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Neuro-Assessment of Leadership Training

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Abstract:

The rapid growth of coaching practices has outpaced the current best-practice empirical research and created a difficult landscape to navigate for coaches and consumers alike. To overcome these challenges the present study proposed to employ the neuro-screening measure to develop and monitor an individually tailored coaching intervention for training senior-managers' inspirational leadership. We have used the quantitative electroencephalogram (qEEG) screening to build the individual profiles of every coachee to assess their baseline (trait) characteristics in order to develop the coaching interventions to enhance effective and minimize ineffective behavior. The qEEG-screening profile resulted in nine metrics characterizing different traits and features of every coachee. Based on these profiles individualized 4-month coaching programs were suggested to coachees. The results indicated that participation in the individually designed 4-month coaching program was associated with significant improvement (70.7%) or optimization (55.6%) of metrics in the 71.7% of coachees. This was paralleled by reduced scores in independent Beck Anxiety Inventory and Beck Depression Inventory scales. We concluded that the employment of qEEG-screening profiling allows coaches and trainers to assess deep dynamic neurological mechanisms that underpin baseline traits and features essential for effective, flexible and sustainable leadership, as well as track their development over time.

Keywords:
Coaching, personalized coaching, transformational leadership, electroencephalogram, EEG, EEG-screening profile, brain neuroimaging, neuroleadership, personal characteristics, traits, feedback interventions.

INTRODUCTION

During last few decades the interest in coaching (life, workplace, executive, and leadership) has burgeoned. Workplace coaching in particular has been quick to shift from a latest seemingly overhyped management fad (Tobias, 1996) to an essential component of organization development and leader management (Cavanagh, Grant, & Kemp, 2005; Grover & Furnham, 2016). Such rise in popularity of coaching as a principle method of human and organizational change brings with it many new opportunities along with numerous challenges for coaches and trainers, as well as for researchers in the field.

In research related to leadership coaching, the traditional concern has been with the full range leadership model (FRLM) as the most comprehensive and studied leadership model of all (Avolio, 2011; Bass & Avolio, 1993). The FRLM describes the full range of leadership behaviors, from the undesired and ineffective passive leadership (called laissez-faire leadership) to a desired and effective active leadership (called transformation leadership) (Richter et al., 2016). Here, the focus will be on the transformational (also referred to as visionary, charismatic or inspirational) leadership since it is the most widely studied form of effective leadership (Waldman, Balthazard, & Peterson, 2011a). Transformational or inspirational leaders are managers who are charismatic, act as role models and are able to devise an inspiring vision of the future (Bass & Bass, 2009; Waldman et al., 2011a). By being creative and innovative, transformational leaders bring out the same characteristics in their team members, while at the same time giving them enough autonomy to make their own decisions and guiding them towards the development of needed skills and abilities (Conger & Kanungo, 1998; Judge & Piccolo, 2004; Shamir, House, & Arthur, 1993). Many meta-analyses and reviews have systematically documented the positive effects of transformational leadership on employee effectiveness, productivity, team performance and job satisfaction (Avolio, Reichard, Hannah, Walumbwa, & Chan, 2009; DeGroot, Kiker, & Cross, 2000; Dumdum, Lowe, & Avolio, 2013; Judge & Piccolo, 2004; Lowe, Kroeck, & Sivasubramaniam, 1996; Wang, Oh, Courtright, & Colbert, 2011). Furthermore, it has been documented that transformational leadership is particularly efficient for change processes (Avolio et al., 2009; Eisenbach, Watson, & Pillai, 1999), positive organizational climate (Corrigan, Diwan, Campion, & Rashid, 2002), organizational commitment, and staff retention (Leach, 2005).

Given the relevance of leadership coaching to organizational effectiveness and considering that leadership development is a multibillion-dollar industry (Waldman et al., 2011a), some researchers have begun to focus their efforts on studying whether personal characteristics (strengths and weaknesses) can be predictive of the formation of an effective leader (Judge & Bono, 2000; Zaccaro, Green, Dubrow, & Kolze, 2018). In other words, there is increased recognition of the need for understanding how transformational leadership may be traced back to personal qualities of the leader. For example, there were attempts to show some possible links between the Big Five personality factors and the expression of transformational leadership (Bono & Judge, 2004; Judge & Bono, 2000).

Critically, demand from the rapid growth of coaching practice has outpaced the empirical research output (Bennett, 2006; Lowman, 2005; Grover & Furnham, 2016), and as result many serious challenges need to be addressed.

Current Challenges

Organisation vs individual

As rightly pointed out by Leonard (2003), "major [if not all] theories of leadership were developed from the point of view of the organization, not the individual" (p. 10). Consequently, most coaching feedback interventions are problem driven rather than person oriented (Smither & Walker, 2004). At the same time, according to J. Hogan, R. Hogan, and R. B. Kaiser (2010), it is the person (self), where change is required (see also Boyatzis, 2008; Dixon, Rock, & Ochsner, 2010; Passarelli, 2015), especially in "postmodern" organizations which frequently face new challenges in relation to feelings, psychological climate, and sensibility (Hirschhorn, 1998; Leonard, 2003). This position is supported by Elliott (2003) who suggested that deeper levels of personal transformation (sustainable flexibility, commitment and motivation) are required if an organization aims to achieve successful development. Thus, the focus should be placed on the individuals (coachees) to help them achieve their full potential (Elliott, 2005). Indeed, recently more attention has been directed to the personal strengths and virtues of coachees as a basis of successful coaching (Grant, 2003; Lord & Hall, 2005). However, the research interventions are lacking and badly needed. The current research study aims to add to the limited empirical base (see Aim section).

Healthy coaching vs clinical therapy

It is systematically stressed that the crucial difference between coaching and therapy is that coaching deals with nonclinical populations (Grant, 2003), whereas therapy addresses the needs of people who either suffer from diagnosable mental disorders like, for example, depression and anxiety, or seek to repair a specifically diagnosed cognitive or behavioral dysfunction (Kemp, 2005). Thus, coaching is a "therapy" for those who do not need clinical help but would benefit from a structured, facilitated approach to solving life/work problems (Filippi, 1968). While this distinction is very important, and should be taken seriously by coaches, the actual boundary between psychopathology and the normal range of human functioning is a lot harder to discern (Cavanagh, 2005). Indeed, when is a coachee simply sad, and when is he or she clinically depressed? Likewise, anxiety related to public speaking may be a temporary worry in one person and a symptom of social phobia in another. These are normal but nuanced considerations frequently faced by coaches when they encounter clients with latent and manifest mental-health problems. For example, it is well documented that managers are exposed to more stress and have higher rates of anxiety and depression than skilled, semiskilled and unskilled individuals (Eaton, Anthony, Mandel, & Garrison, 1990; Moss, 1991). So, it is simply not the case that coaching is always a benign activity (Berglas, 2002). Therefore, as rightly pointed by Cavanagh (2005):

> When coaches do not have sufficient knowledge about mental-health issues, they are unlikely to notice the subtle signs of mental disorder in their clients. It can be difficult even for coaches with mental-health training, as clients often attempt to disguise their distress. The clinically depressed client may put on a public display of enthusiasm and happiness, and the anxious person may feign indifference or downplay their worries. Nevertheless, as identified in the code of conduct of the International Coaching Federation (and similar to other professional codes of conduct), two central ethical imperatives in coaching are for coaches to know the limits of their abilities and services, and to always act in the best interest of their clients. These require coaches to ensure that they make informed judgements about the nature of the emotional and mental issues their clients are grappling with, and about their ability to help them with these. (p. 23)

Thus, it is important for coaches to have the means for deciding when their client would be better served by a qualified therapist. It is important to note here that not all "problematic personality features" indicate mental disorders, neither do they immediately indicate unsuitability for coaching. According to the dimensional approach to psychological constructs, personality and behavior, the expression of individual features is continuously distributed in the general population ranging from "disordered" to "healthy" (Fingelkurts & Fingelkurts, 2018; Insel et al., 2010). From this perspective, challenging clients could be defined as those whose personal features and behaviors cause them difficulties, but are nonetheless adaptable enough to avoid being classified as disordered (Cavanagh, 2005). While dealing with such challenging executives, the main goal is to help them shift their features and related behaviors toward the healthy range of the spectrum. The monitoring tool used in the current study aims to help with these issues (see Methods section).

Social psychology vs cognitive neuroscience

It is a fact that long-held theories and concepts utilized in coaching practice and research have largely focused on social psychology theories (Ochsner & Lieberman, 2001; Ringleb & Rock, 2008) and behavioral sciences (Grant, 2005). Many of such theories and concepts are criticized for the lack of replicability. Recently, greater attention has been paid to the actual mental processes of leaders to explain their behavior and effectiveness, thus reflecting the cognitive revolution in leadership and organizational studies. However, this revolution has been largely limited to conjectures about what goes on inside the "black box" (brain) of leaders (Hannah, Balthazard, Waldman, Jennings, & Thatcher, 2013). Thus, another revolution is overdue, to bring neuroscience methodology and knowledge of normal and abnormal brain-mind functioning into coaching practice (Ringleb & Rock, 2008). In recent years neuroscience research has made and continues to make unprecedented advances in the understanding of the human brain and its relation to mental process, cognitive operations and emotions (Amunts et al., 2016; Grillner, 2014). It is expected that such integrative research will revolutionize current approaches to the assessment and development of leaders. The current study takes a step in this direction (see Aim section).

Coaching effectiveness

There is growing recognition that there is little empirical evaluation of coaching effectiveness, likewise only few attempts have been made to develop evidence-based theoretical models of coaching (Bennett, 2006; Cavanagh et al., 2005; Grant, 2003, 2005; Lowman, 2005; Ringleb & Rock, 2008; for a comprehensive review and meta-analysis see Grover & Furnham, 2016). Thus, it is not surprising that the efficacy of traditional leadership coaching methods has repeatedly been called into question (Haines, 2009; Waldman et al., 2011a). For example, in the latest review study (Grover & Furnham, 2016) that critically analyzed five previous meta-analytic studies of the coaching effectiveness it has been stated that:

> Although coaching has become an established and popular intervention within organisations, there is limited evaluation of coaching programs by organisations [Leonard-Cross, 2010] and little consensus among academics as to the best mechanism for evaluation [Grant, 2012]. As a result, the perceptions of the effectiveness of coaching differ widely: some believe there is "evidence of absence" in the sense that studies have shown it to be not very effective, while others argue there is in fact an "absence of evidence" in the sense that, as yet, few good studies have been done. (p. 2).

