes, 2021).

One key measure used is heart rate variability (HRV), which can be analyzed in terms of time or frequency domains. In the time domain, commonly used indices include the standard deviation of normal-to-normal intervals (SDNN), the root mean square of successive differences (RMSSD), and the percentage of successive beats differing by more than 50 milliseconds (PNN50). In the frequency domain, high-frequency power (HF) indicates variability in the HF band (0.15-0.4 Hz), mainly influenced by parasympathetic activity (De Looff et al., 2018) or respiratory sinus arrhythmia (RSA). RSA refers to heart rate changes related to the respiratory cycle, with heart rate increasing during inspiration and decreasing during expiration, primarily regulated by vagal activity (Porges, 2022). RSA can be measured at rest (tonic) or after a stressor to evaluate bodily response modulation (phasic). Only tonic RSA strongly predicts psychophysiological well-being (Fanning et al., 2020). Higher HRV scores indicate a more adaptive system.

Another autonomic measure is electrodermal activity (EDA), which records the degree of arousal through skin conductance, increasing in stressful states due to heightened sweating. Key indices include skin conductance level (SCL), non-specific skin conductance responses (ns.SCR), which capture non-specific spikes, and the amplitude of skin conductance responses (SCR.amp; De Looff et al., 2018). Higher EDA values suggest the body is experiencing stress with ortho-sympathetic activation.

Pupillary dilation (Giannakakis et al., 2019) can also be measured using wearable devices like eye trackers, which are convenient (Graff et al., 2019; Salanova et al., 2013).

Additionally, central nervous system (CNS) measurements can be made using electroencephalogram (EEG) or functional near-infrared spectroscopy (fNIRS). EEG indicators can show psychological stress through increased brain synchronization and elevated high beta band power at the expense of alpha (Alonso et al., 2015), while fNIRS can indicate the correlation between oxygenated and deoxygenated hemoglobin in the PFC (Fukuda et al., 2014). Biomarkers such as salivary or serum cortisol and adrenal metabolites may also be helpful tools (Velana & Rinkenauer, 2021).

The ANS plays a central role in measuring interoception, with the vagal component being crucial for internal perceptions (Leganes-Fonteneau et al., 2021). Techniques like baroreflex sensitivity (Robbe et al., 1987) measure how quickly the ANS reacts to pressure changes using the arterial baroceptive reflex, while cardiac modulation of startle (Shulz et al., 2009) examines the relationship between internal signals and the heartbeat's startle response.

At the CNS level, EEG measures visceral evoked potentials (Schandry et al., 1986), reflecting encephalic electrical changes upon perceiving internal alterations, such as heartbeat-evoked potentials (HEPs) or respiration-evoked potentials (REPs).

Personal interoceptive perception accuracy is often assessed with behavioral tasks measuring consistency between conscious perception and actual internal changes (Desmedt et al., 2023) or using HRV metrics (Rominger et al., 2021).

However, the instrumentation discussed is primarily used in research and rarely in applied contexts. Introducing wearable devices could enhance the detection of indices in the workplace. One proposed ecological option includes using a specific mouse to detect movements and muscle tension (Banholzer et al., 2021; Pepa et al., 2021). Nevertheless, the ecology of instruments is vital in assessing work context parameters; most ecological devices are designed for ANS detection, while CNS instruments are lacking.

Another approach could involve multi-method measurement for greater agility, although not in real-time. For example, Contreras et al. (2018) proposed the idea of neuropattern, an integrated assessment combining self-report, psycho-neuro-physiological, and biomarker findings, to implement effective interventions in work contexts.

5. Interventions to mitigate WSR

Accurate measurement is essential in a good intervention; however, using neuroscientific assessment and intervention tools in workplaces is still limited (Contreras et al., 2018; Restrepo & Lemos, 2021). Van der Klink et al. (2001) reviewed common types of interventions in WSR and found that cognitive-behavioral interventions are the most prevalent in the literature. These interventions are also among the most effective and integrated. They often include training focused on developing soft skills and problem-solving (Catapano et al., 2023; Molek-Winiarska & Kawka, 2024). Many of these interventions combine relaxation techniques (Van der Klink et al., 2001) or mindfulness sessions (Good et al., 2016). Mindfulness interventions, structured over 8 weeks, incorporate meditation and exercises that yield excellent organizational results (Bartlett et al., 2019). Moreover, practicing mindfulness can positively impact other related areas, such as emotional regulation, which can lead to cortical and subcortical restructuring (Guendelman et al., 2017) and improved ANS modulation (Ditto et al., 2006). Crivelli et al. (2019) proposed an innovative protocol that pairs breath-focused mindfulness sessions with neurofeedback, showing promising results in managing stress and anxiety, enhancing attentional orientation, and improving autonomic regulation. Biofeedback has also shown reductions in anxiety and stress levels (Goessl et al., 2017).

