Neurofeedback in the workplace: from neurorehabilitation hope to neuroleadership hype?

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Brain–computer interface neurofeedback has rapidly become an engaging topic for occupational research at large. Notwithstanding some criticism, research and practice have begun converging on the efficacy of brain–computer interface neurofeedback as a part of holistic interventions in rehabilitation. Yet, its use in vocational contexts has recently blossomed into wider attributes, beyond rehabilitation practice *per se*, additionally targeting performance enhancements and leadership interventions in healthy individuals. By exploring this emerging scenario, this paper aims to provide an interdisciplinary forum of analysis on the deriving implications for rehabilitation professionals, signaling how these may invite both possible threats for the field and opportunities to engage in novel translational partnerships. *International Journal of Rehabilitation Research* **00:000–000**

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The journey of science has rapidly progressed our understanding of brain functioning and its links to behavior. In our endeavor to decipher how these elements work, a number of neuroscientific and neurotechnological advances have also offered promise to improve recovery of individuals with physical and mental disorders, as well as help them maintain daily skills, including optimal working life capabilities (Umphred *et al.*, 2013). Owing to these developments, society is rapidly witnessing offers of brain–computer interface (BCI) interventions in the workplace, not only related to occupational therapy (Millán *et al.*, 2010), but also attempting to improve healthy individuals' cognitive responses and performance (Randolph, 2013). In the midst of this alluring scenario, BCI neurofeedback is rapidly re-emerging as a popular answer to these demands (Gruzelier, 2014).

At the same time, the prospect of implementing neurofeedback as a broader routine in the workplace is opening a number of viewpoints that go deep into the core of rehabilitation professions. As ongoing research is increasingly showing that BCI neurofeedback may be effective in improving signs of neurological conditions, shall attempts to transfer these practices to modulate healthy workers' behavior represent concerns for the rehabilitation sector? Or, instead, may they help cross-fertilization of occupational research and support its standing as a fuller translational domain?

This paper seeks to answer these questions by both reporting current applications of BCI neurofeedback and offering a critical analysis to better our understanding of this incipient context.

Neurofeedback in the workplace: a word for multiple meanings

BCI technology has generated increasing interest in its possibilities for neurorehabilitaiton (Daly and Wolpaw, 2008; Jackson and Zimmermann, 2012). Research has also focused on the potential of BCI neurofeedback to promote rehabilitation effectiveness by controlling and modulating brain activity (Wolpaw *et al.*, 2002).

Although neurofeedback refers to the monitoring of brain activity to deliver information used as real-time feedback to voluntarily modulation of that activity (Hammond, 2011), even among healthcare professionals, misconceptions of its meaning are recurrent, and it is often simply equated to biofeedback on EEG amplitudes. However, rather than a singular system, neurofeedback is a conditioning protocol entailing a number of technologies, from near-infrared spectroscopy (Mihara *et al.*, 2013) to functional MRI (Monti *et al.*, 2010). It has recently been incorporated into several approaches including functional electrical stimulation (Lourenção *et al.*, 2008), robot-assisted movement (Lo *et al.*, 2010), and visual displays (Buch *et al.*, 2008).

The key rationale is that, relative to other rehabilitation avenues, the dependence on modulation of the nervous system to promote feedback goes beyond a 'passive-patient' approach (Young *et al.*, 2014). This is well exemplified in cases of neuromotor disorders where neurofeedback requires patient engagement to modulate their brain activity patterns associated with movement; implementation of low-resolution EEG tomography neurofeedback (z-score LORETA) in patients with

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occipital cerebrovascular accident leads to promising improvement in both cognitive and motor functions (Koberda and Stodolska-Koberda, 2014). Similar beneficial effects have been reported for a number of conditions relevant to vocational therapy, from spinal cord injuries to epilepsy (Birbaumer *et al.*, 2009).

What's more, part of the interest in neurofeedback at the workplace has traditionally been associated with research targeting occupational psychology issues, like stress, anxiety, and emotional regulation (Moore, 2000; Johnston *et al.*, 2010). However, as this body of behavioral studies has oftentimes been criticized for low statistical power and incomplete grasp of long-term causality between neurofeedback and rehabilitation potential (Ossebaard, 2000), research is currently converging in understanding neurofeedback as an instrument that may be most effective when part of a holistic treatment, rather than as a 'fix-it-all' intervention (Yucha and Montgomery 2008).

Although more assessments on these aspects are still needed, BCI neurofeedback has also rapidly assumed wider-ranging connotations at the workplace. The re-emergence of its applications for optimal performance – targeting professionals spanning from musicians to sportsmen (Vernon, 2005; Gruzelier, 2014) – has rapidly expanded into a novel stream of business research, known as neuroleadership (Ringleb and Rock, 2008). Because leadership is a multibillion-dollar industry, this interest in leaders' development is of little wonder. For instance, initial insights have focused on how employees could peak performance and on the positive effects of qEEG neurofeedback in anger management at the workplace (Waldman *et al.*, 2011). Yet, with still little ecological validity and replications, the vigor of the neuroleadership wave may risk echoing the likes of those meditation hypes built around the early studies on EEG alpha wave biofeedback: as Beyerstein stated, such correlations were equivalent to that of how 'opening one's umbrella can make it rain' (Beyerstein, 1999).

More compelling, together with this scholarly drive, a number of commercial performance-boosting neurofeedback initiatives have begun offering affordable yet poor-performing EEG headsets (Duvinage *et al.*, 2013), educational programs (Arns and De Ridder, 2011), and expensive 'therapies' in private clinics, often resonated by media's accolades, even with advice to public National Health Systems to 'take note' (The Sunday Times, 2013).

A threat or an opportunity?

With such a strong neuroscience vibe on the vocational horizon, occupational therapy is facing a double-edged sword. On the one hand, the use of neurofeedback beyond clinical approaches, especially if focused on a very narrowed understanding, may add concerns to its already troubled scientific validity. For instance, EEG-driven management intervention may not exemplify representative approaches without accounting for long-term and more complex contextual factors. Rather, the jeopardy is to promote neuromyths together with due ethical concerns (Tamburrini, 2009). Moreover, questionable degrees and clinics may impact the social esteem of the rehabilitation profession, thereby calling for a reaction to prevent widespread pseudomedical claims on what BCI neurofeedback means and what its realistic opportunities are.

On the other hand, overlooking the call for having neuroscience-informed solutions at the workplace to enhance performance risks detaching rehabilitation from its broader societal context and in turn ending up as a missed opportunity. Rather, pending cautious exploration, accurate methodological and ecological validities, BCI neurofeedback may offer a key to engage in novel fruitful partnerships. As it requires specialized experts, knowledgeable about much more than elementary brain functioning and software setups, this demand can put rehabilitation specialists in a favorable spotlight position in future occupational studies and activities.

These researchers and practitioners may then hold a more active role in interdisciplinary-oriented teams, offer more accurate instruments to report ethical and research guidelines, prevent unwitting emergence of brain tales, and overall help disseminate one of the core principles of their field – that is, to improve individuals' psychophysical conditions, both inside and outside the workplace, a holistic and synergistic approach is the most desirable framework (Bakheit, 2009). If achieved, this fuller translational stand of looking at individuals' 'functioning in the outer world' (Tesio, 2012) will also allow expansion of our current understanding on how neurofeedback can help regulate behavior and, ultimately, on how our brain works.

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Conflicts of interest

There are no conflicts of interest.

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