Authors of the same review study (Grover & Furnham, 2016) presented their own meta-analysis of the last 10 years of academic and practitioner research in relation to the coaching effectiveness. Based on this analysis they concluded that:

> Unfortunately, it is clear there is not enough data to make a definitive judgment about the effectiveness of coaching on each of the outcomes investigated in these studies because few of

> them have been investigated multiple times, with experimental rigour or with large enough sample sizes. […] However, the results above do lean towards coaching being an effective intervention that helps individuals in terms of their self-efficacy, goal attainment and organisations in terms of their leadership but it also benefits organisations indirectly through the individual. (Grover & Furnham, 2016, p. 23).

While there are known objective limitations of quantitative coaching research (Antonakis, Bendahan, Jacquart, & Lalive, 2010) and the use of multiple outcome measures add to a large variability of effect sizes (Grover & Furnham, 2016), coaching research has improved a lot during last several years (see for example, Grant, 2014; Ladegard & Gjerde, 2014; MacKie, 2014). The increased number of researchers involved in leadership coaching studies recognize the need to go beyond traditional assessment methods, which typically involve evaluating coachee behaviors and qualities through some sort of self-reports, surveys and ratings.

Self-reports and questionnaires vs neuromonitoring

Traditional coaching assessment/evaluation methods rely on self-assessment surveys, semi-structured interviews and questionnaires like (for example, the Big Five survey or resilience assessment). At the same time, both theory and empirical research indicate that self-report responses are largely a product of psychological, sociological, linguistic, experiential and contextual variables, which may have little to do with the construct of interest (Harrison, McLaughlin, & Coalter, 1996; Lanyon & Goodstein, 1997). Generally, response distortions are introduced by expectation and social desirability biases, subconscious drivers such as, for example, the tendency to respond positively "true" or "yes", or endorse all statements (even when contradictory) regardless of the actual question content (Razavi, 2001). The tendency to pick extreme responses while rating oneself is yet another distortion, which may be due to demographic factors. For example, women, on average, give more extreme responses compared to men (Crandall, 1973; Hamilton, 1968). Furthermore, age, education, and culture have also been shown to lead to extreme response bias (Hui & Traindis, 1989; Marin, Gamba, & Marin, 1992). Another important response distortion is the social desirability bias (see Edwards, 1953, 1990) which is the tendency to rank the self-report items in such a way as to intentionally (consciously) or unintentionally (unconsciously) represent oneself in a favorable light (Crowne & Marlowe, 1964; Furnham & Henderson, 1982; Paulhaus, 1984; Paulhaus & Reid, 1991). While many factors may contribute to the motivation of coachees to provide responses which they believe are more socially desirable than a truthful answer, organizational ratings and surveys are particularly prone to deliberate misrepresentation, as coachees may think that the result of their responses will impact their careers promotion, salary-level, and job security (Razavi, 2001). This type of biases is especially prevalent among managers (Niszczota, 2015). Therefore, self-report methodologies should be complemented by more objective methods of data collection such as for example neuromonitoring. The brain responses measured by neuroimaging techniques cannot be consciously perceived by the participants and thus reflect their true neurophysiological reactions effectively bypassing any rational, conscious, or cognitive "censors" and "filters" that typically provide the socially motivated "correct" answers (Fingelkurts & Fingelkurts, 2007). Neuroimaging approaches go straight to the core – the human brain, and target biological predispositions of the personality traits including the unconscious operations. The use of these technologies is poised to revolutionize leadership coaching practice, both in deciding about the type of coaching program and monitoring training progress over time. The current study offers one such possibility.

Drawbacks of feedback conversations

Coaching engagements typically begins with multi-rater feedback. Currently there are several performance review tools (360-degree, Edwards & Ewen, 1996; or GROW – Goals, Reality, Options, Wrap-Up/Way-Forward, Alexander, 2010; Whitmore, 1992; or GAPS – Goals, Abilities, Perceptions, Standards, Peterson, 1996; just to mention a few) that jointly referred to as feedback interventions (Kluger & DeNisi, 1996). Despite being a valuable instrument and broadly used (Edleson, 2012), it is well documented that feedback interventions require a significant investment of time, energy, and money, as well as impose anxiety on both coach or rater and coachee (Dixon et al., 2010; Buckingham & Goodall, 2019) and are not always as effective as coaching on its own (Jones, Woods, & Guillaume, 2016). Furthermore, as demonstrated by Kluger and DeNisi (1996) in their seminal meta-analysis, on average, feedback interventions improve performance only in 41 percent of cases, and making it worse or doing nothing in 38 and 21 percent of cases respectively (see also DeNisi & Kluger, 2000). For example, after analyzing over 750 large North American companies Watson-Wyatt (2002) concluded that the "truth is that it is a challenge to get multisource feedback right. […] multisource feedback can be a lengthy distraction that interferes with teamwork and reduces productivity and, ultimately, shareholder value" (p. 10). Studies indicate that between 40-70 percent of managers fail through incompetence or due to "overriding personality defects" (Hogan, Hogan, & Kaiser, 2010). So, it would make sense if corporate feedback approaches could correct some of those personality defects, but the abovementioned statistics indicate otherwise. Another serious problem with feedback interventions is that people often perceive them as 'threatening', because of possibility to affect sense of 'status'. Indeed, studies show that feedback can threaten self-esteem, leading to anxiety, stress and social pain (Levy, Albright, Cawley, & Williams, 1995; Dickerson & Kemeny, 2004; Lieberman & Eisenberger, 2008). Given that a "sense of status" is a fundamental human need (Rock, 2008), a threat or an attack on it in the feedback ratings setting causes strong negative reactions in people (Dixon et al., 2010). Furthermore, research indicates that it is significantly more difficult for people to self-regulate their state if they feel threat (Rock, 2009) and, as a result, in such situations they tend to resort to the so-called habit reaction, which is a sequence of thoughts, actions, or behaviors happening outside of awareness and without any conscious monitoring (Dickinson, 1985; Schwabe & Wolf, 2009). Such reaction relies on neurophysiological underpinnings of individual traits and personality characteristics (Sosic-Vasic, Ulrich, Ruchsow, Vasic, & Grön, 2012). Thus, ironically, feedback interventions may actually deplete the very coping mechanism they are designed to augment and further fail to leverage the transformational power of personal change (Passarelli, 2015; Buckingham & Goodall, 2019). Again, the neuroimaging technology may help in elucidating the true responses of coachees along with evaluation of their strong and weak individual features (see Methods section).

Biases of the decision-making

When reasoning and making decisions, effective leaders have a skill to form a greater understanding of the bigger picture (Bass & Bass, 2009). Indeed, big picture thinking, foresight, and insight are the key elements of transformational leadership (Lowe et al., 1996). At the same time, the cognitive processes and operations that lead to either effective or ineffective managerial decision-making are understood to operate below the level of conscious awareness (Bazerman, 2005; Kahneman, Slovic, & Tversky, 1982; Plous, 1993; Simon, 1987), thus making it difficult to understand the true affects and motivations that lead to a concrete decision-making. This in turn makes it very difficult to design coaching interventions that improve managerial decision-making. Indeed, a vast amount of empirical research supports the conclusion that a substantial portion of mental processes, including information integration, thoughts, affective and motivational processes, is unconscious (Kihlstrom, 1987, 1990; Westen, 1998). Even so, the brain is at the core of every single decision that managers (as well as any other people) make. Due to recent advances in brain neuroimaging, we now have unprecedented access to the neurobiological bases of instinctual drives, motivations and basic emotions (Berlin, 2011; Fingelkurts & Fingelkurts, 2007; Yarkoni, 2014). In relation to this, there is a pressing need to translate the methodology and knowledge gained through basic brain research into effective leadership coaching practice (Ringleb & Rock, 2008).

Real and ideal self

In relation to positive leadership, the "self" of a leader provides the structural means through which various social roles, knowledge, skills, abilities, and self-regulatory systems associated with those roles are organized (Hannah, Woolfolk, & Lord, 2009; Lord & Hall, 2005; Lord, Hannah, & Jennings, 2011).

More specifically, the self serves as the interface between the observable surface-level traits and behaviors that leaders exhibit and the deeper neurocognitive structures that enable leaders to construct a sophisticated understanding of situations and help them respond to the complex dynamics of their social and organizational environments (Lord & Hall, 2005; Lord et al., 2011). The self-concept is thus central to leader self-regulation and performance. As noted by Kihlstrom and Klein (1994), the self is “the point at which cognitive, personality, and social psychology meet” (p. 194). Thus, the coaching interventions that, besides other aspects, include personal learning, enhancing an individual’s understanding of his or her identity, capabilities, and behaviors are crucially important for effective task accomplishment and sustained change (Hannah et al., 2013; Karaevli & Hall, 2006; Stober & Parry, 2005). At the same time, as was discussed by Boyatzis (2001, 2006), to have just a proper perception of the self alone is not sufficient for the efficient leader coaching and development; an image of the ideal self is also crucially important (Boyatzis, 2008). It initiates enduring personal change, which is the cornerstone of executive coaching (Passarelli, 2015). Indeed, successful self-directed learning arises out of a perceived (but not insurmountable) gap between the ideal and the currently present real self (King, 2001; Tice & Bratslavsky, 2000), where the ideal self serves as a catalyst for change process because it exposes a discrepancy between coachee’s current real self and the self to which he or she aspires (Higgins, 1987; Oettingen, 1995). It has also been proposed that such learning gives rise to a growth-oriented psychophysiological state (Howard, 2006). However, current coaching practice methods and approaches lack an objective assessment of the real and ideal self. The current study tries to fill this gap by adopting an objective neuro-screening procedure that examines within the same tool the individual’s current (stable) strengths and weakness (the real self) in relation to the ideal self (see Methods section).