This same instrumentation can help design interoceptive empowerment interventions to improve the perception of internal sensations (Meyerholz et al., 2019). Suggested interventions encompass vagus nerve stimulation and slow breathing techniques (Weng et al., 2021). Despite the broad implications that interoceptive training can have on overall psychophysical health (Pinna & Edwards, 2020) and its flexible application in remote interventions (Smith et al., 2023), such interventions remain limited within the organizational-occupational context (Angioletti, 2022).

Our theoretical work aims to address this gap by facilitating research and application in these underexplored fields by designing a potential intervention protocol.

6. Neuro-interoceptive protocol intervention proposal for WRS organizations

We aim to enhance interoceptive brain training procedures alongside established WRS reduction interventions (Van der Klink et al., 2001). Improving interoceptive skills may help individuals detect their body's initial stress signals and improve WSR management skills preventively (Schultchen et al., 2019).

In their literature review, Angioletti and Fronda (2024) highlighted the importance of neuro-empowerment training in the workplace, especially in tackling challenges such as technostress. Interoceptive brain training has the potential to activate key areas involved in interoception, and when structured effectively, intersubjective interaction can significantly enhance these processes (Balconi & Angioletti, 2022; Balconi & Angioletti, 2023a). Research indicates that focusing on internal sensations during simple motor coordination tasks engages the PFC and parieto-occipital areas significantly, while vocal coordination tasks show comparable or potentially even more significant benefits (Balconi & Angioletti, 2022; Balconi & Angioletti, 2023b). Moreover, flexible motor and vocal exercises provide practical, scalable intervention strategies tailored to various organizations' needs.

However, a lack of clearly defined, empirically validated protocols for interoceptive brain training to reduce WRS remains. This gap highlights the necessity of the proposed protocol, which seeks to connect theoretical knowledge with practical application through an innovative and structured approach.

Our protocol spans approximately one and a half months and is divided into two assessment phases and three modalities for interoceptive training (Figure 1). The training phase is organized to progress from the most tangible level of the body to the more abstract interpretations of stress in that context. Interoceptive skills serve as a bridge between these two extremes.

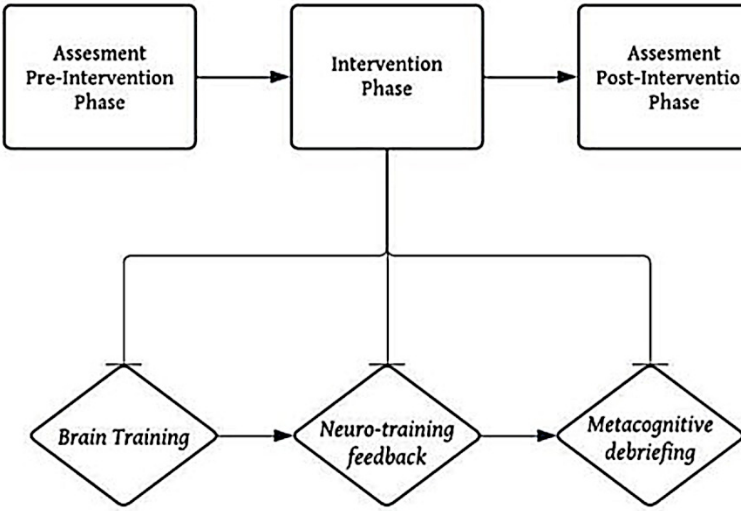

Figure 1. Protocol flowchart

Assessment (Pre-Intervention). The neuro-assessment phase may utilize basic and advanced tools to evaluate participants' interoceptive and stress management capabilities. Biofeedback tools are particularly effective at monitoring autonomic regulation (Kennedy & Parker, 2019), while neurofeedback facilitates the calibration of interoceptive accuracy by analyzing changes in brain frequencies during exercises. When resources allow, advanced instrumentation, such as EEG and fNIRS hyperscanning, can assess interoceptive synchronization during interactions. These tools offer invaluable insights into participants' baseline capacities. A thorough evaluation should combine psychophysiological data with psychometric surveys, such as the Maslach Burnout Inventory-General Survey (Bakker et al., 2002), and data from organizational life (absenteeism, productivity).