Analysis of the abovementioned challenges leads to the conclusion that the underlying subtleties and complexities of leadership development depend on individual differences (Zaccaro et al., 2018) that, in their turn, are conditioned by the efficiency and sensitivity of the underlying brain structures and processes (Yarkoni, 2014). Such understanding is gradually gaining traction in the coaching community (Lieberman, 2003) and leading to the emergence of the Neuro-Leadership branch of coaching research (Ringleb & Rock, 2008). It aims to reframe traditional leadership practice and leadership development theories through the lens of neuroscience, where identification of objective neuro-biological markers/signatures can significantly improve leadership development efficacy (Ringleb & Rock, 2008).

Indeed, the human brain is a proximal source of thoughts, cognition, emotions, actions and behaviors (Yarkoni, 2014), which are reflected in the dynamics and spatial distribution of the electromagnetic fields it generates (Fingelkurts, Fingelkurts, & Neves, 2009, 2010, 2013). If the brain is in fact the proximal source of human cognition, personality, and behavior then it follows that it is also the proximal source of individual differences in behavior (Yarkoni, 2014): "Where we observe that two people behave differently (on average) in similar situations, we can conclude that some aspect of their brain structure and function must also be different" (p. 62). Nevertheless, stating that all personality differences are ultimately driven by neurophysiology does not deny the crucial role of the developmental environment and culture in guiding the trajectory and expression of personality (Yarkoni, 2014). However, such environmental influences are also mediated by the brain, which due to its plasticity allows change (in terms of the capability to change the dynamics and pattern of electrical brain activity – and as a consequence behavior), thus enabling the leadership development (Waldman et al., 2011a). For example, there is limited evidence that long-term training programs may have an impact on some personality characteristics (Norlander, Bergman, & Archer, 2002; see also Spence & Grant, 2005).

Such an understanding – identifying the neural mechanisms that support stable differences in personality (regardless of their distal origin) – is the focus of the emerging field of personality neuroscience; but it is still lacking in the coaching practice, despite widespread knowledge that not every coaching strategy is going to work for everybody and that there are real individual differences needed to be addressed to achieve efficient coaching (Dixon et al., 2010; Luthans, Avolio, Avey, & Norman, 2007; Ringleb & Rock, 2008). While brain research could be extremely useful in this respect and the "hunger" for more effective and neuroscientifically-informed coaching tools and techniques has been clearly articulated (Rock & Schwartz, 2006), there is generally a lack of knowledge and technology for how to apply neuroscientific findings to leadership development and coaching.

Aim of the Study

The aim of the current study was to apply the neuro-screening measure to develop and monitor an individually tailored coaching interventions for training senior-managers' inspirational leadership. The intervention aimed to improve managerial leadership by using their specific individual characteristics (traits) and optimizing their expression in order to achieve the best performance with the least pshychophysiological cost. We hypothesized that such neuro-assessment and based on it coaching program, individually adjusted to a given coachee, would help to reveal every coachee's individual potential and predispositions (traits) thus allowing personal growth and maximizing performance (the strategy that is compatible with a role of coaching proposed by Whitmore (1992) and Grant (2005); for similar reading see also Roberts, Dutton, Spreitzer, Heaphy, & Quinn, 2005; Tice & Wallace, 2003).

The very notion of personality or individual traits implies that the observed inter-individual heterogeneity is a reflection of neural system function differences (Asendorpf, 1992) that are interpreted at the construct level as traits which are relatively stable over time (Kirkpatrick & Locke, 1991; Seligman et al., 2005). While trait theories have had a very long history in psychology, they are gradually gaining attention in organizational behavior and human resource management fields (Luthans et al., 2007), though some earlier attempts to associate personal factors with leadership have been also done (see for a review Stogdill, 1948). It is important to note that despite traits and states often being considered as independent and dichotomous categories of constructs, they are presented within a continuum that is largely determined by the relative degrees of stability in measurement and openness to change and development (Allen & Potkay, 1981): going from stable traits (that represent the person's biases or predispositions in the way they are likely to interpret and respond to novelty, danger or punishment, and reward), to trait-like, and then all the way down to state-like and further to transient states (that represent the momentary and very malleable properties).

While it is generally true that personality biases and traits tend to be enduring, it is also a fact that most people are able to regulate their reactions, emotions and behavior so that they usually operate in healthy, flexible, and productive ways (Cavanagh, 2005; Yarkoni, 2014). This gives some interesting implications for coaching: by understanding the underlying neurophysiologic factors or dimensions that make up coachees' personality, use that knowledge to create coaching training that would from one side match the coachee's predispositions, and from the other side lead to a more balanced and adaptive responses (so called "allostasis" – achieving stability through change; McEwen, 1998) to difficult situations the coachees face, motivate their personal growth, and maximize performance. This strategy is particularly important when working with coachees who show maladaptive patterns of behavior and responses to stressful situations. Such cases can be quite challenging, because many normally used coaching practices would be ineffective or even counterproductive (Cavanagh, 2005). Having an objective neuro-assessment of the individual's traits that reflect the coachee's true neurophysiological predispositions underlying cognition, personality, temperament and character factors can help the coach identify the strong and weak features and thus figure out which coaching strategies are likely to be effective or ineffective. For example, persons that fall in the high-end of sociability dimension, have positive emotional and high approach-motivation tendencies are also high in novelty-seeking trait and low in harm-avoidance trait (Davies, 2012; Eysenck, 1990). Such people are likely to find extravagance, novelty, and excitement motivating, but will be relatively insensitive to the feelings of others, punishment for breaching rules, or possibility of failure (Cavanagh, 2005). So, the appeals that would emphasize risk and bending the rules may be attractive to such coachees and most likely would trigger impulsive urge to act, rather than give reason for pause. On the contrary, linking adaptive behaviors with personal gain and achieving material goals can be used in such coachees to promote more productive behaviors that are both more cautious and respectful of others.

In agreement with the aim of this study, we propose that there is an inherent brain functional organization and dynamic structure, which, while being relatively stable, is nevertheless malleable over time and can be developed through leaders' experience, thus providing a neurobiological basis for personal features and traits development (see for example, Waldman, Balthazard, & Peterson, 2011b). This intrinsic neurophysiological organization and structure can be reliably examined through brain activity measurement when an individual is in a resting (i.e., not confronted by the induced task or external stimulation) although awake state (Deco, Jirsa, & McIntosh, 2011; Doucet et al., 2011). The advantage of the resting-state condition is that it "avoids the confounding effects of visual scenes, instructions, and task execution (i.e., capability to perform a task and strategies employed, motivation or lack of it, fatigue and anxiety associated with task performance)" (Fingelkurts & Fingelkurts, 2015a; p. 1051). A growing body of neuroscientific evidence suggests that the neural patterns and their dynamics found when the brain is at rest reflect its core functional organization and the inherent and relatively stable capacities of the individual (Cacioppo et al., 2003; Fox & Raichle, 2007; Raichle & Snyder, 2007; Tambini, Ketz, & Davachi, 2010). But much more importantly, the functional brain organization measured in the resting condition is predictive of task execution, performance, and behavior reactions during the actual activity or task (Fingelkurts, 1998; Fingelkurts & Fingelkurts, 2015b; Klimesch, 1997; Klimesch, Freunberger, & Sauseng, 2010; Mattar et al., 2018; Müller, Langner, Cieslik, Rottschy, & Eickhoff, 2015; Spadone et al., 2015).

The most tempting option for measuring brain functioning is to use the Electroencephalogram (EEG) sensors placed on the scalp (Niedermeyer & Lopes da Silva, 2005). In contrast to other neuroimaging techniques such as functional Magnetic Resonance Imaging (fMRI), Positron Emission Tomography (PET), or Single Photon Emission Computed Tomography (SPECT), EEG is the only technique that is completely non-invasive, portable, low-cost, risk-free method, which is used to *directly* monitor brain activity (that is the electricity produced by many cortical neurons firing in nonrandom partial synchrony; for review see Fingelkurts & Fingelkurts, 2015b; Freeman, 2005). EEG monitoring combined with automatic mathematical-statistical analysis (so-called quantitative electroencephalography, or qEEG; Hughes & John, 1999) provides a practical means to derive neurophysiologically based indexes of intrinsic brain activity that support individual cognitive and information processing, self-regulatory functions, decision-making, behavior, and consciousness (for review, see Easton & Emery, 2005; Fingelkurts et al., 2010). In fact, qEEG has been used to investigate personality and cognitive differences for more than half a century (see Buzaski, 2006; Frolov & Milovanova, 1996; Gale, 1983; Gale & Edwards, 1983; Thatcher & John, 1977; Thibodeau, Jorgensen,

& Kim, 2006; Wacker, Chavanon, & Stemmler, 2010). Thus, qEEG derived variables may help provide a better understanding of why leaders have certain behavioral predispositions. That is, if such variables are associated with personality traits and features that support effective (or poor) leadership behavior, then insight may be gained with regard to developing effective behaviors and minimizing ineffective ones. For example, the usefulness of qEEG for leadership has been documented in a study, where it was shown that individuals who score high on transformational leadership questionnaire can be accurately distinguished from those who score low based on resting state qEEG variables alone (Balthazard, Waldman, Thatcher, & Hannah, 2012).

We see such research program as fitting within a broader set of emerging approaches to understanding leadership that involve biologically-based factors alongside socially-determined ones (Arvey, Rotundo, Johnson, Zhang, & McGue, 2006; Zhang, Ilies, & Arvey, 2009) by bringing in the neuroscientific perspective (Ochsner & Lieberman, 2001; Senior, Lee, & Butler, 2011). Current research can add to an understanding of neurophysiologically conditioned features of leadership as a first step in advancing leader development through interventions individually tailored for every coachee. Such a perspective is compatible with the “complexity” approach to leadership (see Hannah et al., 2013) originated in the conceptualizations of Day and Lance (2004) who “argued that leader development is similar to the growth of an organism as it matures and achieves greater complexity over time, thereby leading to its successful adaptation to a changing environment. Accordingly, an examination of psychological and neurological markers of leader complexity is an important first step in advancing leader development” (cited from Hannah et al., 2013; p. 394).

To summarize, the overall conceptual basis behind the present study is that instead of simply putting coachees through a one-size-fits-all leadership (or any other) development program, the addition of neuro-assessment may give coaches the needed insights about specific individual features and traits of coachees. Armed with this knowledge, leadership development could be individually customized to fit the unique neurological “blueprint” of every coachee.

METHODS

Participants

The target population of this study was comprised of senior-level managers from a variety of industries (including Finance and Banking, Business/Management, Insurance, Health Care, and Training and Education) based in a metropolitan area of large Helsinki. The senior-level managers were chosen because it has been documented that senior executives behave in a more transformational manner and need those skills more than other employees with lower hierarchical positions (Leach, 2005). Due to resource constraints and the fact that it was a 4-month real-world coaching intervention designed to target the senior-level managers, the number of participants was restricted to 11. Participants were included in the program if they did not have a history of neurological or psychiatric pathology and had not used psychoactive medications in the last 3 years preceding the EEG registration. The exclusion criteria comprised (a) change of job, place of residence, or preoccupation in the last 3 years, (b) change of lifestyle or a diet in the last 3 years, (c) any serious disorder in the last 3 years.

The mean age of the sample was 53 years (*SD* = 7). Further demographic data are presented in Table 1. Consistent with the senior-level positions of the participants, 100% of participants self-reported themselves as senior executives and/or owners.

Table 1. Demographic data of participants.

Subject ID	Gender	Age	Race	Handedness	Marital status	Education	Position	Field
1	M	48	Caucasian	Right	Married	University	CEO	Business/Management
2	F	58	Caucasian	Both	Divorced	University	Senior Manager	Business/Management
3	F	49	Caucasian	Right	Married	University	CEO	Insurance
4	M	49	Caucasian	Right	Married	PhD	Head of Education	Training and Education
5	F	54	Caucasian	Right	Married	PhD	Human Resources Director	Food/Consumer goods
6	F	55	Caucasian	Right	Married	University	Occupational Health Manager	Health Care
7	M	74	Caucasian	Right	Married	University	Human Resources Director	Business/Management
8	F	50	Caucasian	Left	Married	University	Project Director	Finance and Banking
9	M	47	Caucasian	Right	Married	University	Vice President	Food/Consumer goods
10	F	50	Caucasian	Right	Married	University	Human Resources Director	Finance and Banking
11	F	53	Caucasian	Right	Married	University	CEO	Business/Management

Subject IDs were changed in order to remove possibility of identifying every concrete participant/coachee.

All participants completed the neurological (qEEG-screening) and psychometric (Beck Anxiety Inventory [BAI], Beck, Epstein, Brown, & Steer, 1988; Beck Depression Inventory [BDI], Beck, Ward, Mendelson, Mock, & Erbaugh, 1961) protocols as well as subjective state ranking. Table 2 provides mean values of BAI and BDI scales. The inclusion of BAI and BDI in this study was in agreement with increased attention in the coaching research to the psychological factors such as anxiety, stress, depression, resilience and well-being (Grover & Furnham 2016). Indeed, improvements in psychological factors caused by coaching is of important benefit to both coachees and organizations in the form of improved work performance (Wright & Cropanzano, 2000; Avey, Reichard, Luthans, & Mhatre, 2011; Robertson, Birch, & Cooper, 2012). Both BAI and BDI are standardized metrics that are used as comparison measures with disparate interventions (not only in patients but also in healthy populations) to create a comparable tangible value for them. Additionally, they served as independent measures of analogous (but neurophysiologically derived) metrics from the qEEG-Screening Profile (see below). The concurrent use of qEEG procedure, psychometric screening, and subjective reports provided a multifaced approach that limits common method biases (see Podsakoff, MacKenzie, Lee, & Podsakoff, 2003).

Table 2. Study participants psychometric group characteristics.

Characteristic	Assessment-I	Assessment-II	Statistics	p-Value
BAI ± SD	10 ± 8	5 ± 3	0.0366	< 0.05
BDI ± SD	6 ± 3	3 ± 2	0.0321	< 0.05

The values are reported as means and standard deviation. SD: Standard Deviation. BAI: Beck Anxiety Inventory. BDI: Beck Depression Inventory. Statistics: Wilcoxon Signed-Rank Test.

The study was carried out in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki), and standards established by the BM-Science – Brain and Mind Technologies Research Centre Review Board. Experimental procedures were explained to participants prior to EEG scanning, and participants signed an informed consent form. This study and the use of the data for scientific research was authorized by written informed consent of subjects and ethical approval by the organisational Review Board.

EEG Procedure and Significance

EEG electrodes were positioned on the head at 19 scalp locations (i.e., O_1, O_2, P_3, P_4, P_z, C_3, C_4, C_z, T_3, T_4, T_5, T_6, F_z, F_3, F_4, F_7, F_8, F_{p1}, F_{p2}) according to the International 10–20 system of the EEG electrode placement (Jasper, 1958). EEG signals were acquired at 256Hz sampling rate using an EEG data acquisition system (Mitsar, St. Petersburg, Russia) with a monopolar montage and linked earlobes as a reference electrode during the eyes-closed (6 min) and eyes-opened (6 min) resting (but awake) conditions. Such timing of EEG recording is longer than required to obtain a highly reliable and internally consistent data (Gasser, Bacher, & Steinberg, 1985; van Albada, Renni, & Robinson, 2007), well tolerated by participants and is resource-efficient when used in a real-world design. The following recording parameters were additionally enforced: 0.5–30Hz bandpass; 50Hz notch filter ON;

electrooculogram (0.5–70Hz bandpass). It has been documented that the scalp EEG-electrode locations reflect accurate voltage recordings of the intended underlying anatomic structures (Thatcher, Krause, & Hrybyk, 1986; Thatcher, North, & Biver, 2012).

Participants were instructed to sit upright and encouraged to relax, minimize movement (especially eyes) and engage in no specific mental activity. The presence of an adequate EEG-signal was determined by visual inspection of the raw signal on the computer screen. Artefacts due to eye movement, eyes opening, significant muscle activity, movements on EEG channels, and drowsy episodes were algorithmically corrected or eliminated prior to further qEEG analysis.

It is important to note that the qEEG data collected in our study represents the brain's intrinsic activity (i.e., activity that is not directly related to any external task, event, or stimulation). A growing body of neuroscientific evidence suggests that the brain operating in a baseline or rest condition (when the person is in a wakeful but relaxed state) reflects most accurately the basic psychophysiological features and performance potential of an individual (Cacioppo et al., 2003; Fingelkurts & Fingelkurts, 2015a; Raichle & Snyder, 2007). A large number of studies demonstrated that resting condition qEEG characteristics can quantify functionally important psychophysiological determinants – "signature patterns" of brain activity – that are predictive of individual traits and behaviors (see Thatcher & John, 1977; Buzaski, 2006; Lazarev, 2006; Hannah et al., 2013). Given the extensive data on functions of frequency-dependent qEEG oscillatory activity (Arroyo et al., 1993; Basar, 1998, 1999, 2008; Basar, Basar-Eroglu, Karakas, & Schurmann, 2001a; Basar, Schurmann, & Sakowitz, 2001b; Basar, Schurmann, Demiralp, Basar-Eroglu, & Ademoglu, 2001c; Bullock, 1997; Buzaski, 2006; Doppelmayr, Klimesch, Schwaiger, Auinger, & Winkler, 1998; Fingelkurts & Fingelkurts, 2010, 2014; Gevins, 1998, 2002; John et al., 1977; Klimesch, 1996, 1999; Klimesch, Doppelmayr, Russegger, Pachinger, & Schwaiger, 1998; Knyazev, Savostyanov, & Levin, 2005; Pfurtscheller, Stancak, & Neuper, 1996; Pulvermuller, Keil, & Thomas, 1999), different aspects of such qEEG oscillatory activity (as well as their dynamics and spatial distribution) may help reveal and differentiate brain functioning during different levels of cognitive processing, cognitive engagement, information recall, skill integration, and regulation of arousal and emotion (just to mention a few) (Arns, Conners, & Kraemer, 2013; Cohen & Donner, 2013; Corsi-Cabrera, Herrera, & Malvido, 1989; Cavanagh & Frank, 2014; Gordon, Barnett, Cooper, Tran, & Williams, 2008; Hallschmid, Mölle, Fischer, & Born, 2002; Herrmann & Knight, 2001; Lazarev, 2006; Lehmann, 1990; Nunez, 2000). Thus, qEEG can be considered as a "natural" and noninvasive window into the human brain and cognitive processes. Considerable number of studies proved the stability, specificity and validity of certain qEEG parameters (PubMed, 2018). For example, in large samples of healthy functioning individuals across different nations and wide age ranges, the high specificity of normative distributions of qEEG parameters within delta (0.5–3 Hz), theta (3.5–7 Hz), alpha (7.5–13 Hz), and beta (13.5–30 Hz) frequency bands has been consistently documented (for the review see Basar, 1998; Gevins, 1998; Gordon, Cooper, Rennie, Hermens, & Williams, 2005; Prichep, 2005; see also Fingelkurts & Fingelkurts, 2014). Deviations from the normative databases in healthy, normally functioning individuals have been repeatedly shown to be within chance levels (nonsignificant), indicating individual variation with very high test–retest reliability (Sokolov, Danilova, & Khomskaya, 1975; Thatcher & Lubar, 2008). On the other hand, statistically significant deviation of qEEG characteristics from a normalized reference range, and the degree to which they deviate are indicative of inefficiency of brain processes, when brain spends more energy and resources to achieve a given task or process (John & Prichep, 1993; John et al., 1977; Sokolov et al., 1975). Since neuro-cognitive processes form and shape individual behaviors, suboptimal neuro-cognitive capacity can translate into behavioral symptoms and particular dysfunctions, or abnormalities that may be already associated with neurological, developmental, and psychiatric disorders when the threshold for clinical significance is crossed (Jirmunskaya, 1996; Sokolov et al., 1975; Thatcher & Lubar, 2008). Considering this experimental and theoretical context, it is possible to use advanced qEEG analysis to objectively quantify individual differences across the traits that are important for the organizational and leadership development, such as level of vigilance, focus and attention, speed of information processing, stress regulation and resilience, emotional-motivational tendency, anxiety, and overall brain resources (see references in the Discussion section, and also Fingelkurts, Fingelkurts, Ermolaev, & Kaplan, 2006; Fingelkurts, Fingelkurts, & Kallio-Tamminen, 2015). Profiling a coachee across a wide range of personal attributes/traits allows designing the individually tailored coaching training programs that match to every coachee's profile. Further, by comparing qEEG-derived profile before and after a particular coaching (or any other training) program it is possible to obtain objective results on how coaching affects different brain-mind functions in every concrete coachee.