Brain training. After the pre-intervention assessment, the protocol introduces exercises to enhance interoceptive awareness. For instance, the static handgrip exercise activates the ACC and aIC (Williamson et al., 2003), enabling participants to focus on and interpret their stress signals. Another example is interlocutor synchronization exercises, which involve replicating organizational scenarios in training contexts. These scenarios may include reproducing dysfunctional communication patterns that have been identified. Such exercises not only enhance individual interoceptive awareness but also improve organizational dynamics by addressing real and concrete challenges within the workplace. Interoceptive stimulation can also aid professionals in helping roles by increasing empathic sensitivity toward others (Balconi & Angioletti, 2021). Furthermore, the exercises provide flexibility in training interoceptive sensitivity to various physiological states, ranging from enteric sensations, which are more challenging to perceive, to heartbeats and respiratory cycles, which are comparatively easier to detect (Herbert et al., 2012). This adaptability ensures that the intervention meets diverse individual and organizational needs. There is no indication or cue in the literature regarding the duration and number of brain training sessions, so we assume that six sessions distributed over two weeks may be sufficient.

Neuro-training feedback. Building on interoceptive awareness, the neuro-training phase enhances participants' accuracy in perceiving internal physiological states. This phase employs feedback mechanisms adapted from assessment tools. Exercises such as conscious breathing (Good et al., 2016), body-scan techniques, and autogenic training (Ernst & Kanji, 2000) are complemented by bio-neurofeedback to increase participants' sensitivity to enteric sensations, heartbeats, and respiratory cycles (Herbert et al., 2012). Integrating physiological feedback methods (Crivelli et al., 2019; Meyerholz et al., 2019) ensures that participants receive precise, real-time insights into their physiological responses, promoting sustained improvement. Based on the findings of previous studies (Meyerholz et al., 2019; Schillings et al., 2022), a 20-minute intervention was proposed to be conducted every seven days for three weeks.

Metacognitive debriefing. This phase includes group metacognitive discussions that encourage participants to reflect on their bodily sensations and emotional reactions to stressors. Drawing on Heim et al. (2023), these sessions aim to reinterpret and reframe stress-related experiences, fostering a more adaptive and resilient mindset. The debriefing phase consolidates individual learning and strengthens group cohesion and mutual understanding by creating a collaborative and supportive environment. Eid et al. (2001) demonstrated that even a 2.5 hour session could lead to significant changes, albeit in a different context. Additionally, the information on stress experiences reported by participants can serve as valuable qualitative data to integrate with the results of the post-intervention assessment phase.

Assessment (Post-Intervention). This phase is crucial for evaluating the efficacy and modification of the intervention. The intervention's protocol targets key brain areas, such as the PFC, ACC, and aIC, to enhance participants' ability to detect and manage stressful stimuli. This ability could be operationalized through the analysis of brain areas (e.g., fNIRS) alongside increases in HRV or RSA, with an expectation for improvement by the end of the intervention. Other useful outcome metrics could include the surveys conducted during the pre-intervention assessment phase, such as validated self-reports and organizational data.

This proposed protocol is intended to operate at both individual and organizational levels. It also highlights the potential for stress management to evolve into empowerment strategies by activating certain regions of the Salience Network (Vartanian et al., 2020). This approach recognizes that risk reduction and creative enhancement exist on a continuum, shifting the focus according to organizational context and intervention goals.

Moreover, while these anticipated outcomes are theoretically promising, our work is limited in exploring an area with sparse literature, particularly regarding the effectiveness of interoceptive interventions for WRS management. This is especially true for our most innovative proposal involving brain training exercises, which currently lack indicative data for potential organizational or clinical applications. Our intervention protocol could be a foundation for validating new interoceptive intervention tools for organizational management. However, robust evidence is needed through randomized controlled trials to establish new stress reduction and organizational empowerment standards, addressing significant gaps in the interoception and occupational health literature.

7. Conclusion

In conclusion, this contribution presents a new protocol for managing WRS and promoting organizational empowerment through interoceptive training. The protocol focuses on reducing stress and enhancing organizational empowerment by using adaptable, neuroscientific interventions. Its structured phases aim to measure and improve stress management for individuals and groups. While the protocol shows promise, its effectiveness needs validation through thorough empirical studies to address existing gaps in the literature and improve occupational health practices.

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