The qEEG-Screening Profile

The qEEG-screening *profile* used in this study has been developed in research aimed to characterize the individual variability and personalize training protocols (Fingelkurts et al., 2015). Using a collection of mathematical functions up to 499 characteristics of the qEEG-signal were used to automatically calculate and combine in different configurations the feature-values for the qEEG-screening profile of every coachee. Since the profile was aimed for use by people (coaches or trainers) without any specific neurophysiological knowledge, the rather complicated nuanced and technical aspects of the qEEG-signal have been collapsed down into 9 easy to understand metrics related to key mental, cognitive, and motivational features (see Figure 1) that are compatible with a dimensional approach to mental and cognitive capabilities (Insel et al., 2010). The selected 9 metrics were chosen based on experimental evidence and theoretical work related to association between particular qEEG-features and cognitive, emotional, and motivational functions that were identified across the spectrum of brain health disciplines that spanned neurophysiology, neurology, psychology, and psychiatry within an integrative neuroscience framework (Gordon, 2000; Insel et al., 2010; Sokolov et al., 1975; Thatcher & John, 1977). The selection criteria were that the chosen metrics had to demonstrate reliability and validity in published literature, being conceptually independent from one another and have relevance to the organizational and workplace matters (as analyzed in Discussion section).

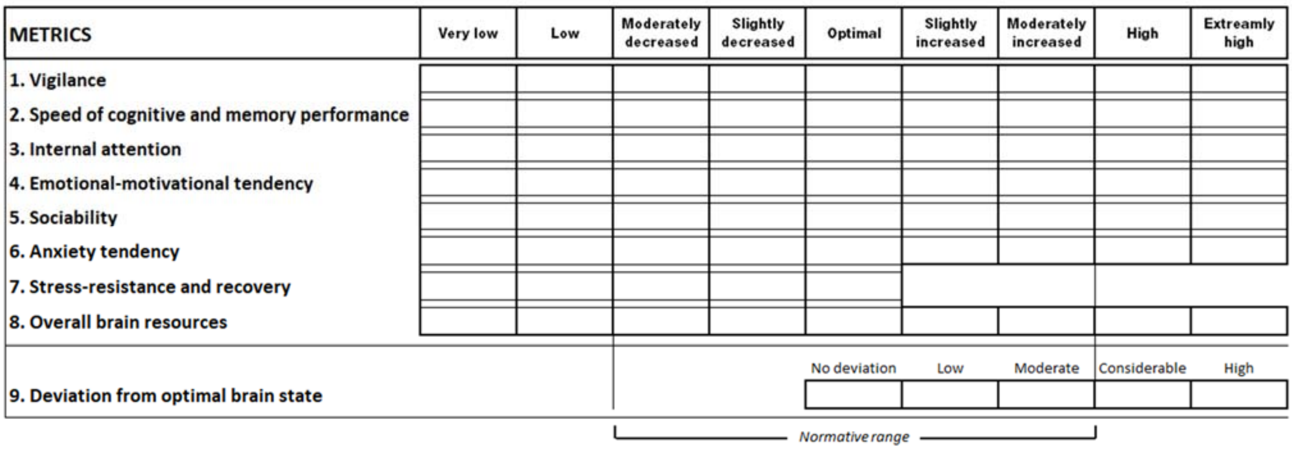

***Figure 1*. qEEG-screening Profile.**

In the effort to verify a relationship between neurological functioning (qEEG-features) and cognitive/motivational/mental traits used in the qEEG-screening profile, a series of regression analyses were conducted in agreement with the work of Thatcher, North, and Biver (2005), Thatcher et al. (2001) and others (e.g., Fridell, Newcom-Belcher, & Messner, 2009; Perreault, French, & Harris, 1977). The analyses revealed a high degree of association between selected metrics included in the qEEG-screening profile and particular cognitive, psychological, and motivational traits (independently measured) they are meant to represent (statistical significance was between $p < .05$ and $p < .00004$ for different metrics). The same analyses combined with the standard deviation estimations, Chi-Square test, Wilcoxon test and Mann-Whitney U test were used to define the cut-offs for the boundaries marking the degree of deviation from the *optimal range* (from slight, moderate, strong to very strong) for every metric (see Figure 1; Fingelkurts et al., 2015). The optimal range, derived from population normative qEEG values (Gordon et al., 2005; John & Prichep, 1993; John, Prichep, Friedman, & Easton, 1988; Thatcher & Lubar, 2008), represents certain "idealised" characteristics displayed by the majority of subjects within the same age and gender group, without current or past neurologic or mental health complains, family history of neurologic and psychiatric diseases, or other illnesses that might be associated with brain dysfunction (Jirmunskaya & Losev, 1980; Sokolov et al., 1975). It is important to keep in mind, that "deviation from the optimal range does not necessarily reflect abnormality or a pathological process. Deviation means that the brain functions outside the optimal range, thus spending more energy and resources to achieve needed results/aims" (Fingelkurts et al., 2015; p. 6). If the compensatory mechanisms of the brain are intact, then typically the deviation of qEEG characteristics is rather small and correspondingly pathogenically insignificant. However, the pathogenic significance of qEEG deviations from the optimal range increases along with exhausting of the brain compensatory mechanisms (Jirmunskaya & Losev, 1980). This process is usually associated with strong and very strong deviations from the optimal range.

Description of the 9 evaluation metrics comprising the qEEG-screening profile is presented in the Table 3 below.

Table 3. Description of metrics.

1. Vigilance Reflects the predominant level of supply energy available to the brain's regulatory systems when fulfilling a task
2. Speed of cognitive and memory performance Reflects the speed of information processing (information encoding and retrieval). At the behavioural level it determines a speed of reaction time
3. Internal attention Reflects the intensity of a person's level of mental "focus" or "attention" on oneself
4. Emotional-motivational tendency Reflects the tendency or predisposition of an individual to engage in certain types of emotional (positive versus negative) and motivational (approach versus withdrawal) responses
5. Sociability Reveals tendency of interacting well with others and degree to which a person can tolerate sensory stimulation from people and situations
6. Anxiety tendency Reflects the individual's predisposition to react to external stimuli by the excitement patterns of behaviour. It also reveals readiness to process information and mobilize resources in anticipation of difficult task or threat
7. Stress-resistance and recovery Reveals the person's adaptability to stress and his/her brain's ability to recover after the stress (resilience)
8. Overall brain resources Reflects the brain's morpho-functional integrity, capacity for self-reorganization, self-regulation and adaptation, and how optimal information processing is
9. Deviation from optimal brain state Provides information about the probable brain dysfunction

This nine-metric qEEG-screening profile provides detailed information on performance-relevant features and traits of cognition for any given participant. When obtained before the coaching program, it allows to a coach or trainer to understand the baseline cognitive and neurophysiological demands of the coachee and choose/adjust the coaching program accordingly aiming to reach optimal range for every metric. In this context, the second (final) testing will provide the information about the dynamics of the values for every metric of the profile and thus allow to coachee and coach/trainer to monitor objectively a progress of the coaching. A prior validation study, conducted in our laboratory, has shown the effectiveness of such a strategy (Fingelkurts et al., 2015).

The described qEEG-screening profile overcomes the shortcomings and challenges discussed in the Introduction. Indeed, the profile is focused first of all on the individual, elucidating in an accessible visual way the personal strengths and weaknesses of coahees helping them to reflect upon themselves and adapt their behavior accordingly. Further, different levels of deviation from the optimal range, marked in the profile, make it easy for the coach or trainer to see which metrics (and related with them personal traits) get "problematic/challenging" level but still suitable for a coaching and which may already indicate a probability of cognitive/mental disfunctions and thus requiring a specialized therapeutic intervention (see Figure 2). The proposed qEEG-screening profile explicitly utilizes the neuroscience methodology and knowledge of brain functioning, its connection to mind in norm and pathology, and the known individual variability, thus bringing the needed objectivity that goes beyond traditional assessment methods of coaching, which typically involve self-reports, surveys and ratings. Furthermore, such qEEG-screening profile allows access to the neurobiological bases of instinctual drives, motivations and emotional tendencies that underlie the individual decision-making, thus permitting insights into a more efficient leadership coaching training. Lastly, the described profile presents within the same matrix the individual current (stable) strengths and weakness (the real self) in relation to the optimal (ideal) self, thus giving coachee a visually clear representation of his/her identity, capabilities, and tendencies that is crucially important to motivate the enduring personal change as an aspiration to fill the gap between the real and ideal self. Indeed, as it has been documented, leaders who can get access to an informative set of relevant knowledge about themselves and their skills are better positioned to involve the personality (self) in the deliberations and guide their actions toward their goals and priorities (Hannah et al., 2013).

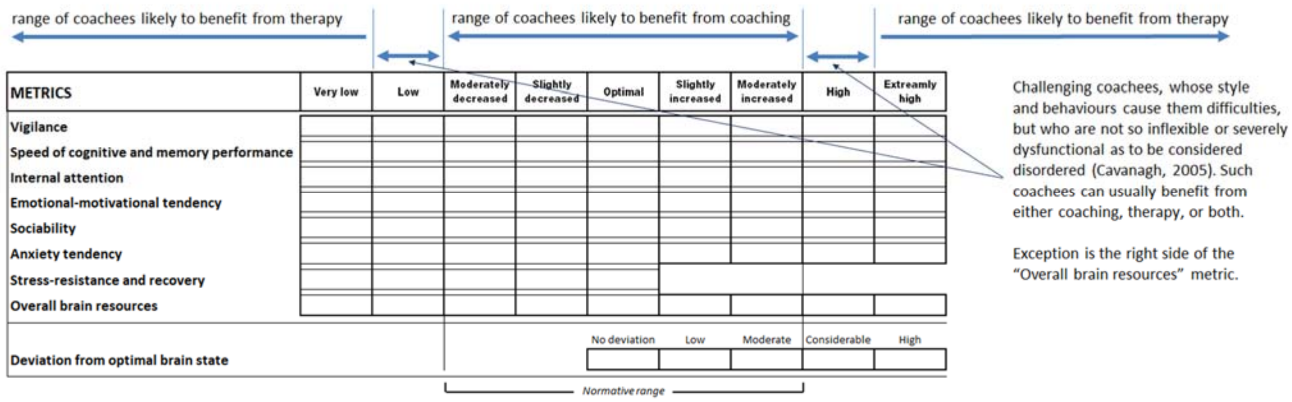

Figure 2. **Relating qEEG-screening profile to coaching and dimensional approach to personality.**

Intervention

After completing a baseline psychometric (BAI and BDI) screening and qEEG-registration procedure with consequent qEEG-screening profile calculation (*Assessment-I*), all coachees were enrolled in a 4-month coaching leadership training program. Based on the Assessment-I individual's qEEG-screening profiles, a personalized coaching program was designed for every coachee by a coach, taken into consideration different needs and skills of coachees. Within one week of completing the 4-month leadership training, all coachees were reassessed again with the same BAI and BDI questionnaires and qEEG registration resulting in a final qEEG-screening profile (*Assessment-II*). They were also asked to characterize by one word their subjective state *before* (Assessment-I) and *after* (Assessment-II) the training.

The leadership training program required every coachee to have an initial 2-hour reflection conversation with a coach, during which the qEEG-screening profile was discussed in order to build a comprehensive picture of the coachee and his/her cognitive-motivational-behavioral constructs. This self-exploring conversation served as a foundation for moving forward toward the purposeful planning of future-oriented goals, and desired skills and behaviors. Here the coach and coachee worked closely together to achieve the coachee's targeted goals and maintain reflective awareness of individual cognitive-motivational-behavioral patterns and reactions that may impede further leadership development. For example, the right-sided distribution within the metric 4 (Emotional-motivational tendency) indicates over-positive affect and approach-oriented motivational tendency (see Table 3), with maximum values indicative of "excessive risk acceptance", which at its worst may lead to over commitment and arrogant jealousy. Conversely, the left-sided distribution of the same metric characterizes certain forms of negative affect and withdrawal-related motivational tendency (see Table 3), thus leading to "excessive caution" and therefore to the missed opportunities or lack of initiative. Another illustrative example is metric 7 (Stress-resistance and recovery; Table 3). Research shows that there is quite high individual variation in respect to how stress is perceived, physiological responses to stress, as well as the psychophysiological effects of the stress response on individuals (Joels & Baram, 2009). For some, stress debilitates mental and physical health, causing a loss in productivity and diminished performance, as well as bringing interpersonal conflicts, whilst in others it can enhance health and performance, leading to mental toughness, heightened of new perspectives, a sense of mastery, strengthened priorities, deeper relationships, and greater appreciation of life (for a review see Crum, Salovey, & Achor, 2013). This means that coachees with optimal values on the metric 7 would have stress-related enhancing effect from experiencing stress and its elements should be included in the coaching program, while coachees with low values within this metric would most likely get debilitating effects of stress and it should either be avoided or, if this is not possible, the stress-as-negative mindset should be changed into a stress-as-enhancing mindset throughout coaching training.

Using these principles, the coach, independently from the researchers of this study, generated individual plans for every coachee, which consisted of 4 one-to-one 2-hour coaching sessions, 2 half-day group sessions, and homework between the sessions. Motivating emails and telephone calls were also used by the coach between the sessions.

Since all participants of this study were senior-level managers with a usual for their positions long work hours, lack of sleep and information overload, a sufficient nutritional supply was required to support their considerable cognitive and physical demands (Dye, Lluch, & Blundell, 2000). Accumulated evidence in nutritional cognitive neuroscience indicates that optimal nutrition may preserve cognitive function especially under stress conditions, maintain the psychological health, and enhance brain-cognitive reserve in healthy populations (Durga, Van Boxtel, Schouten, Kok, Jolles, et al. 2007; Gómez-Pinilla, 2008; Jacka, Overland, Stewart, Tell, Bjelland, & Mykletun, 2009; Zamroziewicz & Barbey, 2016). Therefore, the coaching program also included a set of nutrients and vitamins (developed by the authors of this study) individually adjusted for every coachee based on strong and weak features revealed by the qEEG-screening profile and their subjective complaints.

Statistical Analyses

To examine differences in the number of metrics of the qEEG-screening profile that improved, worsened or did not change from Assessment-I to Assessment-II, or in the number of coachees whose metrics of the qEEG-screening profile improved, worsened or did not change from Assessment-I to Assessment-II, the Kruskal–Wallis test was used. Where the interaction effects of time and number metrics or coachees were found to be significant, further analyses were conducted: the Wilcoxon Test was performed for every pair combination. To estimate the difference over time in how many participants every metric was in the optimal range, or improved vs worsened+not changed, the Chi-Squared test was used. Also, the Wilcoxon Signed-Rank Test was performed to examine differences between values of the Beck Anxiety Inventory and Beck Depression Inventory.

RESULTS

Figure 3 presents an overview (distribution) of values for all coachees for 9 metrics of the qEEG-screening profile *before* (Assessment-I) and *after* (Assessment-II) the coaching training program. While in the assessment-I the distribution of values was characterized by a shift toward the low-side values away from the optimal range, except the "overall brain resources" metric that showed rather increased resources for all coachees, in the assessment-II there was a clear shift of values toward the optimal range in all metrics, thus indicating a noticeable improvement in studied individual cognitive, motivational, and emotional traits.

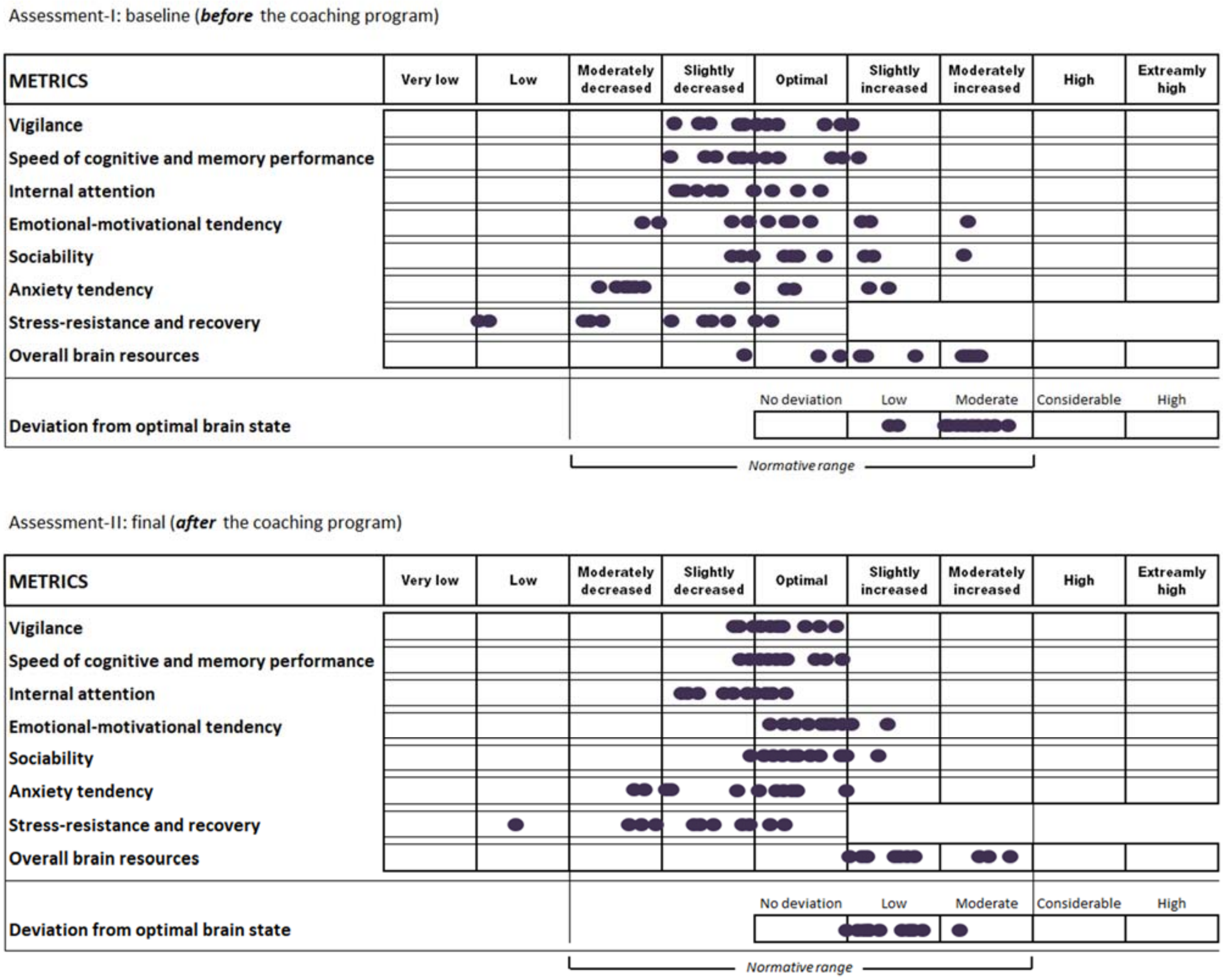

Figure 3. **qEEG-screening profile (total view for all coachees) before and after the coaching training program.** Dark circles represent individual metric value for every coachee (some of them over-imposed on each other because they occupy the same position within the metric distribution).

More precise inspection of the data revealed that not all metrics improved for every given coachee, some of them did not change or even worsened as a function of coaching training. On average for all coachees, 70.7% of metrics improved, 22.2% of metrics did not change, and 7.1% of metrics worsened. This result was significant as indicated by the Kruskal–Wallis test: H = 23.87, p = .00001. Post-hoc pairwise comparisons were estimated further to examine simple effects. This analysis revealed the statistically significant differences between the number of improved vs worsened metrics (Wilcoxon

Test: *W* = 121, *p* = .00006) and number of improved vs not changed metrics (Wilcoxon Test: *W* = 121, *p* = .00006).

The primary goal of the study was to maximally optimise the coachees traits by means of the individually tailored coaching programs. The comparison of the number of metrics that were in the optimal range before (Assessment-I) and after (Assessment-II) coaching training revealed a significant increase (18.2%) in the number of the metrics that reached optimal range (37.4% before vs 55.6% after; Wilcoxon Test: *W* = 31, *p* = .01).

Further analysis indicated that, on average, in the vast number of coachees (71.7%) the metrics improved, with a small fraction showing no change (16.2%) or worsening (12.1%). This result was significant as indicated by the Kruskal–Wallis test: *H* = 17.24, *p* = .00018. Post-hoc pairwise comparisons revealed statistically significant differences between the number of coachees with improved vs worsened metrics (Wilcoxon Test: *W* = 80, *p* = .0004) and number of coaches with improved vs not changed metrics (Wilcoxon Test: *W* = 81, *p* = .0003). Additionally, number of coachees with metrics in optimal range increased in average on 20% when compared between before (Assessment-I) and after (Assessment-II) coaching training (36.4% before vs 56.4% after; Wilcoxon Test: *W* = 31, *p* = .03).

Detailed analysis of the number of coachees with metrics in the optimal range before and after coaching training for every metric is presented in the Table 4. There was a notable increase for all metrics except two. The number of coachees with metric "Internal attention" and "Stress-resistance and recovery" in the optimal range did not change as a result of coaching training (even though there was improvement, see Figure 3). Another two metrics clearly stood out as having optimised in most coachees: "Speed of cognitive and memory performance" and "Emotional-motivational tendency" (see Table 4).

Table 4. Number of coachees with metrics within the optimal range.

Metric	before %	after %	difference %	Chi-Squared	
				T	p-Value
Vigilance	45.5	72.3	26.8	13.97	0.00019
Speed of cognitive and memory performance	36.4	90.9	54.5	65.26	0.00001
Internal attention	36.4	36.4	0.0	0	1
Emotional-motivational tendency	36.4	72.3	35.9	26.09	0.00001
Sociability	45.5	72.3	26.8	13.97	0.00019
Anxiety tendency	18.2	36.4	18.2	8.22	0.00414
Stress-resistance and recovery	18.2	18.2	0.0	0	1
Overall brain resources	90.9	100.0	9.1	6.74	0.009
Deviation from optimal brain state	0.0	9.1	9.1	6.74	0.009

Subjective wellbeing measured by the psychometric testing revealed that anxiety and depression scores decreased significantly as a result of the coaching training (see Table 2). Additionally, all coachees were asked to characterize by one word their subjective state in both assessments (before and after the training). At the beginning of the study (Assessment-I), 64% of coachees described their subjective state as “confused”, 36% as “happy”, and none as “neutral”; by the end of the study (Assessment-II), only 27% of coachees described their state as “confused”, 9% as “neutral” and 64% – as “happy”. These differences were statistically significant: Chi-squared = 29, p = .00001.

DISCUSSION

This study sought to employ the neuro-screening measure (qEEG) to build the individual profile of every coachee and use these profiles to develop and monitor an individually tailored coaching intervention with the aim of achieving the best performance with the least pshychophysiological price. Given the logistical challenges present in such “real world” research as the current one, it should be stressed that the results presented in this study are preliminary.

Results indicate that participation in a qEEG-informed and individually designed coaching program was associated with (i) significant optimization of vigilance level, speed of cognitive and memory performance, emotional-motivational tendency, sociability, anxiety tendency, (ii) improvement in stress-resistance and recovery (resilience), overall brain resources and (iii) minimized deviation from the optimal brain state as indicated by the metrics in the qEEG-profile (see Figure 3). This optimization is related to traits which characterize successful transformational leadership. For example, successful transformational leaders have a tendency to keep anxiety levels low, and able to control their emotions, keeping some level of positivity even in difficult and stressful situations (Balthazard et al., 2012). These features are reflected in the “Anxiety tendency” and “Emotional-motivational tendency” metrics in the qEEG-screening profile. As for the anxiety metric, deviation to either side away from the optimal range indicates an increase in anxiety – leading to anxious arousal (left deviation) or anxious apprehension (right deviation) (see Table 3). In the emotional-motivational metric the optimal range represents adequate levels of positive affect and approach-oriented motivational tendency, which translates into optimism and self-control (see Table 3). This is in sync with leadership research that shows that effective leaders demonstrate a proper level of optimism and control of emotions that drive their thinking in decision-making, allowing them to manage criticism and deal with difficult situations productively (Boyatzis & McKee, 2005; Daft, 2008; Goleman, Boyatzis, & McKee, 2002). At the same time, only some (optimal) level of optimism is desirable, since over-optimism or over-positivity may lead to risky decisions or unjustified over commitments (Venkatraman, Huettel, Chuah, Payne, & Chee, 2011). Furthermore, transformational leaders have good interpersonal relationships and communication skills that contribute to their charismatic image (Avolio, 2011; Bass & Bass, 2009; House, 1977). Indeed, leaders do not exist in a vacuum, they are constantly interacting with and relying on other people to help inform and implement their decisions, and also provide social and cognitive support (Rilling & Sanfey, 2011). Without adequate sociability skill it would be difficult to identify what motivates another people, leading to a possibility that a leader may stop to be seen as inspiring in the eyes of followers and lose their support. However, only an optimal level of sociability is crucial for leaders to succeed, because hyper-sociability can result in excessive sensation-seeking and over-dominance (see Table 3), which would have a negative impact on organizational climate and performance (Ben Hador, 2016). In this context, optimization of sociability observed in this study after the coaching program (see Figure 3 and Table 4) clearly points that personalized coaching program guided by the qEEG-screening may result in the appropriate level of communication skills that promote leaders to interact with followers in a manner that inspires them to be productive, positive and commit to their organizations (Kumar, 2014). Indeed, extraversion (which correlates with the "sociability" metric) is the most consistent/systematic predictor of transformational leadership behavior (Bono & Judge, 2004; Do & Minbashian, 2014).

Stress-resistance and resilience are another important features of a successful transformational leadership (Qutob, 2013), since executives, instead of a short encounter with a stressful situation, may work under stress for months, or even years (Levinson, 1981). Although chronic stress usually has debilitating effects on people's physical and mental health, in some individuals it could enhance health and performance (Park & Helgeson, 2006). The so called "growth effect" of stress is observed in leaders who have a "stress-is-enhancing" mindset (Crum et al., 2013), which is typical for transformational leaders (Qutob, 2013). In this context, we may propose that the improvement in the stress-resistance and recovery metric observed after the coaching training (see Figure 3) in this study, creates the needed conditions for stress-related growth effect that is accompanied by mental and cognitive toughness (Crum et al., 2013). This conclusion is also supported by the improvement in the metric "Speed of cognitive and memory performance" as a function of the coaching training (see Figure 3), and the fact that it was the metric that reached the optimal range in the absolute majority (90.9%) of coachees (see Table 4). The latter result is of particular interest as it corroborates with the studies showing that transformational leaders tend to have greater cognitive flexibility and enhanced neural resource available to tackle cognitive issues (Balthazard et al., 2012). These features enhance the leaders' ability to cognitively comprehend and react fast, proactively and adaptively to dynamic decision-making situations (Hannah et al., 2013; Hannah, Lord, & Pearce, 2011). Furthermore, there is strong evidence that cognitive parameters are predictive of job performance (Ackerman, 1992; Hunter & Hunter, 1984; Schmidt & Hunter, 1998), thus indicating that optimal speed of cognitive and memory processes would guarantee an optimal job performance.

It is noteworthy that the above discussed improvements and optimisations need to be supported by the appropriate (optimal) levels of arousal (see Table 3), that is having enough vigilance to meet the task demands and goals at hand, but not excessively much that it compromises performance or debilitate health in the long run. Indeed, it has been documented that arousal impacts thinking and performance (Arnsten, 1998) and that performance is at its peak at a moderate (optimal) level of arousal/vigilance (Crum et al., 2013; Duffy, 1957; Yerkes & Dodson, 1908). Further, scientific research has found that optimally vigilant decision-making processes are superior to hypervigilant decision-making processes (Baradell & Klein, 1993; Keinan, 1987). Thus, a clear optimisation effect observed in this study after the coaching training in the metric "vigilance" (see Figure 3 and Table 4) could be interpreted as laying the foundation for the optimisation and improvement of other important traits for the successful transformational leadership discussed above.

In order to keep the cognitive, mental and emotional stability, as well as high resiliency for prolong time and under the stress pressure of working environment (which executives usually are facing), the brain should have large resources (Medaglia, Pasqualetti, Hamilton, Thompson-Schill, & Bassett, 2017). The "Overall brain resources" metric helps coaches to objectively measure such brain reserve and monitor its dynamics as a function of training. The nutritional element of the coaching programs used in this study was aimed to further enhance brain resources, which were already rather high before training (Assessment-I) in the sample of executives participated in this study (see Figure 3). Four months of the intervention program resulted (Assessment-II) in further brain resources gains (see Figure 3 and Table 4), thus allowing leaders to maintain their neurophysiological and psychological strength, keep focus, and improve performance under challenging and uncertain circumstances and pressures common in the life of executives (Bass & Bass, 2009; Yukl, 1981).

In regard to the last metric of the qEEG-screening profile ("Deviation from the optimal brain state") that estimates the potential of probable brain dysfunction (see Table 3), its clear improvement after four months of personalised coaching programs suggests that intensive interventions adjusted individually to every given coachee have enough power to optimise the overall neurophysiological brain state, thus allowing more optimised functioning of cognitive, mental, emotional, and other qualities characterising effective leaders (Bass & Bass, 2009; Lowe et al., 1996). This result contributes to the growing body of evidence that shows the capability of brain for plasticity (Szuhany, Bugatti, & Otto, 2014; Wall, Xu,

& Wang, 2002) and self-regulation/self-organisation (Fingelkurts et al., 2013; Thibault et al., 2016). In other words, it may be concluded that training the brain, similar as training the body using physical exercise, allows it to learn to regulate itself and function better with spending less resources. The framework proposed by Rock, Siegel, Poelmans, and Payne (2012) suggests a number of mechanisms how different elements of coaching interventions can improve brain functional state.

Only one metric – "Internal attention" – exhibited a slight and nonsignificant deterioration as a result of coaching program (see Table 3) in 54.5% of coachees. This finding can be explained by the fact that the used in this study personalised coaching programs focused mostly on other traits that are considered important for the transformational leadership (such as proper level of vigilance, emotional-motivational stability and control, communication skills and sociability, stress-resistance and resilience) at the expense of internal attention. This is an obvious drawback in the coaching programs' design, since proper self-awareness, and the ability to monitor and regulate one's own thoughts and behaviour are crucially important to enable the leader efficiency (Hannah et al., 2009; Zaccaro, Foti, & Kenny, 1991). It is through self-awareness and self-regulation that the individual is able to mobilize his/her resources, prioritise the lower-order targets, and successfully pursue longer-term goals (King, 2001; Tice & Bratslavsky, 2000). Thus, future usage of qEEG-screening for the purposes of guiding the development of personalised coaching programs should pay more attention to this particular metric. Self-regulation techniques such as mediation (or mindfulness) are especially effective in enhancing self-awareness and internal attention (Tang et al., 2007; Vago & Silbersweig, 2012) and should therefore be part of the coaching programs. For example, in a previous study with the same qEEG-screening procedure it has been shown that meditation can effectively improve the "Internal attention" metric during 4-month training in 90% of novices – persons who have never meditated before (Fingelkurts et al., 2015). Further, it has been documented that participating in the mindfulness program significantly improves different aspect of individual performance, including decision-making (Alfonso, Caracuel, Delgado-Pastor, & Verdejo-García, 2011).

There is yet one more finding that warrants additional discussion. Although the majority of metrics (70.7%) improved in the 71.7% of coachees, a small number of metrics (7.1%) worsened in about 12.1% of coachees as a result of coaching intervention. There might be several lines (not necessarily mutually exclusive) for interpretation of this finding. One reason could be that some coachees followed less accurately some of the advices and instructions from the coach due to their tough executive positions and associated duties. Also, some neurophysiological mechanisms may play a role. For example, when metrics optimization is appropriate and complete, even functions that were not targeted directly may begin to normalize. However, when improvement is partial, the brain may "find" other avenues of expressing its dysregulation (and it can be more pronounced in some persons). This phenomenon is conceptualized as a “neuronal hydraulics” (Collura, 2009), which states that if we push on the system (brain-mind in this case) without holding a sufficient number of variables constrained then, the system may find other outlets, that is, other dysregulations may emerge. Unfortunately, such processes can limit an individual from reaching his or her leadership potential. We propose that in such coachees, the 4th month of the program (Assessment-II) should be considered as an intermediate stage which is used to further adjust the coaching program, with a specific focus on the worsened metrics, aiming to “clean up” problems that might prevent effective leadership potential.

Importantly, the positive neurophysiological findings reflected in the qEEG-screening profile metrics in the post-intervention – Assessment-II (see Figure 3) – were also accompanied by improved wellbeing of coachees evidenced by significant decreases in anxiety and depression scores, which are measures independent from qEEG profile metrics (see Table 2). This result is in agreement with Grant (2003) and Green, Oades, and Grant (2005) who also showed that proper coaching strategies may significantly enhance mental health and improve quality of life. The coachees participated in our study reported that having a visually comprehensive, yet easy-to-interpret profile (see Figure 1), helped them understand themselves much better than before, as well as realize their own strengths and limitations, and actively use those to develop new more effective behaviors and goals, in the pursuit to express their “ideal selves”. In this way, a visual presentation of the qEEG profile metrics is compatible with a so-called “vision-based” coaching which has been shown to correlate with positive work outcomes (Boyatzis, Rochford, & Jack, 2014). For example, a recent study found that vision-based coaching that emphasizes the individual’s “ideal self” resulted in greater work engagement, higher quality work, career satisfaction, and positivity among executives (Cable, Gino, & Staats, 2013; Van Oosten, 2013). Furthermore, Higgins (2000) proposed that when people subjectively experience a “good fit” between personally meaningful goals and their own self-regulatory styles they report feeling good about what they are doing. “Feeling good” is thus a normative assessment, which forms the basis of a positive psychology where happiness and wellbeing are the desired outcomes for effective leadership (Webb, 2005). Indeed, in the current study, at the Assessment-I the majority of coachees described themselves as “confused”, whereupon training completion (Assessment-II) that changed to mostly “happy”, which is yet another indicator that qEEG-personalized coaching program works.

To summarize, the above discussion demonstrates that neuro-monitoring may provide objective information about underlying brain processes associated with traits important for inspirational/transformational leadership and allows designing the personalized coaching programs tailored to every individual and further to objectively monitor the efficacy of the coaching training. In this regard, neuro-profiling and monitoring makes coaches better poised to develop inspirational/transformational leaders in a more objective and systematic manner. Thus, in agreement with Waldman et al. (2011a), “through neuroscience methodology, cognition and emotion can be theorized and examined simultaneously in order to fully understand the neurological basis of effective leadership” (p. 68) and in such way develop a scientifically informed evidence-base for coaching theory and techniques (Cavanagh et al., 2005). This strategy can be expected to maximize the effectiveness of both the coaching intervention itself and the coachee’s developmental outcomes.

CONCLUSIONS

While the concepts, ideas and results of this study have relevance to many types of training interventions (or their individual components), the main focus has been on the effectiveness of coaching on transformational, visionary, charismatic or inspirational leadership as the most effective leadership model (Waldman et al., 2011a).

The main theoretical contribution of this study is highlighting the importance of the brain’s role in mediating effective leadership behavior and objective exploration of how the brain itself (its strengths and weaknesses) might be used to better develop leadership potential. This study expands the literature on leadership by bringing the neuroscientific perspective and measurement. We are aware of only two other published studies which assessed leadership using neurophysiologic measures (Balthazard, et al., 2012; Hannah et al., 2013). Together, the present study and the mentioned two other research demonstrate the utility of employing neuro-measuring in developing a deeper understanding and monitoring of brain activity and, hence, the so called “black box” of effective leadership (Senior, et al., 2011).

From a practical perspective, results of the current study suggest that qEEG-screening profiling could potentially be used either for a leader selection or for effective leader development guidance. More specifically, the employment of qEEG-screening profiling allows coaches and trainers to assess the latent and dynamic neurological processes that are associated with traits important for effective (transformational) leadership and allows their tracking and development over time.

Limitations

Several limitations of the current study should be noted when interpreting the results. The first limitation is the sample size. Indeed, the sample size of the current study was small; however, it was comprised of individuals who occupied the top tiers of their respective organizations, as opposed to a potentially larger sample size comprised of lower level managers, or other employees. Second, the study involved self-selected participants who actively choose to be part of a qEEG-screening coaching program, which may have resulted in larger effects size as participants were more motivated to learn and apply the leadership skills at work. In this respect, a more pragmatic study design could test whether the results still hold in larger and non-self-selected population study. At the same time, it can also be argued that in the real-world settings the majority of coaching clients are already self-selected and highly motivated. Third, the evaluations were based on changes over time (the personalized coaching intervention) without the use of a comparison (control) group. Without such a control group, it can be argued that the obtained effects may not have occurred as a result of the coaching intervention but as a function of time. This, however, is highly unlikely. In this particular real-world design, the participants were senior-level managers who by the fact of their executive positions are exposed to considerable levels of stress (Eaton et al., 1990). Our unpublished data shows that in the situation of long-lasting stress and in the absence of any remedying interventions, the majority of qEEG-screening profile metrics deteriorated significantly contrary to what was found in the present study, where the vast majority of metrics improved in majority of participants. Fourth, the current study did not assess whether the reported qEEG metric improvements were sustained beyond the 4-month intervention window. Future studies could determine the period during which the effects last and the reinforcements necessary to introduce stable long-term changes. Fifth, the design of the current study did not allow to determine whether the qEEG informed personalized coaching interventions were more effective than standard support group offering just support and information about goals. At the same time, it has been shown that the presence of another person (whether skilled or unskilled) is not a necessary and sufficient condition for successful behavior change, even when assisted by skilled helpers (Miller & Rollnick, 2002; see also Spence & Grant, 2005). Sixth, the study design did not permit to differentiate the effects of coaching from nutritional support. However, in this study the coaching program included many elements and nutrition was one of them – part of a package, so it was not intended to be considered separately from the coaching intervention. While it would be useful to have a control group to isolate the specific effects of coaching from nutritional intervention, from an organisational standpoint showing the effectivity of the whole coaching package is value in itself (De Meuse, Dai, & Lee, 2009).

The main strength of the current study was the usage of multimethod approach (Podsakoff, et al., 2003) to formulate and test hypotheses, as well as the employment of the state-of-the-art qEEG-screening profiling and neuromonitoring.

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